Review of European Studies; Vol. 8, No. 4; 2016
ISSN 1918-7173 E-ISSN 1918-7181
Published by Canadian Center of Science and Education

Computerized Finger Tapping Task in Adult Unipolar Depressed Patients and Healthy Subjects: Influence of Age, Gender, Education, and Hand Dominance

Marco Moniz[1,2,3,4], Saul Neves de Jesus[3,4], Andreia Pacheco[1,5], Eduardo Gonçalves[1] & João Viseu[3,4]

[1] Department of Psychiatry and Mental Health, Hospital Center of Algarve, Faro, Portugal

[2] António Silva Leal Foundation, Lisboa, Portugal

[3] Faculty of Human and Social Sciences, University of Algarve, Faro, Portugal

[4] Research Centre for Spatial and Organization Dynamics (CIEO), Faro, Portugal

[5] Centre for Biomedical Research (CBMR), Faro, Portugal

Correspondence: Marco Moniz, Centro Hospitalar do Algarve, Departamento de Psiquiatria e Saúde Mental, Rua Leão Penedo, 8000-386 Faro, Portugal. E-mail: emmoniz@gmail.com

Received: June 8, 2016 Accepted: July 14, 2016 Online Published: July 26, 2016

doi:10.5539/res.v8n4p1 URL: http://dx.doi.org/10.5539/res.v8n4p1

Abstract

Introduction: Current diagnostic criteria for depression include psychomotor retardation, being the Finger Tapping Test (FTT) as one of the most utilized instruments to assess fine psychomotor performance.

Method: This study aimed to compare the performance of a sample of 51 unipolar depressed patients (30 women and 21 men, with a mean age of 45.12 years old [*SD* = 14.09]) with 51 healthy controls (29 women and 22 men, with a mean age of 44.49 years old [*SD* = 15.59]) in a computerized version of the Finger Tapping Test (FTT) from the Psychology Experiment Building Language (PEBL). Another objective was to test this version's validity in comparison to other FTTs.

Results: We found significant differences between depressed patients and healthy controls. Significant effects of age and gender were found.

Conclusion: Results allowed us to identify differences in performance between the two groups, therefore this version of the FTT revealed adequate reliability values, one instrument accessible to all clinicians.

Keywords: unipolar depression, fine psychomotor performance, Finger Tapping Test, normative data

1. Introduction

Given that motor retardation is a common feature of depression (American Psychiatry Association, 2013; Caligiuri & Ellwanger, 2000), tests of fine psychomotor performance, such as the Finger Tapping Test (FTT), have been widely utilized in several studies on depression (Arnold et al., 2005; Bashir, Khade, Kosaraju, Kumar, & Rani, 2013; Caligiuri & Ellwanger, 2000; Hill, Keshavan, Thase, & Sweeney, 2004; Hueng et al., 2011; Kertzman et al., 2010; Lampe, Sitskoorn, & Heeren, 2004; Meyer et al., 2006; Rohling, Green, Allen, & Iverson, 2002; Schrijvers, Hulstijn, & Sabbe, 2008; Swann, Katz, Bowden, Berman, & Stokes, 1999) proving to be reliable to access impairments and discard malingering (Arnold et al., 2005; Rohling et al., 2002).

The FTT was developed as part of the Halstead-Reitan Battery (Halstead, 1947) and consists in a test of fine psychomotor performance, measured through self-directed manual motor speed and control (Christianson & Leathem, 2004; Strauss, Sherman, & Spreen, 2006), recurrently employed to assess impairment resulting from traumas, diseases, and other clinical conditions, such as brain injury (Arnold et al., 2005; Hubel, Yund, Herron, & Woods, 2013a; Kane, Roebuck-Spencer, Short, Kabat, & Wilken, 2007), Alzheimer's disease (Arnold et al., 2005; Dwolatzky et al., 2003, 2004; Kane et al., 2007), Parkinson's disease (Kane et al., 2007; Shimoyama, Ninchoji, & Uemura, 1990), multiple sclerosis (Kane et al., 2007; Wilken et al., 2003), mild cognitive impairment (Dwolatzky et al., 2003, 2004; Schweiger, Doniger, Dwolatzky, Jaffe, & Simon, 2003), and mental retardation (Arnold et al., 2005).

Several researchers have utilized it to assess psychomotor effects of some drugs, like antiepileptics (Aldenkamp, Van Meel, Baker, Brooks, & Hendriks, 2002), chemotherapy (Stewart, Bielajew, Collins, Parkinson, & Tomiak, 2006), and antidepressants (Bashir et al., 2013). Furthermore, many find it resourceful to detect fake symptoms in forensic contexts (Arnold et al., 2005; Hubel et al., 2013a; Rohling et al., 2002), having also been used to study the relationship between manual dexterity and performance, in order to draw inferences about the functional integrity of the two cerebral hemispheres (Hervé, Mazoyer, Crivello, Perchey, & Tzourio-Mazoyer, 2005; Peters, 1980; Schmidt, Oliveira, Krahe, & Filgueiras, 2000; Strauss et al., 2006).

The original manual of the FTT utilized a mechanical counter and a stopwatch (Christianson & Leathem, 2004): many limitations were pointed out, as it could take several hours, needing additional time for scoring and presenting results, and was exhausting for patients and too laborious for examiners (Hubel et al., 2013a). However, its efficacy still justifies its place among the most used instruments (Strauss et al., 2006). Therefore, recently, in an attempt to overcome such limitations, several computerized versions have emerged, which are able to measure the response time more precisely, requiring less time to administer, and generating instant scoring (Wilken et al., 2003). The FTT is now part of several recent batteries, such as the Computerized Neurocognitive Battery (Coleman, Moberg, Ragland, & Gur, 1997; Gur et al., 2010), the Automated Neuropsychological Assessment Metrics-ANAM4tm (Kane et al., 2007; Reeves, Winter, Bleiberg, & Kane, 2007; Wilken et al., 2003), the FePsy (Aldenkamp et al., 2002; Stewart et al., 2006), and the NeurotraxTM MindstreamsTM (Dwolatzky et al., 2003, 2004; Schweiger et al., 2003).

Our aim was to study the fine psychomotor performance of depressed patients, regarding effects of age, gender, education, and hand dominance. A computerized version of the FTT from the Psychology Experiment Building Language (PEBL) (Mueller, 2013), a free access battery, was used. Another objective was to test this version's validity, comparing our results to others obtained by Christianson and Leathem (2004) and Hubel and colleagues (2013b).

According to the literature, in FTT men tap faster, younger subjects show faster tapping rates; education is related to faster motor speed, and the dominant hand performs better. Our research hypotheses are based upon these premises, as well as in the prediction that depressed patients are slower than healthy controls.

2. Method

2.1 Participants

Both studied samples, experimental and control groups, were comprised of 51 subjects each. The experimental (patients') group was composed of 30 women and 21 men, with a mean age of 45.12 years old (*SD* = 14.09), and a mean of 8.29 (*SD* = 3.72) years of education. The participants from this group were recruited in the city of Faro (Portugal), more precisely from the Department of Psychiatry and Mental Health of Hospital Center of Algarve (a state owned entity). With analogous characteristics, healthy controls comprised 29 women and 22 men, with a mean age of 44.49 years old (*SD* = 15.59), and a mean of 9.50 (*SD* = 3.63) years of education. Patients and controls did not differ significantly regarding gender (χ^2 = .040, df = 1, p = .841), age (t = .213, df = 100, p = .832, d = .042), and education (t = -1.668, df = 100, p = .099, d = -.330). In respect to gender, there are no differences in age in the patients group (t = -.816, df = 49, p = .419, d = -.225) and in the healthy controls group (t = .627, df = 49, p = .534, d = .172).

Statistically, participants were divided into three age groups: (a) 17-40; (b) 41-50; and (c) more than 51 years old. Regarding education, participants were also divided into three groups: (a) up to 6 years of education; (b) 9 years of education; and (c) 12 or more years of education. We only considered the completed cycles of education (i.e., 4th grade, 6th grade, 9th grade, 12th grade, and university), but then, only three groups were considered, since there were very few elements with 4 years of education, as well as with higher education. All participants were Caucasians and Portuguese speakers.

2.2 Measures

The computerized Finger Taping Task (Mueller, 2013), a free software from PEBL Test Battery (Mueller & Piper, 2014), was performed with the left and right index fingers: five consecutive trials in each hand, with a brief rest following each trial (10-seconds), and a longer one (30-seconds) every five trials. The mean of taps was averaged over five trials for each hand.

2.3 Procedures

Each participant completed a health and demographic questionnaire and depression diagnoses were confirmed through the MINI (Mini International Neuropsychiatric Interview) (Sheehan et al., 1997) and the BSI (Brief Symptom Inventory) (Canavarro, 2007). Those with current or prior history of bipolar disorders, schizophrenia, major psychosis, or who met criteria for dementia, substance abuse, neurologic disease, including head injury involving a loss of consciousness, and subjects who did not complete the full 50-second tapping period for both fingers or reported having a problem with their hands or indicators were excluded. To discard malingering, Rey 15-Item Memory Test (15-IMT) was used (Simões et al., 2010).

This study was approved by the Hospital Center of Algarve Ethics Committee, in conformity with the Helsinki declaration. After being provided with all the information about the study, all the participants signed an informed consent statement.

All analyzes were conducted using the Statistical Package for the Social Sciences (SPSS) version 20.0. The level of significance was set at $p < .05$.

3. Results

We confirmed effects of slowing over in depressed patients, and, for both groups, significant effects of hand dominance (faster tapping in the dominant hand), gender (faster tapping in men), and age (slower tapping on participants over 51 years old).

Results showed statistically differences between total scores for depressed subjects and healthy controls, concerning both dominant (D) (t = -4.040, df = 100, p = .001, d = -.800) and Non-Dominant (ND) hands (t = -.2.873, df = 100, p = .005, d = -.569). A one-way analysis of variance (*ANOVA*) showed significant group differences regarding education (depression D: $F(2,48)$ = 8.78, p = .001, η_p^2 = .268; ND: $F(2,48)$ = 4.91, p = .011, η_p^2 = .170. *vs.* healthy D: $F(2,48)$ = 7.06, p = .002, η_p^2 = .227; ND: $F(2,48)$ = 7.06, p = .002, η_p^2 = .228) and age (depression D: $F(2,48)$ = 5.91, p = .005, η_p^2 = .198; ND: $F(2,48)$ = 2.96, p = .061, η_p^2 =.110. *vs.* healthy D: $F(2,48)$ = 8.39, p = .001, η_p^2 = .259; ND: $F(2,48)$ = 7.91, p = .001, η_p^2 = .248). *T*-tests demonstrated significant group differences concerning gender (depression D: t = .2.167, df = 49, p = .035, d = .608; ND: t = .2.721, df = 49, p = .009, d = .750 *vs*. healthy D: t = .2.167, df = 49, p = .012, d = .743; ND: t = .2.274, df = 49, p = .027, d = .629) (Table 1).

Table 1. Descriptive statistics (*N* = 102)

	Dominant		Non-dominant	
	Depression[a]	Healthy[b]	Depression[a]	Healthy[b]
	M (*SD*)	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)
Age				
17-40	56.82 (7.85)	62.57 (5.14)	48.94 (9.51)	53.94 (6.87)
41-50	50.35 (9.64)	56.56 (7.94)	44.47 (9.54)	49.43 (6.81)
+51	46.70 (8.46)	54.12 (5.74)	41.29 (8.50)	45.12 (5.84)
F	5.915	8.394	2.963	7.911
p	.005	.001	.061	.001
η_p^2	.198	.259	.110	.248
Education (grades)				
≤ 6th	46.04 (9.35)	53.13 (6.33)	40.65 (9.25)	45.46 (5.33)
9th	54.21 (7.66)	58.52 (6.18)	47.57 (8.94)	48.88 (6.64)
≥ 12th	57.00 (6.88)	61.47 (6.78)	49.21 (8.16)	53.94 (7.49)
F	8.781	7.061	4.910	7.068
P	.001	.002	.011	.002
η_p^2	.268	.227	.170	.228
Gender				

Men	54.61 (9.90)	60.90 (6.63)	49.00 (10.72)	52.36 (8.28)
Women	48.96 (8.62)	55.86 (6.94)	42.03 (7.58)	47.79 (6.07)
t	2.167	2.621	2.721	2.274
p	.035	.012	.009	.027
d	.608	.743	.750	.629
Total Score	51.29 (9.50)	58.03 (7.19)	44.90 (9.55)	49.76 (7.39)
t (BS)	-4.040		-2.873	
p	.000		.005	
d	-.800		-.569	

Note. [a]$n = 51$, [b]$n = 51$, BS = Between Samples.

For demographic variables, a shared variance of 49% to both hands was found for healthy subjects (ND: $R^2 = .495$, $F(3, 47) = 15.38$, $p = .001$; D: $R^2 = .493$, $F(3, 47) = 15.25$, $p = .001$) and 35% to non-dominant hand, and 42% to dominand hand for patients with depression (ND: $R^2 = .357$, $F(3, 47) = 8.70$, $p = .001$; D: $R^2 = .429$, $F(3, 47) = 11.77$, $p = .001$) (Table 2).

Table 2. Percentage of variance accounted for by demographic variables

	Depression[a]						Healthy[b]			
	(% of variance)									
	Age	Educ	Sex	Comb	BSI-D	Comb	Age	Educ	Sex	Comb
Dominant	24^1	26^1	8^2	42^1	23^2	53^2	22^1	25^1	12^2	49^1
Non-dominant	14^2	19^1	13^2	35^1	34^2	62^2	24^1	26^1	9^2	49^1

Note. [a]$n = 51$, [b]$n = 51$, $^1p \leq .001$, $^2p < .05$, BSI-D = Depression scale from Brief Symptom Inventory; Educ = Education; Comb = Combined.

Christianson and Leathem (2004) compared four versions of the FTT, involving minor differences in procedures and response devices, namely the Halstead-Reitan manual FTT (Halstead, 1947), the Massey University manual FTT, the Western Psychological Services Digital FTT, and a Computer FTT, having verified high correlations between the tapping scores of all four instruments, confirming the construct validity of the latter. Likewise, Hubel and colleagues (2013b) tested the validity of a novel FTT from the California Cognitive Assessment Battery (CCAB), obtaining analogous results through the comparison to the Halstead-Retain FTT, the Computerized Finger Tapping, the T3 Computer-assisted Finger Tapping Task, the Western Psychological Services Electronic Tapping Test, and the Computerized Neurocognitive Scanning Vital Signs (CNSVS).

Similarly, aiming to validate the FTT from the PEBL Test Battery (Mueller, 2013; Mueller & Piper, 2014), we compared our study's results with those obtained by Christianson and Leathem (2004) and Hubel and colleagues (2013b) and confirmed similar results regarding mean tapping rates in three studies (*ANOVA* D: F = .890, $df = 2, 1.653$, $p = .411$; ND: $F = .502$, $df = 2, 1.653$, $p = .606$) (Table 3).

Table 3. Comparison of the FTT from PEBL to other tapping test data

	Dominant		Non-dominant	
	Current Study[a]	Christianson (2004)[b]	Current Study[a]	Christianson (2004)[b]
	M (*SD*)	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)
Total Score	58.03 (7.19)	56 (7.1)	49.76 (7.39)	49.6 (5.4)
t	1.610		.145	
p	.109		.884	
d	.284		.024	
	Current Study[a]	Hubel (2013b)[c]	Current Study[a]	Hubel (2013b)[c]
	M (*SD*)	*M* (*SD*)[d]	*M* (*SD*)	*M* (*SD*)[d]
Total Score	58.03 (7.19)	56.3 (9.6)	49.76 (7.39)	50.4 (8.5)
t	1.274		.531	
p	.202		.595	
d	.203		-.080	

Note. [a]n = 51, [b]n = 86, [c]n = 1.519, [d]1st 10-sec. average.

4. Discussion

As in previous studies, men tapped faster than women (Arnold et al., 2005; Ashendorf, Vanderslice-Barr, & McCaffrey, 2009; Bornstein, 1985; Christianson & Leathem, 2004; Coleman et al., 1997; Elias, Robbins, Walter, & Schultz, 1993; Gur et al., 2010; Heaton, Miller, Taylor, & Grant, 2004; Hubel et al., 2013a, 2013b; Mitrushina, Boone, Razani, & D'Elia, 2005; Peters, 1980; Peters & Campagnaro, 1996; Ruff & Parker; 1993; Schmidt et al., 2000; Ylikoski et al., 1998), outperforming women by three to five taps (Ashendorf et al., 2009; Mitrushina et al., 2005). Heaton and colleagues (2004) reported that about 16% to 20% of the test scores were accounted for by gender. Our results showed gender differences for depression and healthy groups. Nicholson and Kimura (1996) analyzed gender differences regarding manual speed and concluded that men's speed advantage might be explained by a relative gain in the amount of fast-twitch muscle at puberty. Ruff and Parker (1993) suggested that gender differences in FTT performance may also be a reflection of different age effects, hypothesis contradicted with our study because in our sample there are no age differences between genders.

The FTT has been reported to be sensitive to changes related to aging (Ylikoski et al., 1998). Better performance is usually associated with younger age, as many studies have shown older subjects tend to have significantly slower tapping rates (Aoki & Fukuoka, 2010; Ashendorf et al., 2009; Bartzokis et al., 2010; Bornstein, 1985; Elias et al., 1993; Gur et al., 2010; Hubel et al., 2013a, 2013b; Ruff & Parker, 1993; Shimoyama et al., 1990; Turgeon, Wing, & Taylor, 2011; Ylikoski et al., 1998). To Bartzokis and colleagues (2010), age-related trajectory of finger tapping speed can be associated with brain myelin integrity, reaching its peak in mid-life and declining in older age, eventually leading to psychomotor slowing. Heaton and colleagues (2004) reported in their large normative sample (aged 20-85 years) that about 16% to 18% of the variance in finger tapping scores was accounted for by age. We also verified age-related effects, with older subjects performing poorly, with variance in the scores between 14% to 24% in both samples (depression and healthy groups).

We noticed effects of education on tapping speed. Nevertheless, according to Strauss and colleagues (2006), results on motor tasks have a propensity to be very modestly influenced, if at all, by such factors. Heaton and colleagues (2004) verified that education accounts for only about 2% to 4% of the variance in tapping scores. Still, as reported by other studies, best performances are often associated with more years of education, concerning not only higher levels of formal instruction (Ashendorf et al., 2009; Bornstein, 1985; Gur et al., 2010; Ruff & Parker, 1993), but also parental education (Gur et al., 2010).

Consistent with many reports (Hervé et al., 2005; Hubel et al., 2013a, 2013b; Peters, 1980; Schmidt et al., 2000; Teixeira, 2008; Todor & Smiley-Oyen, 1987), we corroborated considerable differences between the dominant and the non-dominant hands regarding both groups. Tapping performance has been employed as an indicator of hand dominance (Ashendorf et al., 2009; Hervé et al., 2005; Hubel et al., 2013a, 2013b; Peters, 1980; Ruff & Parker, 1993; Schmidt et al., 2000; Teixeira, 2008; Todor & Smiley-Oyen, 1987), with the dominant index finger typically producing approximately 10% more taps (Ashendorf et al., 2009; Hubel et al., 2013b). In the FTT, the preferred hand tends to perform more quickly, and regularly (Peters, 1980), and precisely (Todor & Smiley-Oyen, 1987). This may be explained by differential effects of fatigue (Peters, 1980).

Also comma as expected (Bashir et al., 2013; Hill et al., 2004; Hueng et al., 2011; Kertzman et al., 2010; Lampe et al., 2004; Rohling et al., 2002; Swann et al., 1999), we found significant impairment in psychomotor speed between unipolar depressed subjects and controls. Psychomotor performance in depressed subjects may be further influenced by other factors, such as hospitalization status/duration, severity, subtype and duration of depression, and medication (Bashir et al., 2013). Many studies have addressed specifically effects of medication on psychomotor speed (Aldenkamp et al., 2002; Bashir et al., 2013; Stewart et al., 2006). First-line medication for depression often includes substances (e.g., fluoxetine, venlafaxine, and paroxetine) liable to affect cognitive and function performance (Bashir et al., 2013). Bashir and colleagues (2013) verified a significant speed impairment regarding patients on antidepressants. Therefore, there are researchers (e.g., Hueng et al., 2011; Meyer et al., 2006; Swann et al., 1999) who chose to study only drug-free depressive subjects to access more precisely the actual impact of the illness itself on psychomotor function. This may represent a limitation to our study, but, for ethical reasons, we could not assess the clinical sample of medications.

In order to share these initial data, we present a percentile tables of the present sample, healthy subjects (Table 4) and depressive subjects (Table 5).

Table 4. Percentile of healthy subjects by age and gender

	Dominant					Non-dominant					
	Age			Gender		Age			Gender		
	17-40	41-50	More than 51 years	M	W	17-40	41-50	More than 51 years	M	W	
5	53.00	40.00	45.00	49.15	42.50	41.00	37.00	38.00	40.00	37.50	5
10	54.00	47.00	47.80	50.00	49.00	47.00	40.50	39.40	40.60	41.00	10
25	60.00	52.00	50.00	56.25	52.00	48.00	44.50	42.00	44.00	43.00	25
50	63.00	55.00	53.00	62.00	54.00	53.00	48.50	43.50	53.00	47.00	50
75	64.00	62.50	59.50	63.25	60.50	58.00	55.50	49.25	59.25	52.00	75
90	71.00	70.60	63.90	70.70	66.00	66.00	59.60	55.10	64.50	58.00	90
95	-	-	-	73.55	70.00	-	-	-	66.85	59.50	95

Note. n = 51.

Table 5. Percentile of depressed subjects by age and gender

	Dominant					Non-dominant					
	Age			Gender		Age			Gender		
	17-40	41-50	More than 51 years	M	F	17-40	41-50	More than 51 years	M	F	
5	44.00	33.00	31.00	33.90	31.55	33.00	29.00	26.00	30.60	27.65	5
10	48.00	33.80	31.80	43.20	33.10	38.60	33.00	29.20	36.20	30.30	10
25	51.50	45.00	43.50	48.50	45.00	43.50	37.00	36.50	41.00	36.75	25
50	55.00	50.00	48.00	51.00	49.50	47.00	43.00	40.00	48.00	42.00	50
75	61.50	56.50	52.00	61.00	55.00	53.00	50.00	47.00	55.50	47.50	75
90	73.00	67.00	58.40	71.80	60.90	68.60	60.40	54.60	67.60	51.90	90
95	-	-	-	73.00	62.00	-	-	-	70.70	54.80	95

Note. $n = 51$.

Acknowledgments

We thank all participants of this study.

References

Aldenkamp, A. P., Van Meel, H. F., Baker, G. A., Brooks, J., & Hendriks, M. P. H. (2002). The A-B Neuropsychological Assessment Schedule (ABNAS): The relationship between patient-perceived drug related cognitive impairment and results of neuropsychological tests. *Seizure*, *11*, 231-237. http://dx.doi.org/10.1053/seiz.2002.0672

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders* (5th ed.). Washington, DC: American Psychiatric Publishing.

Aoki, T., & Fukuoka, Y. (2010). Finger tapping ability in healthy elderly and young adults. *Medicine and Science in Sports and Exercise*, *42*, 449-455. http://dx.doi.org/10.1249/MSS.0b013e3181b7f3e1

Arnold, G., Boone, K. B., Lu, P., Dean, A., Wen, J., Nitch, S., & McPherson, S. (2005). Sensitivity and specificity of finger tapping test scores for the detection of suspect effort. *The Clinical Neuropsychologist*, *19*, 105-120. http://dx.doi.org/10.1080/13854040490888567

Ashendorf, L., Vanderslice-Barr, J. L., & McCaffrey, R. J. (2009). Motor tests and cognition in healthy older adults. *Applied Neuropsychology*, *16*, 171-176. http://dx.doi.org/10.1080/09084280903098562

Bartzokis, G., Lu, P. H., Tingus, K., Mendez, M. F., Richard, A., Peters, D. G., … Mintz, J. (2010). Lifespan trajectory of myelin integrity and maximum motor speed. *Neurobiology of Aging*, *31*, 1554-1562. http://dx.doi.org/10.1016/j.neurobiolaging.2008.08.015

Bashir, M., Khade, A., Kosaraju, S., Kumar, C. V., & Rani, U. (2013). Comparative study of psychomotor performance in depression patients with healthy volunteers. *Research and Reviews: A Journal of Medical Science and Technology*, *2*, 15-18.

Bornstein, R. A. (1985). Normative data on selected neuropsychological measures from a nonclinical sample. *Journal of Clinical Psychology*, *41*, 651-659. http://dx.doi.org/10.1002/1097-4679(198509)41:5<651::AID-JCLP2270410511>3.0.CO;2-C

Caligiuri, M. P., & Ellwanger, J. (2000). Motor and cognitive aspects of motor retardation in depression. *Journal of Affective Disorders*, *57*, 83-93. http://dx.doi.org/10.1016/S0165-0327(99)00068-3

Canavarro, M. C. (2007). Inventário de Sintomas Psicopatológicos (BSI). Uma revisão crítica dos estudos realizados em Portugal. In M. R. Simões, C. Machado, M. M. Gonçalves, & L. S. Almeida (Eds.), *Avaliação psicológica: Instrumentos validados para a população portuguesa* (Vol. III, pp. 305-330). Coimbra, Portugal: Quarteto Editora.

Christianson, M. K., & Leathem, J. M. (2004). Development and standardisation of the computerised finger tapping test: Comparison with other finger tapping instruments. *New Zealand Journal of Psychology*, *33*, 44-49.

Coleman, A. R., Moberg, P. J., Ragland, J. D., & Gur, R. C. (1997). Comparison of the Halstead-Reitan and infrared light beam finger tappers. *Assessment*, *4*, 277-286.

Dwolatzky, T., Whitehead, V., Doniger, G. M., Simon, E. S., Schweiger, A., Jaffe, D., & Chertkow, H. (2003). Validity of a novel computerized cognitive battery for mild cognitive impairment. *BMC Geriatrics*, *3*, 4-16. http://dx.doi.org/10.1186/1471-2318-3-4

Dwolatzky, T., Whitehead, V., Doniger, G. M., Simon, E. S., Schweiger, A., Jaffe, D., & Chertkow, H. (2004). Validity of the Mindstreams™ computerized cognitive battery for mild cognitive impairment. *Journal of Molecular Neuroscience*, *24*, 33-44. http://dx.doi.org/10.1385/JMN:24:1:033

Elias, M. F., Robbins, M. A., Walter, L. J., & Schultz, N. R. (1993). The influence of gender and age on Halstead-Reitan neuropsychological test performance. *Journal of Gerontology*, *48*, 278-281. http://dx.doi.org/10.1093/geronj/48.6.P278

Gur, R. C., Richard, J., Hughett, P., Calkins, M. E., Macy, L., Bilker, W. B., … Gur, R. E. (2010). A cognitive neuroscience-based computerized battery for efficient measurement of individual differences: Standardization and initial construct validation. *Journal of Neuroscience Methods*, *187*, 254-262. http://dx.doi.org/10.1016/j.jneumeth.2009.11.017

Halstead, W. C. (1947). *Brain and intelligence*. Chicago, IL: University of Chicago Press.

Heaton, R. K., Miller, S. W., Taylor, M. J., & Grant, I. (2004). *Revised comprehensive norms for an expanded Halstead-Reitan battery: Demographically adjusted neuropsychological norms for African American and Caucasian adults*. Lutz, FL: Psychological Assessment Resources.

Hervé, P. Y., Mazoyer, B., Crivello, F., Perchey, G., & Tzourio-Mazoyer, N. (2005). Finger tapping, handedness and grey matter amount in the Rolando's genu area. *NeuroImage*, *25*, 1133-1145. http://dx.doi.org/10.1016/j.neuroimage.2004.12.062

Hill, S. K., Keshavan, M. S., Thase, M. E., & Sweeney, J. A. (2004). Neuropsychological dysfunction in antipsychotic-naive first-episode unipolar psychotic depression. *American Journal of Psychiatry*, *161*, 996-1003. http://dx.doi.org/10.1176/appi.ajp.161.6.996

Hubel, K. A., Yund, E. W., Herron, T. J., & Woods, D. L. (2013b). Computerized measures of finger tapping: Effects of hand dominance, age, and sex. *Perceptual & Motor Skills: Motor Skills & Ergonomics*, *116*, 1-24. http://dx.doi.org/10.2466/25.29.PMS.116.3.929-952

Hubel, K. A., Yund, E. W., Herron, T. J., & Woods, D. L. (2013a). Computerized measures of finger tapping: Reliability, malingering and traumatic brain injury. *Journal of Clinical and Experimental Neuropsychology*, *35*, 745-58. http://dx.doi.org/10.1080/13803395.2013.824070

Hueng, T. T., Lee, I. H., Guog, Y.-J., Chen, K. C., Chen, S. S., Chuang, S. P., … Yang, Y. K. (2011). Is a patient-administered depression rating scale valid for detecting cognitive deficits in patients with major depressive disorder? *Psychiatry and Clinical Neurosciences*, *65*, 70-76. http://dx.doi.org/10.1111/j.1440-1819.2010.02166.x

Kane, R. L., Roebuck-Spencer, T., Short, P., Kabat, M., & Wilken, J. (2007). Identifying and monitoring cognitive deficits in clinical populations using Automated Neuropsychological Assessment Metrics (ANAM) tests. *Archives of Clinical Neuropsychology*, *22*S, S115-S126. http://dx.doi.org/10.1016/j.acn.2006.10.006

Kertzman, S., Reznik, I., Hornik-Lurie, T., Weizman, A., Kotler, M., & Amital, D. (2010). Stroop performance in major depression: Selective attention impairment or psychomotor slowness? *Journal of Affective Disorders*, *122*, 167-173. http://dx.doi.org/10.1016/j.jad.2009.08.009

Lampe, I. K., Sitskoorn, M. M., & Heeren, T. J. (2004). Effects of recurrent major depressive disorder on behavior and cognitive function in female depressed patients. *Psychiatry Research*, *125*, 73-79. http://dx.doi.org/10.1016/j.psychres.2003.12.004

Meyer, J. H., McNeely, H. E., Sagrati, S., Boovariwala, A., Martin, K., Verhoeff, N. P. L. G., … Houle, S. (2006). Elevated putamen D(2) receptor binding potential in major depression with motor retardation: An [11C] raclopride positron emission tomography study. *The American Journal of Psychiatry*, *163*, 1594-1602. http://dx.doi.org/10.1176/appi.ajp.163.9.1594

Mitrushina, M., Boone, K. B., Razani, J., & D'Elia, L. F. (2005). *Handbook of normative data for neuropsychological assessment* (2nd ed.). Oxford, UK: Oxford University Press.

Mueller, S. T. (2013). *The psychology experiment building language* (Version 0.13) [Software]. Retrieved from http://pebl.sourceforge.net

Mueller, S. T., & Piper, B. J. (2014). The Psychology Experiment Building Language (PEBL) and PEBL Test Battery. *Journal of Neuroscience Methods*, *222*, 250-259. http://dx.doi.org/10.1016/j.jneumeth.2013.10.024

Nicholson, K. G., & Kimura, D. (1996). Sex differences for speech and manual skill. *Perceptual and Motor Skills*, *82*, 3-13. http://doi.org/10.2466/pms.1996.82.1.3

Peters, M. (1980). Why the preferred hand taps more quickly than the non-preferred hand: Three experiments on handedness. *Canadian Journal of Psychology*, *34*, 62-71. http://dx.doi.org/10.1037/h0081014

Peters, M., & Campagnaro, P. (1996). Do women really excel over men in manual dexterity? *Journal of Experimental Psychology: Human Perception and Performance*, *22*, 1107-1112. http://dx.doi.org/10.1037/0096-1523.22.5.1107

Reeves, D. L., Winter, K. P., Bleiberg, J., & Kane, R. L. (2007). ANAM® genogram: Historical perspectives, description, and current endeavors. *Archives of Clinical Neuropsychology*, *22S*, S15-S37. http://dx.doi.org/10.1016/j.acn.2006.10.013

Rohling, M. L., Green, P., Allen, L. M., & Iverson, G. L. (2002). Depressive symptoms and neurocognitive test scores in patients passing symptom validity tests. *Archives of Clinical Neuropsychology*, *17*, 205-222. http://dx.doi.org/10.1093/arclin/17.3.205

Ruff, R. M., & Parker, S. B. (1993). Gender-and age-specific changes in motor speed and eye-hand coordination in adults: Normative values for the Finger Tapping and Grooved Pegboard Tests. *Perceptual and Motor Skills*, *76*, 1219-1230. http://dx.doi.org/10.2466/pms.1993.76.3c.1219

Schmidt, S. L., Oliveira, R. M., Krahe, T. E., & Filgueiras, C. C. (2000). The effects of hand preference and gender on finger tapping performance asymmetry by the use of an infra-red light measurement device. *Neuropsychologia*, *38*, 529-534. http://dx.doi.org/10.1016/S0028-3932(99)00120-7

Schrijvers, D., Hulstijn, W., & Sabbe, B. G. C. (2008). Psychomotor symptoms in depression: A diagnostic, pathophysiological and therapeutic tool. *Journal of Affective Disorders*, *109*, 1-20. http://dx.doi.org/10.1016/j.jad.2007.10.019

Schweiger, A., Doniger, G. M., Dwolatzky, T., Jaffe, D., & Simon, E. S. (2003). Reliability of a novel computerized neuropsychological battery for mild cognitive impairment. *Acta Neuropsychologica*, *1*, 407-413.

Sheehan, D. V., Lecrubier, Y., Sheehan, K. H., Janavs, J., Weiller, E., Keskiner, A., ... Dunbar, G. C. (1997). The validity of the Mini International Neuropsychiatric Interview (MINI) according to the SCID-P and its reliability. *European Psychiatry*, *12*, 232-241. http://dx.doi.org/10.1016/S0924-9338(97)83297-X

Shimoyama, I., Ninchoji, T., & Uemura, K. (1990). The finger-tapping test. *Archives of Neurology*, *47*, 681-684. http://dx.doi.org/10.1001/archneur.1990.00530060095025

Simões, M., Sousa, L., Duarte, P., Firmino, H., Pinho, M. S., Gaspar, N.,… França, S. (2010). Avaliação da simulação ou esforço insuficiente com o Rey 15-Item Memory Test (15-IMT): Estudos de validação em grupos de adultos idosos. *Análise Psicológica*, *28*, 209-226. http://dx.doi.org/10.14417/ap.269

Stewart, A., Bielajew, C., Collins, B., Parkinson, M., & Tomiak, E. (2006). A meta-analysis of the neuropsychological effects of adjuvant chemotherapy treatment in women treated for breast cancer. *The Clinical Neuropsychologist*, *20*, 76-89. http://dx.doi.org/10.1080/138540491005875

Strauss, E., Sherman, E. M. S., & Spreen, O. (2006). *A compendium of neuropsychological tests: Administration, norms, and commentary* (3rd ed.). Oxford, UK: Oxford University Press.

Swann, A. C., Katz, M. M., Bowden, C. L., Berman, N. G., & Stokes, P. E. (1999). Psychomotor performance and monoamine function in bipolar and unipolar affective disorders. *Biological Psychiatry*, *45*, 979-988. http://dx.doi.org/10.1016/S0006-3223(98)00172-3

Teixeira, L. A. (2008). Categories of manual asymmetry and their variation with advancing age. *Cortex*, *44*, 707-716. http://dx.doi.org/10.1016/j.cortex.2006.10.002

Todor, J. I., & Smiley-Oyen, A. L. (1987). Force modulation as a source of hand differences in rapid finger tapping. *Acta Psychologica*, *65*, 65-73. http://dx.doi.org/10.1016/0001-6918(87)90047-3

Turgeon, M., Wing, A. M., & Taylor, L. W. (2011). Timing and aging: Slowing of fastest regular tapping rate with preserved timing error detection and correction. *Psychology and Aging*, *26*, 150-161. http://dx.doi.org/10.1037/a0020606

Wilken, J. A., Kane, R., Sullivan, C. L., Wallin, M., Usiskin, J. B., Quig, M. E.,… Keller, M. (2003). The utility of computerized neuropsychological assessment of cognitive dysfunction in patients with relapsing-remitting multiple sclerosis. *Multiple Sclerosis*, *9*, 119-127. http://dx.doi.org/10.1191/1352458503ms893oa

Ylikoski, R., Ylikoski, A., Erkinjuntti, T., Sulkava, R., Keskivaara, P., Raininko, R., & Tilvis, R. (1998). Differences in neuropsychological functioning associated with age, education, neurological status, and magnetic resonance imaging findings in neurologically healthy elderly individuals. *Applied Neuropsychology*, *5*, 1-14. http://dx.doi.org/10.1207/s15324826an0501_1

Copyrights