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The Effects of dual task (fine motor precision + cognitive charge) on proprioception

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Abstract

The aim of the given preliminary study was to check whether any changes in fine motor behaviour exist in switching from single to double task (with cognition charge) in proprioceptive sensory graphomotor test conditions. Ten students (five males and five females), aged from 20 to 30 years old, took part in the experiment - precision of tracking of the models in both experimental test conditions: without and with cognitive task (counting numbers back). The variables for assessment were obtained with use of the digitalized proprioceptive diagnostics (Tous, 2008; Tous, J.M., Muiños, Tous, O., & Tous J, 2012) of Mira y Lopez laboratory (University of Barcelona) that transformed the measurements of drawn lines on a touch screen from pixels into millimetres. As results showed, in the proprioceptive test condition, the changes in deviations related to spatial (lineograms) or line length variability (parallels) did not reach any statistical significance; while the changes in line length performance (lineograms) were found significant (that corresponds to inhibition-excitatory balance of nervous system).

Key words: proprioception, fine motor precision, graphomotor task, proprioceptive diagnostics, individual differences, dual task.

INTRODUCTION

The dual-task paradigm was studied by researchers to find the effects of attentional demand or distribution of attentional or other cognitive resources in order to perform both tasks well. Many studies reported the results in the performance of different types of dual tasks in an older population showing the connected risk of falls or other characteristics in their implementation such as to perform slower or with less accuracy (Guttentag, 1989; Verhaeghen, Steitz, Sliwinski, & Cerella, 2003; Bherer, Kramer, Peterson, Colcombe, Erickson, & Becic, 2005; Beauchet, & Berrut, 2006; Priest, Salamon, & Hollman, 2008; Beauchet, Annweiler, Dubost, Allali, Kressig, Bridenbaugh, Berrut, Assal, & Herrmann, 2009; Hall, Echt, Wolf, & Rogers, 2011; Beurskens, & Bock, 2012); after brain trauma (McCulloch, Buxton, Hackney, & Lowers, 2010), in persons with pathologies (Kosson, 1996; Nebes, Butters, Houck, Zmuda, Aizenstein, Polloc, Mulsant, Reynolds III, 2001) or in patients with some specific disease, for example, Parkinson's (Brown, & Marsden, 1991; Wu, & Hallet, M, 2009). Schaefer and colleagues also reported the developmental or maturity effects on dual task walking comparing the results of children vs. adults (Schaefer, Lövdén, Wieckhorst, & Linderberger, 2010).

The importance to perform the motor tasks (as well as maintain balance) in an automatic manner has a crucial effect in having more attentional resources for the cognitive tasks (Baltes, & Lindenberger, 1997). The automaticity of performance is highly related to the proprioception that contributes to acquire new skills or to gain the professional experience after multiple repetitions (Liutsko, 2013). The Ingram's study showed that a person with proprioceptive deficit performed the motor task 60% less accurately when the cognitive charge was added, whereas the control group decreased their performance in only 10% (Ingram, van Donkelaar, Vercher, Gauthier, & Miall, 2000).

As per the bibliographical revision of the research concerned with the dual-task paradigm, it is more evident to expect greater difference related to age, trauma, pathology or specific diseases (that alter motor control or proprioception). However, we were interested to test the "baseline" or normal conditions and to see what is happening on this level, where such differences were expected to be minimal. Thus, the aim of the study was to check whether there exist any changes in fine motor behaviour comparing single and dual task (with cognition charge) performance in proprioceptive sensory graphomotor test conditions, since young adults have their proprioceptive state better compared to the adolescents or older population (Liutsko, Muiños, & Tous, 2014). Our hypothesis was to confirm that there would be no or little differences in dual task performance (fine motor precision + counting numbers back) compared to the single one (fine motor precision only) in the proprioceptive test condition in young adult participants (students). From another side it was an exploratory study whose purpose was to observe the tendencies in any changes that occur in the proprioceptive graphical feedback in dual task condition vs. single.

Methods

The Proprioceptive Diagnostics of Temperament and Character (Tous, 2008; Tous et al., 2012; Liutsko, 2012) is a computerized graphomotor test created within tradition of Mira y Lopez' myokinetical psychodiagnosis (Mira, 1958) in the Laboratory of Mira y Lopez of the University of Barcelona.

Participants

Ten students of the faculty of psychology (five men and five women; age range: 20-30 years old) participated in this preliminary study. All the students were self--reported to be right-handers.

Instruments

The test can be realized with help of specially designed program (Tous, 2008) installed on PC and connected to a touch screen (LGE with resolution 1280x1024 and optimal frequency of 60 Hz) (Figure 1). A stool, adjustable to the participant's height is also required together with table and stylus for drawing on a touch screen.

Procedure

The main stimuli for representation are of two types: 1) lineograms (lines of 40 mm length) and 2) parallels (50 mm length with 8 mm of distance between them) (Figure 2). The participant should reproduce the stimuli as per indicated instructions first with visual guidance and without it (proper proprioceptive sensory test condition) by both hands. As per lineograms, they were represented in three movement types: transversal, sagittal and frontal; as per parallels, they were performed in the ascendant and descendent order. The more detailed description of method is provided in its manual (Tous et al., 2012), for lineogramms you can see also (Tous, Muiños, Liutsko & Forero, 2012).

Fig. 1. The DP-TC test.
Source: Photos by Plotka A., & Liutsko L. (Own research).

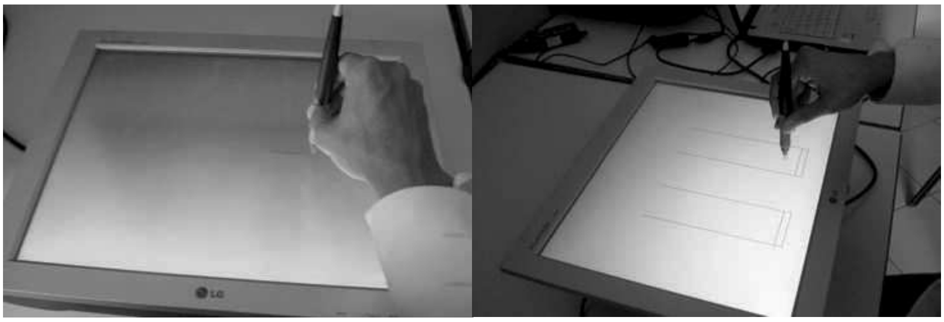

Fig. 2. Tracing the lineograms (on the left) and parallels (on the right).
Source : Photos by Liutsko L. (Own research).

The specific instructions for this study was to perform the proprioceptive test (PD) – trace the lineograms or to draw the parallel lines (Figure 2) twice: 1) in the single condition task the instruction as in usual use of PD – to trace o draw lines as precisely as it is possible; 2) in the dual condition task the participants should perform it together with a cognitive task (counting numbers back starting from 100). There was a five minute pause between both performances.

Data

The following observable variables are obtained by the Proprioceptive Diagnostics of Temperament and Character (Tous, Viadé, & Muiños, 2007; Tous et al., 2012; Liutsko, & Tous-Ral, 2012):

1) Spatial deviations (lineograms):
   a) DP1 and DP2 – directional or primary biases (shifts performed parallel to the model) in the frontal movement type, DP3 and DP4 – directional biases in the transversal movement type, DP5 and DP6 – directional biases in the sagittal movement type;
   b) DS1 and DS2 – formal or secundary biases (shifts performed perpendiculary to the model) in the frontal movement.
2) Line length (lineograms): LL1 and LL2 – an average line length in all three movement types.
3) Line length variability (parallels): LV1 and LV2 – show the difference between the longest and shortest line length in the proprioceptive part of test.

All even numbers in indexing of variables correspond to measurements in non-dominant hand that represents more temperamental (less adaptive qualities) and all odd numbers to those performed by dominant hand.

As per PD-TC description (Tous et al, 2012; Tous, Viade & Muiños, 2007 ; Liutsko, 2013) the variable describes the following six bipolar dimensions:

1. Mood (DP1 & DP2): Pessimism – Optimism
2. Decision makimg (DP5 & DP6): Submission – Dominance
3. Style of Attention (DP3 & DP4): Intratension or intra-atention (focus on

the internal world) – Extratension or exctra-attention(focus on the external world)
4. Emotivity (DS1 & DS2): Cold/distant – Warm/affiliated
5. Irritability (LL1 & LL2): Inhibition – Excitibility
6. Variability or Impulsivity (LV1 & LV2): Rigidness – Variability/Impulsivity/Spontaneity.

Results

Data analysis was performed with the programme SPSS v. 19. The descriptive statistics of means and standard deviations of fine motor precision in single and dual task is performed in Table 1 together with Z-values and significance level for the non-parametric differences paired analysis (sign test of Wilcoxon).

Tab. 1. Descriptive statistics and Wilcoxon sing test results for the difference in the performances between single and dual tasks.

		Single task		Dual task		Sign test (Wilcoxon)	
Variables		*M*	*SD*	*M*	*SD*	*Z*	s.l. (bilateral)
Spatial deviations (lineograms)	DP1	-10.20	23.47	-1.20	29.92	-1.632	0.103
	DP2	-14.00	11.92	-14.30	12.98	-.153	0.878
	DP3	1.00	11.61	-10.00	11.79	-1.785	0.074
	DP4	-0.90	9.54	-4.20	11.10	-.921	0.357
	DP5	12.80	10.41	12.00	12.02	-.612	0.540
	DP6	14.10	9.73	12.00	17.63	-1.276	0.202
	DS1	9.80	8.82	10.80	7.94	-.255	0.799
	DS2	13.50	17.50	16.50	11.88	-.840	0.401
Line length (lineograms)	LL1	41.70	14.34	50.00	11.14	**-2.040**	**0.041**
	LL2	37.70	11.42	44.50	12.39	**-1.989**	**0.047**
Line length variability (parallels)	LV1	18.20	5.29	16.90	3.03	-.422	0.673
	LV2	22.80	9.40	23.90	6.30	-.237	0.812

Notes: All measurements are given in MM. Line lengths are given in absolute values that should be compared to the model line of 40 MM. The significant differences are bolded.
Source: Experimental research performed by authors in the Laboratory of Mira y López

Analysing the changes in fine motor precision that occurred in the dual task compared to the single one, there are some points to mention. First of all, the shift upward of the group mean value in the directional bias, frontal movement and non-dominant hand performance (DP1) (-10.20±23.47 mm vs. -1.20±29.92 mm) corresponds to a tendency to be more optimistic in the Mood dimension. Herewith, in the dominant hand (DP2) these changes were unnoticeable (-14.00±11.92 mm vs. -14.30±12.98 mm). However, these differences did not reach a statistically significant level (Table 1).

As far as the directional bias in the transversal movement type, the left-side shift was performed in both hands; slightly more in non-dominant hand (DP3) (1.00±11.61 mm vs. -10.00±11.79 mm) indicating that Attention style had a tendency to be more internalised (more Intratension compared to the single task performance). Nevertheless, this difference also did not reach a statistically significant level (Z=-1.785, p=0.074) (Table 1).

The changes performed in the directional bias in sagittal movement (DP5 & DP6), in formal bias (DS1 & DS2) and in live length variability (LV1 & LV2) were not significant (Table 1). The only difference in the proprioceptive fine motor performance, that also reached statistically significant level, was line length performance in both hands (LL1 and LL2), indicating the shift in the Inhibition-Excitability balance towards the excitability. Thus, the line length had a mean value of 41.70±14.34 mm in the non-dominant hand (LL1) and of 37.70±11.42 mm for the dominant one (LL2), which was close to the model size of 40 mm in the single task; whereas these values were of 50.00±11.14 mm and 44.50±12.39 mm correspondently (Table 1).

To sum up, in the proprioceptive test condition, the changes in deviations related to spatial (lineograms) or line length variability (parallels) did not reach any statistical significance; whereas the changes in line length performance (lineograms) were found significant (that corresponds to inhibition-excitatory balance of nervous system).

Discussion

Although this study has a limitation of a small sample size, nevertheless, the results showed that in case of multiple tasks (dual in this case) create changes in the proprioceptive precision feedback. A conclusion derived from this study suggests that additional cognitive load affects the fine motor precision in dual task performance by increasing the line length (causing more excitability) in young age participants. Moreover the tendency toward internalization of attention while performing a dual task was also seen (shift in the transversal movement in non-dominant hand), thought it did not reach a statistically significant level.

This study was important in order to see the differences that occurs in the young adults as in theses ages (20-30 years old) as was shown previously in our study related to the age-dependent effects on the proprioceptive fine motor precision, the peaks of the highest precision had been obtained in 23-38 years old range for the major part of variables (Luitsko et al., 2014; Liutsko, 2013). These results show a baseline within which we can compare when carrying out other studies that expect those differences between dual and single task performances to be greater, as it was mentioned in the introduction, related to developmental processes of maturity (Schaefer, Lövdén, Wieckhorst, & Linderberger, 2010) and aging (Priest, Salamon, & Hollman, 2008; Beauchet, Annweiler, Dubost, Allali, Kressig, Bridenbaugh, Berrut, Assal, & Herrmann, 2009; Hall, Echt, Wolf, & Rogers, 2011; Beurskens, & Bock, 2012); pathologies (Kosson, 1996; Nebes, Butters, Houck, Zmuda, Aizenstein, Polloc, Mulsant, Reynolds III, 2001) or illnesses (Brown, & Marsden, 1991; Wu, & Hallet, M, 2009) among others.

This exploratory study suggests that the cognitive charge in the condition of dual task had effects more significant effects in line length performance, resulting in greater representation of line length (higher excitability). This higher excitability was also observed in other studies in the performance of participants of younger ages (12-17 years) and older (more than 60 years old) (Liutsko et al, 2014). Moreover the proprioceptive bias in line length was found to have a negative correlation with visual memory tested by ROCF (Liutsko, Tous, & Muiños, 2012) that could suggest that a dual task can have negative repercussions on working visual memory too. This information should be taken into account in the educational processes, as well as, in other practices that can be dangerous, such as driving, for example.

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References

Baltes, P.B., & Lindenberger, U. (1997). Emergence of a powerful connection between sensory and cognitive funcions across the adult life span: A new window to the study of cognitive aging? *Psychology and Aging, 12(1),* 12-21.

Beauchet, O., Annweiler, C., Dubost, V., Allali, G., Kressig, R.W., Bridenbaugh, S., Berrut, G., Assal, F., & Herrmann, F.R. (2009). Stops walking when talking: a predictor of falls in older adults? *Eur J Neurol, 16(7),* 786-795. doi: 10.1111/j.1468-1331.2009.02612.x.

Beauchet, O., & Berrut, G. (2006). Gait and dual-task: definition, interest, and perspective in the elderly. *Psychol Neuropsychiatr Vieil, 4(3),* 215-225.

Beurskens, R., & Bock, O. (2012). Age-related deficits of dual-task walking: a review. *Neural Plast.,*2012, 9p. doi: 10.1155/2012/131608. Retrived from: http://www.hindawi.com/journals/np/2012/131608/.

Bherer, L., Kramer, A.F., Peterson, M.S., Colcombe, S., Erickson, K., & Becic, E. (2005). Training effects on dual-task performance: Are there age-related differences in plasticity of attentional control? *Psychology and Aging, 20(4):* 695-709. doi: 10.1037/0882-7974.20.4.695.

Brown, R.C., & Marsden, C.D. (1991). Dual task performance and processing resources in normal subjects and patients with Parkinson's disease. *Brain, 114,* 215-231.

Guttentag, R.E. (1989). Age differences in dual-task performance: Procedures, assumptions and results. *Developmental Review, 9,* 146-170.

Hall, C.D., Echt, K.V., Wolf, S.L., & Rogers, W.A. (2011). Cognitive and motor mechanisms underlying older adults' ability to divide attention while walking. *Phys Ther., 91(7),*1039-1050. doi: 10.2522/ptj.20100114.

Ingram, H.A., van Donkelaar, C.J., Vercher, J-L., Gauthier, G.M., & Miall, R.C. (2000). The role of proprioception and attention in a visuomotor adaptation task. *Experimental Brain Research, 132,* 114-126.

Kosson, D.S. (1996). Psychopathy and dual-task performance under focusing conditions. *Journal of Abnormal Psychology, 105(3),* 391-400. doi: 10.1037/0021-843x.105.3.391.

Liutsko, L. (2013). *Age and sex differences in proprioception based on fine motor precision*. PhD dissertation. Barcelona: University of Barcelona. Retrieved from: http://www.tdx.cat/handle/10803/125441.

Liutsko, L. (2012). The book review “Diagnostico Proprioceptivo de Temperamento y Caracter” (Tous, J.M., Muiños, R., Tous, O., and Tous, J., 2012), *Anuario de psicología*, *Vol. 42(3),* 421-422.
Liutsko, L., Muiños, R., & Tous, J.M. (2014, in press, on-line version available). Age-related differences in proprioceptive and visuo-proprioceptive function in relation to fine motor behaviour. *European Journal of Aging,* doi: 10.1007/s10433-013-0304-6.
Liutsko, L., Tous, J.M., & Muiños, R. (2012). The effects of proprioception on memory: a study of proprioceptive errors and results from the Rey-Osterrieth Complex Figure in a healthy population. *Acta Neuropsychologica*, *10(4),* 489-497.
Liutsko, L., & Tous-Ral J.M. (2012). Personality traits based on fine motor individual behavior. In: A.B., Kupreichenko, & V.A., Shtroo (Eds.), National Research University “Higher School of Economics”; Russian Humanitarian Scientific Found. *Психология Индивидуальности. Материалы ШМ всероссийской научной конференции* [Psychology of Individuality. The Materials of IV Russian scientific conference, 22-24 of November]. p.322 (Our abstract in English). Moscow: Logos.
McCulloch, K.L., Buxton, E., Hackney, J., & Lowers, S. (2010). Balance, attention, and dual-task performance during walking after brain injury: association with falls history. *J Head Trauma Rehabil*, *25(3),* 155-163.
Mira, E. (1958). *Myokinetic psychodiagnosis*. (M. K. P.) New York: Logos.
Nebes, R.D., Butters, M.A., Houck, P.R., Zmuda, M.D., Aizenstein, H., Polloc, B.G., Mulsant, B.H., & Reynolds III, Ch, F. (2001). Dual-task performance in depressed geriatric patients. Dual-task performance in depressed geriatric patients. *Psychiatry Research*, *102(2),* 139-151. doi: 10.1016/S0165-1781(01)00244-X.
Priest, A. W., Salamon, K. B., & Hollman, J. H. (2008). Age-related differences in dual task walking: a cross sectional study. *Journal of neuroengineering and rehabilitation*, *5*, 29. doi: 10.1186/1743-0003-5-29.
Schaefer, S., Lövdén, M., Wieckhorst, B., & Linderberger, U. (2010). Cognitive performance is improved while walking: Differences in cognitive-sensorimotor couplings between children and young adults. *European Journal of Developmental Psychology, 7,* 371-389. doi: 10.1080/17405620802535666.
Tous, J.M. (2008). *Diagnostico Propioceptivo del Temperamento y el Carácter DP-TC [*Proprioceptive Diagnostics of Temperament and Character]. Barcelona: Lab. Mira y López. Department of Personality. Barcelona: Assessment and Psychological Treatments, University of Barcelona.
Tous-Ral, J.M., Muiños, R., Tous, O., & Tous Rovirosa, J.M. (2012). *Diagnóstico propioceptivo del temperamento y el carácter* [Proprioceptive diagnosis of temperament and character]. Barcelona: Universidad de Barcelona.
Tous-Ral, J.M., Muiños, R., Liutsko, L., & Forero, C.G. (2012). Effects of sensory information, movement direction and hand use on fine motor precision. *Perceptual and Motor Skills, 115(1)*, 261-272. doi: 10.2466/25.22.24.PMS.115.4.261-272
Tous J.M., Viadé, A., & Muiños, R. (2007). Validez estructural de los lineogramas del psicodiagnóstico miocinético, revisado y digitalizado (PMK-RD). *Psicothema*, *19(2),* 350-356.
Tous-Ral, J.M., & Liutsko, L. (2012). Quantified differences in hand drawing precision from exteroceptive (visual) and proprioceptive versus proprioceptive feedback only. In: *Books of abstracts of Moscow International Congress dedicated to the 110th anniversary of A.R. Luria's birth, p. 101. Conferences "A.R. Luria and the development of the world psychological science", "A.R. Luria and modern neuropsychology",* 29th of November – 1st December, 2012. Moscow: Lomonosov State University, Psychology Department.
Verhaeghen, P., Steitz, D.W., Sliwinski, M.J., & Cerella, J. (2003). Aging and dual-task performance: A meta analysis. *Psychology and Aging*, *18(3),* 443-460. doi: 10.1037/0882-7974.18.3.443.
Wu, T., & Hallet, M. (2009). Dual task interference in Parkinson's disease. *US Neorology*, *5(1),* 30-33.