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Comparison of Hand-eye Coordination in High School and Conservatory Students

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A B S T R A C T

Background: The present study was conducted to determine the effect of selected demographic factors on the hand-eye coordination performance of secondary school students.

Methods: A total of 326 males high school teenagers were selected from 4 districts of Shiraz city (age range 16-18 years, 90.2% right-handed; 7.7% left-handed; 1.5% both hands; non-response 0.6). Then they were investigated using J Plus software, the available targeted sampling method, the Grooved pegboard test, and a researcher-made demographic form under the same implementation conditions.

Results: The one-way analysis of the variance test showed a significant difference between the fields of study (P= 0.02). Tukey's post hoc test in whose right hand was dominant found that this difference is between humanities and technical (P=0.009) and humanities and mathematics (P= 0.005) groups.

Conclusion: Hand-eye coordination performance is more affected by the cognitive aspect and information processing, and all kinds of constraints can be considered an essential and influencing variable in the execution of movement patterns in which coordination plays a significant role.

1. Introduction

Among perceptual-motor abilities, eye-hand coordination can be mentioned; this is one of the components of coordination and is related to the theory of dynamic patterns and limitations as a result of speed and accuracy exchange (Fitts law) and the interactions of degrees of freedom in the body. It also provides new theoretical and methodological strategies for studying motor development and creates an exciting challenge for research. This skill is one of the key and fundamental principles of motor learning and development, which most sports scientists seek. Also, they have considered it effective in learning sports skills and performing many daily activities of life (R. A. Schmidt, Lee, Winstein, Wulf, & Zelznik, 2018), the disorder of which leads to a significant decline in productivity and quality of life (Ives, 2013).

However, despite the importance of coordination in information, they have not paid attention to its importance in life because various scientific surveys confirm the alarming increase in motor coordination problems in manual skills at all ages, especially among teenagers and young adults (Lundergan, Soderstrom, & Chambers, 2007; Moliner-Urdiales et al., 2010) It is also labeled as a hidden problem with much unknown information (Gómez, Ruiz, & Mata, 2006). Therefore, due to many problems, researchers are trying to introduce valid and reliable tests in the field of measuring hand-eye coordination to identify interfering and unknown factors on the execution of coordination.

For this purpose, several types of research were conducted (Jongmans, Smits-Engelsman, & Schoemaker, 2003) However, it was the World Health Organization (WHO) that, in the early 1990s, introduced one of the most widely used and popular tests used to measure eye-hand coordination called the Grooved Pegboard Test (GPT) (Matthews & Klove, 1964; Organization, 1995). In addition to measuring hand-eye coordination, this test measured the speed of information processing, identified functional and cognitive disorders, and was sensitive to hemispheric differences (Egeland et al., 2016; Sivagnanasunderam et al., 2015).

However, this was not the end of the work because, in addition to the need for appropriate measurement tools, there were also known and unknown factors that influenced the implementation of coordination, which researchers should monitor. Therefore, according to Newell's opinion)1986(, this coordination creates a

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coherent framework when these known and unknown factors are formed according to the organization of movement, cognition, and comprehensive decision-making according to the limits of individual, environmental, and task limitations (Payne & Isaacs, 2017; Newell, 1986) .The limitations of the individual include the performer's personal characteristics of the structural type (age, height, weight, and arm length) and performance (cognition, motivation, and emotions). Environmental restrictions include physical, cultural, or social restrictions (weather conditions, training facilities, access to game environments, cultural and family and school restrictions, communication networks, and media shows of a particular sport).

Task restrictions include the specific rules of a sport and educational restrictions (verbal instructions, skills demonstration, types of feedback, and training methods). Therefore, in their subsequent research, the researchers examined, recognized, and influenced these factors on eye-hand coordination and implemented the Grooved Pegboard test. For example, in the research of Bryden & Roy (2005); Van Wijk & Meintjes (2015), they noticed the effect of socioeconomic status on the coordination performance and execution of the pegboard test. In subsequent research, more variables were examined. For example: Kanj, Zeinoun, Roukoz, & Mashmoushi (2022); Wang, Bohannon, Kapellusch, Garg, & Gershon, (2015) the effect of gender on coordination performance; Mitrushina, Boone, Razani, & D'Elia, (2005), Skogan, Oerbeck, Christiansen, Lande, & Egeland, (2018) found the effect of the dominant hand on coordination performance; Heaton et al., (2021); O'Bryant et al. (2018) , found the effect of ethnicity on coordination , Tesio et al. (2016) on the effect of age difference on coordination, Çakıt, Durgun, & Cetik (2015) found out the effect of anthropometric variables on coordination performance, which can in addition to performance It also affects the coordination of the Grooved Pegboard test.

Therefore, according to the recent content, these key constraints act interactively to support the emergence of self-organized movement patterns. As a result, limitations are a powerful and essential aspect of education in facilitating, transferring, and acquiring stable movement behaviors in the learning system rather than performing coordination skills.These factors have been investigated in different research and have shown different results Fredriksen, Mamen, HJEllE, & Lindberg (2018); Skogan et al., (2018); Wilcox & Nordstokke (2022) These conflicting results can be due to intercultural differences or differences in society and the sample used in research.

Study norms are specific to each community. Additionally, different individuals such as parents, teachers and sports coaches, occupational therapists, and behavioral research institutes will benefit from the research results of identifying people with coordination skills, evaluating coordination skills and class grading, identifying people with coordination disorders, and referring them to a doctor. According to the two cases mentioned above, the performance effects of each of the variables related to eye-hand coordination performance should be considered in a special way for the optimization and interpretation of local data. The results of this research can be an effective step in examining several demographic variables that affect coordination performance in the implementation of the Grooved Pegboard test and strengthening the relevant theoretical foundations to be a prelude to conducting more research in this field, especially in Iran.

2. Materials and Methods

2.1 Subjects

After filling out the informed consent form by the participants, the number of 326 male (age range 16-18 years, 90.2% right-handed; 7.7% left-handed; 1.5% both hands; non-response 0.6%, in four fields of study Humanities, 21.5%, Science, 21.2%, Technical, 41.4%, mathematics, 10.7%, non-response, 5.2% and in the three ethnic groups of Fars, 70.6% non-Persians, 25.2% foreign nationals, 1.2% of high school teenagers in the 4 districts of Shiraz city (Iran) studying in the academic year 2021-2022 participated in this research without any specific background disease using the available sampling method (due to the fifth peak of the coronavirus in Iran).

2.2. Procedure

After completing the demographic form, which includes four parts: a) demographic, b) anthropometric measurement and dominance eye (Payne & Isaacs, 2017), c) record information for both hands, and d) The Edinburgh Handedness Inventory (EHI) (Ransil & Schachter, 1994), GPT version 32025 was used according to the instructions in the user manual of Lafayette manufacturer (Instrument, 2015) (**Figure 1**). S. L. Schmidt, Oliveira, Rocha, & Abreu-Villaca, (2000) stated that the GPT has reliability (0.67 to 0.86) in ordinary people aged 15 years and above in retest intervals of 4 to 24 months. This tool has 5 rows and 5 holes in each row, which means 25 holes in total, the direction of each of these holes is different from each other, and it also has 25 pins. Subjects were asked to start with their dominant hand and insert the pins one by one into the pegboard holes (right hand from left to right; left hand from right to left). The test starts when the examiner "gives the command to start at the common point for all subjects" and ends when the subject places the last pin on the pegboard (Strauss, Sherman, & Spreen, 2006). However, if the subject does not complete the task within five minutes, the test is stopped. Then the work was done at the hands of others (Rosselli, Ardila, Bateman, & Guzman, 2001). Finally, the time to place all the pins in five rows was recorded as the record of each subject on the score sheet.

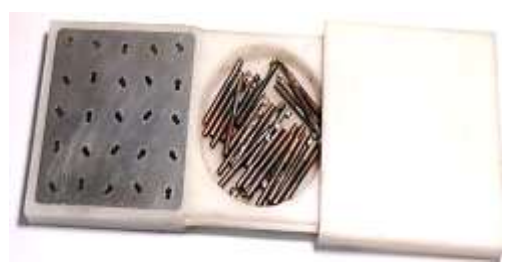

Figure 1. *Grooved pegboard test (GPT-version 32025)*

2.3. Data analysis

After checking the normality of data distribution by Shapiro-Wilk test, descriptive statistics were used to express descriptive variables. One-way analysis of variance test was used to check the significance between groups. Then Tukey's post hoc test was used to check the significance within the groups. Data analysis was performed using SPSS version 24 statistical software at a significance level of $p \leq 0.05$.

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3. Results

In **table 1**, while specifying the subgroups of each variable, the frequency and percentage of the variables: field of study, ethnicity, age, and dominant hand, are observed.

Table 1.
Descriptive information of the demographic variables of the research subjects

Variable	Subgroup	Frequency	Frequency percentage
Field of Study	Humanity	70	21.5
	Nature science	69	21.2
	Technical science	135	41.4
	Math	35	10.7
	No response	17	5.2
	Total	326	100
Ethnicity	Non-Persian	82	25.2
	Persian (Fars)	230	70.6
	Foreign nationals	7	2.1
	No response	7	2.1
	Total	326	100
Age	18 years (second half of 2018)	26	8.0
	18 years	53	16.3
	17 years	42	12.9
	16 years	121	37.1
	16 years (second half of 2015)	83	25.5
	No response	1	.2
	Total	326	100
Dominant hand	Right	294	90.2
	Left	25	7.7
	Both	5	1.5
	No response	2	0.6
	Total	326	100

Table 2 shows the deceptive information related to the variables: height, weight, hand length, thumb size, and index finger size.

Table 2.
Anthropometric information of research subjects

		Height(cm)	Weight(kg)	Hand length(cm)	Thumb size(cm)	Index finger size(cm)
Frequency (N)	**Valid**	325	325	323	323	323
	Missing	1	1	3	3	3
Mean		173.7156	66.2299	19.2616	6.4427	7.4176
Std. Deviation		6.98731	14.13832	.97268	.57427	.55714
Variance		48.823	199.892	.946	.330	.310
Minimum		151.00	38.00	17.00	5.00	5.50
Maximum		195.00	128.00	22.00	8.00	9.00

Descriptive information related to pinning time values in the GPT can be seen according to the domination of the hand (**Table 3**).

Table 3.
Information describing the subjects' performance in the GPT

Dominant hand	Measures	Frequency	M± SD
Right	Right hand time	294	67.74 ± 10.48
	Left hand time	294	74.28 ± 12.03
Left	Right hand time	25	74.63 ± 13.07
	Left hand time	25	67.99 ± 13.19
Both	Right hand time	326	68.20 ± 10.75
	Left hand time	326	73.66 ±12.15

The one-way analysis of the variance test showed a significant difference between the fields of study (p= 0.02). Tukey's post hoc test showed that this difference exists between the humanitarian and technical groups (p= 0.009), the humanitarian and mathematical groups (p= 0.005) in people whose dominant hand is right.

In people with left hand dominance, the only significant difference was observed in the human group compared to mathematics (p= 0.036) (**Table 4**).

Table 4:
One-way ANOVA test between academic fields and pinning time with right and left hand

		Sum of Squares	Df	Mean Square	F	Sig
Right hand time	Between Groups	1630.749	3	543.583	4.902	0.002
	Within Groups	33819.574	305	110.884		
	Total	35450.323	308			
Left hand time	Between Groups	1258.993	3	419.664	2.953	0.033
	Within Groups	43340.859	305	142.101		
	Total	44599.852	308			

4. Discussion and Conclusion

The purpose of this study was to compare hand-eye coordination in high school and conservatory students.

Among the factors examined in the process of the current research, it has been shown that there is a significant difference between the academic fields .The results of this part of the research on the effect of the field of study on hand-eye coordination are in line with previous studies Mathiowetz, Weber, Kashman, & Volland, (1985); Thompson, Heaton, Matthews, & Grant, (1987) The results are inconsistent with the research of R. A. Schmidt et al., (2018); Van Wijk & Meintjes, 2015; Wang et al., (2015) is skewed.

In this research, other variables such as age groups, ethnicity, and dominant hand were also studied; the relevant tests did not show any significant difference in any of the variables Findings related to this part of the research is aligned with studies conducted by Fredriksen et al., (2018); Omar, Alghadir, Zafar, & Al Baker, (2018); Skogan et al., (2018); and are inconsistent with. Flouris et al., (2006); O'Bryant et al., (2018). Another part of the research was related to identifying the correlation between anthropometric variables (height, weight, hand length, thumb size, index finger size) and pinning time. The results in this section indicated the absence of correlation between the variables and lack of coordination (p>0.5). The results of this section are inconsistent with those of Çakıt et al., (2015); Wang et al., (2015). These differences between earlier research and the current research can be attributed to a variety of factors, including intercultural differences, age group variations, sample size and number differences.

According to the above topics, it is acknowledged that movement coordination is always one of the crucial processes in the acquisition of movement skills, which requires the functioning of the nervous system, sensory factors, and cognitive processes to complete all movements. These factors originate from the person's limitations, environment, and task (Rivera Mindt et al., 2021).). Therefore, paying attention to all kinds of constraints and cognitive processing is one of the most critical foundations of cognitive ability. Constraints and cognitive processing include events, actions, or objects, and are also the result of past experiences and play a significant role in screening, decoding, organizing, storing, and retrieving information. When this cognitive system encounters a situation or stimulus, automatic information processing is used to select, interpret and evaluate the stimulus (Rosenbaum, 1980).

The findings presented in this study emphasize the need for norms classified by age and field of study for fine motor performance in adolescence. In addition, individual differences in motor performance are related to age, gender, environment, and complexities that are evident in specific periods of normative development.

Separate scores should always be kept for each hand because the dominant and non-dominant hand's fine motor performance may differ depending on age, gender, and task complexity. Additionally, because fine motor functions are sensitive to how the cognitive system functions, test performance evaluation should be based on socially appropriate normative data (Fong, Jim, Dong, & Cheung, 2013; Lee et al., 2013). The optimal development of coordination is particularly important for humans (Álvarez & Buendía, 2004) and is primarily influenced by cognitive performance (Bezdicek et al., 2014; Tolle, Rahman-Filipiak, Hale, Kitchen Andren, & Spencer, 2020). This is because the research's findings revealed a significant difference between the study fields. This issue indicates the cognitive and processing function of hand-eye coordination. Also, gender is the most important and central factor in coordination processes, especially eye-hand coordination; after that, performance and movement experiences can play a role in this performance to some extent and with conditions. This study's significance is evident in two different ways; First, the introduction of the Grooved Pegboard test and some socio-demographic variables affecting hand-eye coordination performance, and second, its application for teachers, trainers, and occupational therapists. The existing limitations of the research, such as the absence of female subjects, control of factors influencing cognitive performance in the test, bias in the data due to the coincidence of the fifth peak of the coronavirus in Iran with the data collection process, the small age group (16 to 18 years) and other factors, the application of the results makes the application of the results of this research cautious

Authors' contribution

Conception and design of study: U.G, R.R, Gh.N; data collection: U.G, R.R, Gh.N; Data analysis and/or interpretation: U.G, R.R, Gh.N; Drafting of manuscript and/or critical revision: U.G, R.R, Gh.N; Approval of final version of manuscript: U.G, R.R, Gh.N.

Conflict of interest

The authors have no conflict of interests.

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References

Álvarez, J. L. H., & Buendía, R. V. (2004). *La evaluación en educación física: investigación y práctica en el ámbito escolar* (Vol. 200): Grao.

Bezdicek, O., Nikolai, T., Hoskovcová, M., Štochl, J., Brožová, ., Dušek, P., . . . Růžička, E. (2014). Grooved pegboard predicates more of cognitive than motor involvement in Parkinson's disease. *Assessment, 21*(6), 723-730 .

Bryden, P., & Roy, E. (2005). A new method of administering the Grooved Pegboard Test: performance as a function of handedness and sex. *Brain and cognition, 58*(3), 258-268 .

Çakıt, E., Durgun, B., & Cetik, O. (2015). A neural network approach for assessing the relationship between grip strength and hand anthropometry .

Egeland, J., Løvstad, M., Norup, A., Nybo, T., Persson, B. A., Rivera, D .F., . . . Arango-Lasprilla, J. C. (2016). Following international trends while subject to past traditions: Neuropsychological test use in the Nordic countries. *The Clinical Neuropsychologist, 30*(sup1), 1479-1500 .

Flouris, A. D., Cheung, S., Fowles, J., Kruisselbrink, L., Westwood, D. A., Carrillo, A. E., & Murphy, R. J. (2006). Influence of body heat content on hand function during prolonged cold exposures. *Journal of Applied Physiology, 101*(3), 802-808 .

Fong, K. N., Jim, E. S., Dong, V. A., & Cheung, H .K. (2013). 'Remind to move': a pilot study on the effects of sensory cueing treatment on hemiplegic upper limb functions in children with unilateral cerebral palsy. *Clinical Rehabilitation, 27*(1), 82-89 .

Fredriksen, P. M., Mamen, A., HJEllE, O. P., & Lindberg, M. (2018). Handgrip strength in 6–12-year-old children: the health oriented pedagogical project (HOPP). *Scandinavian journal of public health, 46*(21_suppl), 54-60 .

Gómez, M., Ruiz, L. M., & Mata, E. (2006). Los problemas evolutivos de coordinación en la adolescencia: Análisis de una dificultad oculta. *RICYDE. Revista Internacional de Ciencias del Deporte, 2*(3), 44-54 .

Heaton, A., Gooding, A., Cherner, M., Umlauf, A., Franklin, D. R., Rivera Mindt, M., . . . Marquine, M. J. (2021). Demographically-adjusted norms for the Grooved Pegboard and Finger Tapping tests in Spanish-speaking adults: Results from the Neuropsychological Norms for the US-Mexico Border Region in Spanish (NP-NUMBRS) project. *The Clinical Neuropsychologist, 35*(2), 396-418 .

Instrument, L. (2015). Grooved Pegboard user's manual. *PO Box, 5729* .

Ives, J. C. (2013). *Motor behavior: Connecting mind and body for optimal performance*: Lippincott Williams & Wilkins.

Jongmans, M. J., Smits-Engelsman, B. C., & Schoemaker, M. M. (2003). Consequences of comorbidity of developmental coordination disorders and learning disabilities for severity and pattern of perceptual—motor dysfunction. *Journal of learning disabilities, 36*(6), 528-537 .

Kanj, R., Zeinoun, P., Roukoz, C., & Mashmoushi, R. (20 .(22 Factors associated with motor dexterity on the grooved pegboard test in a Lebanese sample. *Applied Neuropsychology: Child, 11*(2), 178-183 .

Lee, J. A., You, J. H., Kim, D. A., Lee, M. J., Hwang, P. W., Lee, N. G., . . . Kim, H.-K. (2013). Effects of functional movement strength training on strength, muscle size, kinematics, and motor function in cerebral palsy: A 3-month follow-up. *NeuroRehabilitation, 32*(2), 287-295 .

Lundergan, W. P., Soderstrom, E. J., & Chambers, D. W. (2007). Tweezer dexterity aptitude of dental students. *Journal of Dental Education, 71*(8), 1090-1097 .

Mathiowetz, V., Weber, K., Kashman, N., & Volland, G. (1985). Adult norms for the nine hole peg test of finger dexterity. *The Occupational Therapy Journal of Research, 5*(1), 24-38 .

Matthews, C., & Klove, H. (1964). Instruction manual for the adult neuropsychology test battery. *Madison, WI: University of Wisconsin Medical School, 36* .

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

Moliner-Urdiales, D., Ruiz, J., Ortega, F., Jiménez-Pavón, D., Vicente-Rodriguez, G., Rey-López, J., . . . Marcos, A. (2010). Secular trends in health-related physical fitness in Spanish adolescents :the AVENA and HELENA studies. *Journal of science and medicine in sport, 13*(6), 584-588 .

Newell, K. (1986). Constraints on the development of coordination. *Motor development in children: Aspects of coordination and control* .

O'Bryant, S. E., Edwards, M ,.Johnson, L., Hall, J., Gamboa, A., & O'jile, J. (2018). Texas Mexican American adult normative studies: Normative data for commonly used clinical neuropsychological measures for English-and Spanish-speakers. *Developmental neuropsychology, 43*(1), 1-26 .

Omar, M. T., Alghadir, A. H., Zafar, H., & Al Baker, S. (2018). Hand grip strength and dexterity function in children aged 6-12 years: A cross-sectional study. *Journal of Hand Therapy, 31*(1), 93-101 .

Organization, W. H. (1995). Constitution of the world health organization .

Payne, V. G., & Isaacs, L. D. (2017). *Human motor development: A lifespan approach*: Routledge.

Ransil, B. J., & Schachter, S. C. (1994). Test-retest reliability of the Edinburgh Handedness Inventory and Global Handedness preference measurements, and their correlation. *Perceptual and motor skills, 79*(3), 1355-1372 .

Rivera Mindt, M., Marquine, M. J., Aghvinian, M., Scott, T. M., Cherner, M., Morlett Paredes, A., . . . Diaz-Santos, M. (2021). Demographically-adjusted norms for the processing speed subtests of the WAIS-III in a Spanish-speaking adult population: Results from the Neuropsychological Norms for the US-Mexico Border Region in Spanish (NP-NUMBRS) project. *The Clinical Neuropsychologist, 35*(2), 293-307 .

Rosenbaum, D. A .(1980) .Human movement initiation: specification of arm, direction, and extent. *Journal of Experimental Psychology: General, 109*(4), 444 .

Rosselli, M., Ardila, A., Bateman, J. R., & Guzman, M. (2001). Neuropsychological test scores, academic performance, and developmental disorders in Spanish-speaking children. *Developmental neuropsychology, 20*(1), 355-373 .

Schmidt, R. A., Lee, T. D., Winstein, C., Wulf, G., & Zelaznik, H. N. (2018). *Motor control and learning: A behavioral emphasis*: Human kinetics.

Schmidt ,S. L., Oliveira, R. M., Rocha, F. R., & Abreu-Villaca, Y. (2000). Influences of handedness and gender on the grooved pegboard test. *Brain and cognition, 44*(3), 445-454 .

Sivagnanasunderam, M., Gonzalez, D. A., Bryden, P. J., Young, G., Forsyth, A., & Roy ,E. A. (2015). Handedness throughout the lifespan: cross-sectional view on sex differences as asymmetries change. *Frontiers in Psychology, 5*, 1556 .

Skogan, A. H., Oerbeck, B., Christiansen, C., Lande, H. L., & Egeland, J. (2018). Updated developmental norms for fine motor functions as measured by finger tapping speed and the Grooved Pegboard Test. *Developmental neuropsychology, 43*(7), 551-565 .

Strauss, E., Sherman, E. M., & Spreen, O. (2006). *A compendium of neuropsychological tests: Administration, norms, and commentary*: American chemical society.

Tesio, L., Simone, A., Zebellin, G., Rota, V., Malfitano, C., & Perucca, L. (2016). Bimanual dexterity assessment: validation of a revised form of the turning subtest from the Minnesota Dexterity Test. *International Journal of Rehabilitation Research. Internationale Zeitschrift fur Rehabilitationsforschung. Revue Internationale de Recherches de Readaptation, 39*(1), 57 .

Thompson, L. L., Heaton, R. K., Matthews, C. G., & Grant, I. (1987). Comparison of preferred and nonpreferred hand performance on four neuropsychological motor tasks. *The Clinical Neuropsychologist, 1*(4), 324-334 .

Tolle, K. A., Rahman-Filipiak, A. M., Hale, A. C., Kitchen Andren, K. A., & Spencer, R. J. (2020). Grooved Pegboard Test as a measure of executive functioning. *Applied Neuropsychology: Adult, 27*(5), 414-420 .

Van Wijk, C. H., & Meintjes, W. (2015). Grooved Pegboard for adult employed South Africans: normative data and human immunodeficiency virus associations. *South African Journal of Psychology, 45*(4), 521-535 .

Wang, Y.-C., Bohannon, R. W., Kapellusch, J., Garg, A., & Gershon, R. C. (2015). Dexterity as measured with the 9-Hole Peg Test (9-HPT) across the age span. *Journal of Hand Therapy, 28*(1), 53-60 .

Wilcox, G., & Nordstokke ,D. (2022). Pediatric co-norms for finger tapping, grip strength, and grooved pegboard in a community sample. *Journal of the International Neuropsychological Society, 28*(1), 85-93 .