PSYCHOMOTOR VIGILANCE TASK AS A MEASURE OF PERFORMANCE-BASED FATIGUE

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ABSTRACT

Psychomotor Vigilance Task (PVT) is used frequently in fatigue's research as a performance test that sensitive to sleep deprivation and under various sleepiness conditions. In general, PVT is stimulus-response test and measure decrement performance as fatigue indicator through response time (RT), number of lapse and number of false to respond. Fatigue can be defined as gradual and cumulative process associated with disinclination towards effort and affected by sleep loss and circadian rhythm. Fatigue research suggested to use 10min version of PVT, however, recently study is validate 5min and 3min PVT as measurement duration. PVT also suggested using along with other subjective and objective method of fatigue measurement to complete the evaluation.

Keywords: PVT, Fatigue, Sleep deprivation, Fatigue objective method

1. INTRODUCTION

Psychomotor vigilance task (PVT) is a performance test to measure the effects of sleep loss on neurobehavioral functioning based on 'stimulus-response" method (Blatter, 2006; Drummond et al, 2005; Loh et al, 2004). The test is tried to measure a sustained attention and reaction time task through speed respond to auditory or visual stimulation.

Drummond et al (2005) stated that PVT was originally developed in 1985 as a measure of sustained attention. Based on large studies after, PVT has demonstrated its sensitivity to unnatural factor such as work schedule, caffeine, and natural factor such as homeostatic, sleepiness, circadian rhythm, and age (Drummond, et al, 2005; Blatter, 2006, Kim et al, 2005).

PVT is also regarded as objective indicator of cognitive impairment under various sleepiness conditions (Lee et all, 2010). And recent studies suggested PVT as practical instrument to assess fatigue (Lee et al, 2005; Saito, 1999) and being widely used for that purposes as gold standard (Dawson et all, 2013). This suggestion based on fatigue can be driven and aggravated by sleep loss (Williamson et al, 2011; Dessai and Haque, 2006). Fatigue itself is often indicated by a decrease in performance (Horrey et al, 2011; Williamson et al, 2011) and PVT is a tool that can measure the performance degradation by measuring attention (Saito, 1999; Petrelli et all, 2006). The ability to indicate performance degradation caused PVT categorized as a performance-based measurement.

This paper summarizes PVT as performance-based measurement of fatigue, arranged to PVT as fatigue measurement tool, supportive devices of PVT, methodology, and correlation to other fatigue measurement method. The paper also discusses some issues for further research on PVT as a fatigue measurement tool.

2. THEORETICAL BACKGROUND

2.1 PVT as a Fatigue measurement tools

Human fatigue is associated with functional impairment (Peterli et al, 2006; Williamson, 2011) and can result in reduced speed of responses, or incorrect responses and/or failures to respond (Williamson et all, 2011). Fatigue is defined as gradual and cumulative process associated with disinclination towards effort (Grandjean, cit by Philip, 2005).

Williamson et all (2011), in her paper state that fatigue is a biological driver for recuperative rest, and can take several form

including sleepiness as well as mental, physical and/or muscular fatigue. She also stated that in our modern transportation system now days, sleepiness and mental fatigue are the most important forms of fatigue. Fatigue itself is a complex phenomenon, and various factors has been identify as causative factors (Saito, 1999; Williamson, 2011, Noy, 2011) moreover fatigue can manifests in various forms such as feeling fo tiredness, sleepiness, or lack of motivation (Saito, 1999).

Fatigue and sleepiness is frequently confusing for us (Phillip, 2005), and it can be caused by its complexity phenomena, the various form it taken as stated before, and the concept which is still not really clear (Rupp, 2013; Shahid et al., 2010; Shen et all, 2006; Williamson, 2011). However, Shen et al. (2006) stated that both are distinct phenomena although sleepiness and fatigue is two interrelated thing.

Sleepiness is a condition when someone has difficulty to remaining awake even while carrying out activities (Dement and Carskadon cit Philp, 2005), and related to circadian and homeostatic influence (Horrey, 2011; Petrilli et al, 2006; Philip, 2005; Shen et al, 2006; Williamson, 2011). However, large number of studies, show that circadian rhythm and homeostatic has also influence to someone fatigue condition (Millar, 2012, Smolensky et all, 2011).

PVT devices are generally in the form of a simple test tool for measuring the reaction time based on certain stimulus, sound or visual. Change in performance measures by PVT, refers to performance variability and can reflect someone fatigue level. There are some variable use as indicator related to performance that refer to fatigue condition. The variable are reaction time (RT) in average, response speed (1/RT), fastest reaction time, number of lapses , and slowest reaction time (Blatter, 2006; Drummon et al, 2005; Kim et al, 2007; Lee, 2010). Response speed is defined as mean 1/RT during the testing period (Kim et al, 2007), total number of lapses is refer to number of response with reaction time >= 500ms since human reaction time in general ~ 250-500ms (Kay et al, 2013), fastest RT refer to 10% fastest data, slowest RT refers to 10% slowest data < 500ms.

Blatter (2006), Kim (2007) and Lee (2010), use a portable PVT device (PVT-192) as electronically measure the ability of sustain attention to a variable stimulus in >5 min to 10 min period. The task consisted of responding to appearing bright red-light as stimulus by pressing the button as soon as possible. This will stopped the counter and displayed reaction time in milliseconds. Stimuli will appear in the range of 2 to 10 seconds randomly. Table 1, show PVT result on their research:

Table. 1 PVT result on some studies

Variable (msec)	Blatter et all (2006)	Drummon et al (2005)	Kim et al (2007)	Lee et al (2010)
Median (RT)	250.6 (W) ; 210.2 (M)	0.269 ±0.33	n/a	n/a
Mean RT	n/a	n/a	n/a	288.01 ±52.33
1/RT	n/a	n/a	396 ± 46	n/a
Mean Fastest (10%RT)	n/a	0.217 ±0.19	268 ± 0.45	n/a
SD RT	n/a	0.139 ±0.275	n/a	n/a
Lapses (RT> 500ms)	n/a	1.55 ± 2.62	2.22 (1.19)	2.63
Mean Slowest (10%RT)	n/a	2.58 ±0.616	492 ± 0.50	n/a
False start	0.18 ± 0.05 (W) ; 0.08 ± 0.05 (M)	n/a	n/a	n/a

Other PVT devices are developed by Saito (1999). It's a visual reaction test (VRT) program consist of moving target on CRT and pursued by *bundling* a paddle and the automatically measured distance between target and the tracer as fatigue index. Recently, availability of sophisticated gadgets and computers, for reasons of practicality, PVT has been also developed for those devices (Kay et al, 2013; Khitrov, 2013; Lamond et al, 2008).

2.2 PVT and its methodology

Impairment performance measures by PVT were conducted in experimental, field study, or clinic situation. PVT as a measurement tool of fatigue is used in experiment to asses decrement attention of driver or other a job that requires constant

attention, as sign of fatigue. Some experiments were using driving simulator and applying sleep and time-awake restriction as independent variable (Blatter, 2006; Davenne, 2012, Baulk et al, 2010).

The research has in common, such as participant is asked to maintained stable sleep-wake time prior to experiment or study and it should consistent with their usual sleep schedules in average (Blatter, 2006; Davenne, 2012; Kline, 2011). Baseline sleep opportunity (8 h or near 8 hr) is also use as normative condition before participant of experiment treated sleep restriction. This baseline is corresponds to the length of sleep needed generally which is 7 and 8.5 h per day (Kripke et al, 2002; Carskadon and Dement, 2005, Alhola and Polo-Kantola, 2007). Applied sleep restriction is varying from one study to another, but it's exceeded 24 h the circadian clock. Baulk et al (2008) use 26 h of sleep deprivation without napping; and Drumman et al. (2005) use 36 h of total sleep deprivation.

Sleep deprivation in this paper correspondent to the condition of not having enough sleep; it can be either chronic or acute. Partial sleep deprivation is caused by limited time sleep, and total sleep deprivation is condition when someone is not having sleep at all (Alhola and Polo-Kantola, 2007).

Study using PVT as test tool has several different methodologies. Loh et al (2004) conducted measurement by PVT at hourly interval during sleep restriction. Kline et al. (2010) measure performance in every 9 h, with 6 trials per participants. Abstain from caffeine and other stimulants are usually applied for the experiment (Loh et al. 2004, Kline et al. 2011). In field study experimental for example driving performance, measurement is conducted before and after driving session is started (Philip et al. 2005).

2.3 PVT and other fatigue measurement methods

Millar (2012) states, variation measurement tool in determining the level of fatigue is necessary, and suggested a combination of measurement of fatigue in the scope of work between the subjective and objective methods. An objective measure of fatigue include circadian rhythms, sleep status, and psychomotor performance status using the Vigilance Task (PVT).

Meanwhile, Baulk et al (2010), in their research, stated that measurement of performance status using simple mental tasks such as PVT as a measure of motor vehicle driver fatigue, performance measures need to be complemented with other more complexes to make it more accurate. Ting et al (2008), using a test for reaction time and to measure the level of sleepiness and alertness decline in the driver's attention long duration.

As stated before, fatigue is often thought to relate to both degree of sleep loss and affected by a circadian rhythm (Fletcher and Dawson, 2003), assessment of fatigue usually accompanied by a subjective method of sleepiness such as Karolinksa Sleepines Scale (KSS) or Epworth Sleepiness Scale (ESS) (Kaida et al., 2006; Philip et al, 2005; Zhang et al. 2012). Other objective method also use together with PVT such as flicker (Saito, 1999), Electrocephalogram (EEG) and alpha attention test (Kaida et al, 2006).

On the usage of PVT as a measure fatigue based on decrement performance 10 minutes test commonly is applied (Alhola and Polo-Kantola, 2007; Baulk, 2010; Blatter, Drumman et al. 2005; Kim et al, 2007; Kline et al., 2011). But some research showed, 5 minutes test and 3 minutes test for practical reason, is still has validity as 10 minutes version of test (Basner, 2011;Loh et al, 2004) .

3. RESEARCH METHOD

In this paper, method was obtained by searching research literature under term fatigue, Psychomotor, Vigilance, fatigue detection and the variation of them. Paper discussion was classified into what is PVT, devices used, methodology applied on the study, result and discussion.

4. RESULT AND DISCUSSION

PVT basically tried to measure a sustained attention and reaction time task. As gold standard fatigue detection devices, PVT is used frequently in fatigue's research (Dawson et all, 2013), but literature show that there various methodologies reported

on use of PVT. For example, setting sleep deprivation through sleep restriction during research is not exactly same, though so the paper show that the measuring conducted at least over 1 (one) cycle rhythm circadian > 24 h on sleep restriction (Blatter, 2006; Davenne, 2012; Kline, 2011).

To complete a fatigue measurement, another method to measure the level of sleepiness was suggested, together with other objective measurement. However, to measure the level of sleepiness subjectively, each study is using different method, but KSS and EES is more often mentioned in the literature of fatigue measurement (Spencer et al, 2006; Zhang et al. 2012, Philip et al, 2005, Kaida et al., 2006).

Fatigue research use different variable as indicator of fatigue on PVT. Some suggestion 1/RT is a more sensitive to indicate decrement of performance, and other studies is suggested number of lapse as indicator. Usage of other method could be help to determine which variable is sould selected. However, in real life, job characteristic and individual sleep deprivation might caused different result.

And for practical reason without compromising the validity and reliability, 3 minutes and 5 minutes version of PVT can be applied (Basner, 2011; Loh et al., 2004). However, availability of sophisticated gadgets and/or computers that can provide the 3 version of PVT, the consideration about technical specification and limitation to record a reaction time should be noted.

5. CONCLUSION

PVT is is suggested as a gold standard tool to assess impairment performance as indicator of fatigue. However, further research on PVT is still needed, such as does fatigue can describe by some PVT's variable or should we adopted all variable; which other tools is more reliable to use together with PVT, and duration of sleep deprivation correlated to PVT sensitivity.

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