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Research Article

MEASURING MENTAL CHRONOMETRY AND COGNITIVE EFFICIENCY THROUGH DISCRIMINATION REACTION TEST FOR ACQUIRED REFLEXES – CASE OF LOCO PILOTS OF WESTERN RAILWAY

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Abstract

In this article 80 Loco Pilots of Indian Railways participated and screened for deployment on EMUs in Mumbai sub-urban as Motorman. Their mental chronometry and cognitive efficiency through discrimination reaction test (DRT) for acquired reflexes measured. Psycho motor performance of left, right hand and foot was studied while responding associated color signals. The mean reaction time was lowest in case of yellow color associated to left hand comparing to green and red color associated to right hand and foot respectively. The correlation coefficient of age and experience with DRT of participants was found positive but not statistically significant. The positive correlation coefficient in case of working experience and DRT is indeed a good sign of inert aptitude of train driving staff of the Indian Railways. Further, based on 't' values, it can be concluded that the difference between DRT means for yellow, green and red color associated to hands and foot is significant at ($p<0.01$) level of significance. Results discussed at length and intervention to improve the DRT suggested.

Keywords: EMUs; Loco Pilots; DRT; Indian Railways; Hemispheres

Introduction

Indian Railways has been serving the people of India since 1853 and covering almost 160 years of its operation. Over the years, the Indian Railways operated as a great integrating drive and lend a hand to the economic structure of India. Indian Railways (IR) not only enjoys the monopoly over Indian railway transport, but it is also one of the second largest and busiest rail networks in the world.

The first suburban service with steam traction was started in April, 1867 in Mumbai. Fig. 1 shows the EMU Cab of first sub-urban train. The Mumbai Suburban Railway consists of rapid transit on exclusive inner suburban railway lines augmented by commuter rail on main lines serving outlying suburbs to serve the Mumbai Metropolitan Region. Mumbai sub-urban covers almost distance equal to moon in one week. The passenger density on Western Railway route is sixty thousand passengers per km per day which is highest among all the leading Metro Railways of the world (Safety book, WR, 2015).

Motormen are working as a pivot/shaft to run the railways transport system which is directly related to the passenger's safety, it is their moral responsibility to give all the information to passengers through your kind goodness to avoid the inconvenience to the commuters as well as to us. Motormen have a very clean and good record of their dedicated services to the railway and also to the commuters.

Fig. 1: EMU Cab

The commuters of Mumbai locals know the efficiency and fidelity of motormen towards the duties and

responsibilities, who are always giving more than anticipated (100%) and a momentary breakdown of motorman may trigger a disaster.

Indian Railways have customized screening of incumbent for the job of Motorman. They are tested for having scholastic brilliance as well as critical psychological attributes to perform the job of Motorman. The critical attributes identified on the basis of scientific job analysis and validation studies are: Intelligence, map memory, numerical ability, ability to identify or detect a known pattern that is hidden in other material (group embedded figure pattern), restraint & emotional stability and discriminating reaction time.Motormen in Mumbai operate suburban trains single-handedly on automatic block routes.

According to Jensen (2006), reaction time tests are well suited for cognitive assessment tests since reaction time tests offer a high sensitivity for detecting variation in cognitive efficiency and they can be repeated virtually an unlimited amount of times.That is, it indicates how fast the thinker can execute the mental operations needed by the chore at hand. The behavioral response of the testeeis typically a button press but can also be an eye movement, a vocal response, or some other observable behavior.

Discrimination reaction time involves comparing pairs of simultaneously presented visual displays and then pressing one of three buttons according to which display appears yellow, green and/or red on some dimension of interest. Due to inattentive or short lapses, there is a significant amount of inconsistency in an individual's response time. This inconsistency/ variability does not tend to follow a normal (Gaussian) distribution at large. To control for this, investigator typically require testee to carry out several trials, from which a measure of the 'typical - average' response time can be calculated.

In this article, attempt is to study 'Mental Chronometry and Cognitive Efficiency in discrimination reaction time for acquired reflexes – Case of Western Railway Loco Pilots' screened for deployment on EMUs. DRT acquired reflexes in reference to visual stimulus (colors) and left/right hand, foot measured and their relationship with age and length of service studied and interpretation in following paragraphs are made.

Objectives of the study

1. To study the average discrimination reaction time of participants for three colors.
2. To study the relationship of discrimination reaction time with age and working experience.
3. To study the mean difference in three different colors for discrimination reaction time.

Method

The participants have been driving goods and passengers' trains for quite some time. They were regular train driving workers of the Indian Railways and undergone the selection programme to adjudge their suitability to drive EMUs as Motorman in Mumbai sub-urban.

Sample

Eighty driving crew (Loco Pilots) of trains of Indian Railways participated in the study. Their age varied from 36 to 48 years with 41.74 years as mean. Their working experience varied from 11 to 24 years with 16.26 years as mean. They all were male and income varied from Rs. 60,000 to 70,000.

Research Design

Present study was confined to non-experimental in nature as research involves observing and measuring things as they are. Unlike experiments, they don't let us explain why the behavior occurs. Still, they provide solid, scientific basis, when correctly analyzed and interpreted.

Measure

Test of Discrimination Reaction Time (DRT)

In this test, three Color lights, viz., Red, Green and Yellow are presented in a predetermined sequence. The subjects are supposed to release the foot key if the visual stimulus is red light, release right hand key if the stimulus is green light and the left hand key on seeing yellow light. Six trials in practice and 15 trials in main test are given. Time lapse between presentation of stimulus and eliciting the response is recorded in milliseconds. Mean Reaction Time for 15 trials constitutes the score. Fig. 2 shows the Discrimination Reaction Time equipment.

This test is one of the test of aptitude test battery used for selection of Motorman to drive EMUs in Mumbai Metro.

Statistical Tools & Techniques

1. Measures of Central tendencies
2. Pearson Product Moment Correlation and Student's t test

Fig. 2: Discrimination Reaction Time (DRT) equipment

Table 1: Central tendencies, Coefficient of Variation and Zero order correlation

Variables	Mean	SD	SE	CV (%)	Correlation (r)		
					Age	Experience	DRT (Ave)
Age	41.74	3.01	0.34	7.21	1	0.50	0.14
Experience	16.26	3.15	0.35	19.37		1	0.01
DRT (Ave)	583.27	43.22	4.83	7.41			1

r=0.18 ($p<0.05$)Two tailed

Results and Discussion

The discussion on the results obtained is presented in the following paragraphs. Before computing the correlation coefficients the scores of DRT were converted into the reverse order as interpretation of Reaction Time is higher the score poor is the performance. Table 1 shows the central tendencies, coefficient of variation and zero order correlations.

Table 1 shows the descriptive statistics for background variables and performance on DRT test. The correlation coefficient of age and experience with DRT of participants was found positive but not statistically significant as probability to reject the hypothesis was ($p>0.05$). The results indicate that as the age of the participants is increasing so as the time taken to react the stimulus is also increasing. The magnitude of the correlation coefficient in case of experience with DRT is very negligible indicating that there is no effect on the performance of DRT as participants are gaining the experience. This is indeed a good sign of static aptitude of train driving workforce of the Indian Railways.

Simple reaction time shortens from infancy into the late 20s. It increases slowly until attaining the age 50s and 60s, and then make longer as the person gets into his 70s and beyond (Welford, 1977; Jevas and Yan, 2001). MacDonald *et al.* (2008) found that reaction time dispersion in older adults was typically linked with slower reaction times and poorer recognition of stimuli, and suggested that dispersion might be a useful measure of general neural integrity. Welford (1980) speculates on the reason for slowing reaction time with increasing age. It may be the affinity of adult people to be more watchful and observe their responses more meticulously (Botwinick, 1966). Myerson*et al.* (2007) found that older adults were as adept as younger people at assimilating information, but they did take longer to react. Lajoie and Gallagher (2004) found that old people who tend to fall in nursing homes had a significantly slower reaction time than those that did not tend to fall.

Results of this study are in the similar direction as reported in earlier paragraphs. The correlation coefficients are not statistically significant and very low especially in case of length of service of participants. Table 2 shows the central tendencies of DRT performance of participants color wise for all fifteen signals.

Table 2: Color and its emergence position in 15 trials for DRT performance

Trial Position	Color	Mean	SD	SE	CV (%)
1	Yellow	511.13	76.98	8.61	15.06
2	Red	722.35	65.16	7.29	9.02
3	Green	533.85	83.58	9.34	15.66
4	Yellow	485.13	82.12	9.18	16.93
5	Red	709.63	81.01	9.06	11.42
6	Green	529.50	88.92	9.94	16.79
7	Red	712.00	74.76	8.36	10.50
8	Green	554.88	74.34	8.31	13.40
9	Green	536.75	75.27	8.42	14.02
10	Yellow	499.50	82.99	9.28	16.61
11	Red	711.75	83.92	9.38	11.79
12	Yellow	523.00	90.49	10.12	17.30
13	Green	518.75	83.13	9.29	16.03
14	Red	714.63	71.79	8.03	10.05
15	Yellow	485.75	79.03	8.84	16.27

It is interesting to note that no consistency in performance in successive same color signals was observed and there is variability among the scores. The line graph to show the variability among scores for different colors is shown in Fig. 3.

Table 3 shows that the reaction time associated with hands was low for left hand comparing to right hand. However, reaction time associated with 'foot' was very high comparing to both hands. The interpretation is higher the score poor is the performance. Further, based on 't' values, it can be concluded that the difference between reaction time means for yellow, green and red color associated to

respective hands and foot is significant at 0.01 level of significance. Time for motor preparation (e.g., tensing muscles) and motor response (in this case, pressing the button) was the same in all three types of colors, implying that the differences in reaction time are due to processing time. Similar findings in his study have been confirmed by Miller and Low (2001).

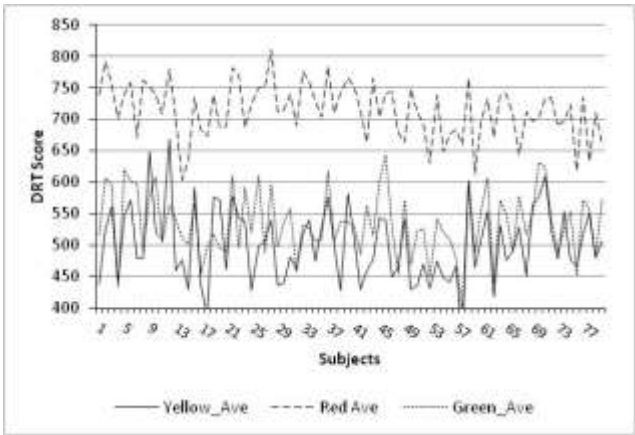

Fig. 3: Variability of DRT scores

Type of experiment, stimulus and stimulus intensity are basic characteristics of any reaction time test, but there are still many factors having affect on reaction time viz., arousal, relevance of stimulus to survival, age, gender, left vs. right hand, direct vs. peripheral vision, fatigue, fasting, distraction, order of presentation, breathing cycle, finger tremors,attentional blink, affective priming, personality type,exercise, punishment, stress & threats, stimulant drugs, depressant drugs, etc.

Left vs. right hand

The left hemisphere of the brain is regarded as the verbal and logical brain, and to the other side right hemisphere governs creativity, spatial relations, face recognition, and emotions, among other things. Right hemisphere dictates the actions of left hand, and the left hemisphere controls the activities right hand. This has made researchers think that the left hand actions should be faster at reaction time concerning spatial relationships. The results of Bartélémy and Boulinquez (2001 and 2002) all supported this idea.

Results of the study are in the similar direction as stated in above paragraph, as left hand response time was faster than right hand. Response time for red stimulus given by foot was slow in comparison to both hands. Miller and Van Nes (2007) found that responses involving both hands were faster when the stimulus was presented to both hemispheres of the brain simultaneously. As the right hemisphere is abounding with input by the left eye, it might be alleged that the left visual field would be the best ever at identifying the stimulus.

An attempt was also made to relate reaction time with the color meaning, wavelength and frequency interval. Color derives from the spectrum of light (distribution of light power versus wavelength) interacting in the eye with the spectral sensitivities of the light sensors. Colortypes and physical properties are also associated with objects, materials and light sources. Table 4 shows the Color meaning, wavelength and frequency intervals of the response stimulus presented through discrimination reaction time.

Table 3: Color and associated Hand/Foot wise mean DRT performance

Color	Hand/Foot	Mean	SD	SE	CV (%)	t value		
						Yellow	Green	Red
Yellow	Left Hand	500.90	59.46	6.65	11.87	-	3.79	25.71
Green	Right Hand	534.75	53.29	5.96	9.97			23.15
Red	Foot	714.08	44.29	4.95	6.20			-

t=1.66 (p<0.05), t=2.374 (p<0.01) Two tailed

Table 4: Color meaning, wavelength and frequency intervals

Color	Meaning	Wavelength interval	Frequency interval
Red	Lust, excitement, love	~ 700–635 nm	~ 430–480 THz
Yellow	Jealousy, competence, happiness	~ 590–560 nm	~ 510–540 THz
Green	Good Taste, envy	~ 560–490 nm	~ 540–610 THz

Table 5: Percentile scores for age, length of service and DRT

Percentile	Age (Yrs.)	Length of Service (Yrs.)	DRT Score		
			Yellow	Green	Red
10	38.00	14.00	430.20	459.00	649.20
20	39.00	14.00	443.20	490.00	676.40
30	40.00	14.00	464.00	504.60	692.00
40	40.40	14.00	476.00	516.80	704.00
50	42.00	15.00	494.00	530.00	713.00
60	43.00	17.00	517.20	545.60	735.20
70	43.00	18.00	539.40	565.40	740.00
80	44.00	18.00	553.20	595.20	752.00
90	46.00	21.80	576.00	607.80	766.00

The wavelength of light determines its color, which is higher for red color followed by yellow and green colors respectively. Researchers at the University of Rochester have found that the number of color-sensitive cones in the human retina differs dramatically among people by even up to 40 times. Even though, people appear to perceive colors the same way. The research findings, strongly suggest that our perception of color is controlled much more by our brains than by our eyes.

50^{th} percentile score is the median of the DRT performance scores. Table 5 shows that 50% participants were found to have less than or equal to discrimination reaction time 494, 530 and 713 ms for yellow, green and red colors respectively.

Conclusion

On the basis of foregoing discussions it can be concluded thatreaction time is a complicated behavior and is affected by a large number of factors. When a person responds to something and hears, sees/feels, the overall reaction time can be decomposed into a sequence of components viz. mental processing Time (sensation,perception/recognition, situational awareness), movement time, device response time (reaction distance, physical force distance).

The correlation coefficient of age and experience with DRT of participants was found positive but not statistically significant as probability to reject the hypothesis was ($p>0.05$). The results indicate that as the age of the participants is increasing so as the time taken to react the stimulus is also increasing. A University of Michigan study suggests that, as our age increases, our brain contacts break down, dawdling up our corporeal response times. According to the study, older adults seem to have unnecessary 'cross-talks' between the two hemispheres (left/right) of the brain.The study is the first known to show that this cross-talk happens even while older adults are at rest, says Rachael Seidler. When both sides of the brain talk all together while one side of the body tries to act, perplexity and slow down responses result, Seidler says. The magnitude of the correlation coefficient in case of experience with DRT is very negligible indicating that there is no effect on the performance of DRT as participants are gaining the experience. This is indeed a good sign of static aptitude of train driving workforce of the Indian Railways.Results of this study are in the similar direction as reported various researchers and are referred in this article.

The reaction time associated with hands was low for left hand comparing to right hand. However, reaction time associated with 'foot' was very high comparing to both hands. Further, based on 't' values, it can be concluded that the difference between reaction time means for yellow, green and red colors associated to hand and foot is significant at 0.01 level of significance. Time for motor preparation (e.g., tensing muscles) and motor response (in this case, pressing the button) was the same in all three types of colors, implying that the differences in reaction time are due to processing time. Similar findings in his study have been confirmed by Miller and Low (2001).

Results of the study are in the similar direction as studies reported in above paragraphs, as left hand response timewas faster than right hand. The values against the 50^{th} percentile for discrimination reaction time were 494, 530 and 713 ms for yellow, green and red colors respectively.Response speed depends on several factors so there can be no single, universal reaction time value. The factors which affect reaction time are: expectation, urgency, cognitive load, stimulus-response compatibility, psychological refractory period, age, gender, nature of the signal, visibility, response intricacy, etc.

Intervention to improve

1. To improve physical reactions in the short span subject need to be vigilant and conscious.
2. Make sure subject had a good night's sleep and had lots of water-soluble carbohydrates (sugars, starch, and cellulose).
3. Subject needs to get rid of all disturbances from his/her mind so that he/she is not pre-occupied with thoughts other than the testing environment.
4. Concentrate on your senses and be informed of the world around you.
5. Improving reaction time involves two things – training your fast muscle and mounting the speed at which neurons fire and communicate to stimulus.
6. Reactions in general refer to reactions of the arms, so this is what the subject needs to speed up. Clapping press ups, shadow boxing, or even clapping may work good exercises.

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