Rethinking The Dental Hygiene Admissions Process To Include Evaluation Of "Working" Hands

Amy L. Sullivan, Angie Garner, Christi D. Hardy

Abstract: The typical dental hygiene school admissions committee regularly considers an applicant's intellectual potential to succeed upon entrance into the program. Since hands-on ability is considered an asset in the dental profession, this research investigates the applicants' clinical potential by way of three very specific hands-on assessment tests. Each applicant was given a hands-on test consisting of the O'Conner Tweezer Dexterity, Grooved Pegboard, and Symbol Digit modalities following the standardized guidelines. The main findings suggest the best indicator of passing the clinical boards is the pre-clinic course grade, and the best indicators of success in the pre-clinic course are the O'Conner Tweezer Dexterity and Symbol Digits Modalities assessment tests. This displays some rationale for selecting a student with better-hands on ability prior to starting the program and can be done by way of these assessment tests.

————————————————◆————————————————

Introduction

Hands-on ability is considered an asset upon entering the dental field. Despite its importance, the majority of dental/dental hygiene programs neglect to consider these skills before investing a student's time, money, and effort into educating a student. Dental/dental hygiene programs accept applicants who are most likely to achieve academic success, typically assessed through grade point average. Admissions committees evaluate potential academics of students by calculating any one or a combination of overall grade point average (GPA), science grade point average (SGPA), and non-science grade point average (NGPA). Other criteria used in dental/dental hygiene schools' admissions processes include test scores, such as those from DAT (dental school), DHCAT (dental hygiene), HOBET (allied health), ACT, SAT, as well as pre-admission interview scores, letters of recommendation, and previous dental office experience or shadowing (American Dental Association Survey Center). Previous studies support some correlation between some of these when compared to national board scores (an academic test); therefore, assessing academic success does prove valuable in evaluating applicant's *intellectual* potential to succeed (Ward, Downey, Thompson & Collins, 2010; Bauchmoyer, Carr & Hoberty, 2004; Schmidt & MacWiliams,2011; Austin, 2011; Downey, Collins & Browning, 2004). Dental/dental hygiene students must also pass a clinical board. Literature is sparse when it comes to evaluating the potential of an applicant to succeed *clinically.*

_____

- *Amy L. Sullivan, RDH, PhD, Dental Hygiene Admissions Chair, Associate Professor in Dental Hygiene and Graduate Studies, asullivan@umc.edu*
- *Angie Garner, RDH, MS, Assistant Professor in Dental Hygiene*
- *Christi D. Hardy, MS, Student Admissions Officer*

With the goal of incorporating hands-on testing during dental hygiene admissions process, this research investigates the efficacy of three very specific hands-on tests in relation to a dental hygienists hands-on ability and future success in clinical performance.

Predictors for Clinical Performance Success

Scientific literature focuses its efforts on intellectual abilities of applicants and current students, but success in dental hygiene education is not solely based upon intellectual ability. Dental hygiene students are tasked to transition from novice to competent clinicians while also learning the didactic portions of their curricula; all in a relatively short amount of time. Fine motor skills must be developed, practiced, and assessed throughout a student's tenure in dental hygiene school. In 2009 Hauser and Bowen discussed the details of preclinical instruction and evaluation, including important theories of motor skills and motor performance. It was reported by Chambers and Geissberger in 1997 that all students beginning their journey of dental education start equally at novice level, but is this really the case? The authors of this article have anecdotally observed certain students easily grasping the fine motor skills needed as a dental hygienist, while others struggle significantly throughout their time as a student. This begs the question, 'How do faculty members evaluate the potential for a student's success in the *clinical* arena of practice?' Various types of healthcare schools evaluate manual dexterity of applicants into their programs (Gansky et al., 2004; Al-Johany et al., 2011) The type of manual dexterity test utilized by each program varies widely; therefore, results of the manual dexterity tests also fluctuate. Out of the 323 dental hygiene schools in existence in ADA's 2010-2011 period of study, only three percent (n=10) of schools across the United States conduct a manual dexterity exam for applicants (American Dental Association Survey Center). After review of the literature and much discussion, the dental hygiene admissions committee of UMMC (2004) met with trained occupational therapists to determine which assessments were available to demonstrate abilities of cognition , dexterity, and perception as do the regional licensure exams (Downing & Haladyna, 2006). After several meetings of reviewing and practicing with numerous standardized assessment tests,

the committee strongly agreed that the top 3 assessments to fit dental hygiene needs were the O'Conner Tweezer Dexterity test, Grooved Pegboard, and Symbol Digit Modalities. Assessment tests were piloted with the enrolled dental hygiene students for clarity and practice.

O'Conner Tweezer Dexterity

The O'Connor Tweezer Dexterity Test (figure 1) was developed in 1926 by Mildred Hines and Johnson O'Connor (Hines & O'Connor, 1926). The test was designed to assess employees potential in jobs that required rapid wrist and finger movements, in fine assembly work requiring both speed and precision, and in jobs involving rapid manipulation of small objects (Fleishman, 1953). The test measures the speed with which an individual is able, with the use of tweezers, to pick up pins or similar objects one at a time and place them in small holes on a board (Yancosek & Howell, 2009). A high score indicates manual aptitude for work involving precision and steadiness in the use of small hand tools (Hines & O'Connor, 1926). The Johnson O'Connor Research Foundation describes tweezer dexterity as an aptitude for working with small tools which are used in delicate tasks such as dentistry, surgery, nursing, mechanical drawing, watchmaking and repair, and miniature instrument assembly (Lundergan, et al., 2007). Many research studies have attempted to evaluate the how utilization of the test impacts admissions into various professional educational programs; specifically dentistry and surgery. The test has been used to aid in correlating manual dexterity with USMLE scores of medical students (Goldberg et al., 2008), and Thomas Kirby utilized the test to investigate whether the utilization of a dexterity test would be beneficial in determining which residents would need more intensive training in surgical techniques before beginning the surgical rotation in their residencies (Kirby, 1979). Lundergan et al., employed the tweezer dexterity test as a predictor for applicants performance in dental school admissions processes (Lundergan et al., 2007), and the tweezer test was also used along with many other perceptual motor skill tests to elucidate differences, if any, between freshman and senior dental students in regard to skills as a result of dental education (Zullo, 1971). In 2011, Suksudaj et al., used the test along with other psychometric tests to assess different abilities before completing a cavity preparation (Suksudaj et al., 2012).

Grooved Pegboard

Hallgrim Kløve developed the Grooved Pegboard (figure 2) in 1963. The test was designed to assess manual dexterity among patients with head injuries (Kløve, 1963). According to Lezak (1995), research shows that the Grooved Pegboard Test requires more complex visual-motor coordination than most other pegboard tests. The Grooved Pegboard has an integrated design with a well above the pegboard holding grooved metal pegs. The pegboard has 25 grooved holes arranged in rows of five; the shape of each hole is identical, but the orientation varies so that subjects must rotate the peg to match the hole before they can be inserted (Wang et al., 2011). The Grooved Pegboard Test has been utilized in neuropsychological evaluations. Bryden and Roy in 2005 used to test as a potential predictor of lesion lateralization to reflect brain damage and determining differences among affected male and female motor skills. Age and gender have been shown to have a significant effect on motor task performances, and the Grooved Pegboard Test has been utilized to assess their impact (Ashendorf et al, 2009). Studies have shown that measures of limb bradykinesia, especially the Grooved Pegboard test, best reflect the nigrostriatal defect in Parkinson's disease (Bohnen et al, 2007). This test has also been used to determine clinically relevant neurocognitive changes in HIV infected individuals (Levine et al., 2007).

Symbol Digit modalities

The Symbol Modalities Test (SMDT) was developed to identify individuals with neurological impairment (figure 3). The SMDT assesses key neurocognitive functions such as attention, visual scanning, and motor speed (Sheridan et al., 2006). SMDT involves the timed coding of numbers with abstract symbols. Scoring is based on the number of correct substitutions made in 90 seconds (Walderman et al., 1992). Due to the SMDT's numeric response requirement, the test can be administered within either a written or an oral response modality (Morgan and Whellock, 1992). The SMDT has demonstrated the ability to evaluate not only cognitive function, but also neurological and neuropsychiatric disorders; for example, multiple sclerosis (Forn et al., 2009). Jorm et at in 1996 assessed the cognitive decline and dementia in the elderly using the SMDT. In 1996, Gabrieli reported the effects upon memory of normal aging, and two neurodegenerative diseases, Alzheimer disease and Parkinson disease, while using the SMDT as one of his assessment instruments. The test has also been utilized to evaluate the effects of serum gonadal steroids on cognition (Ryan et al., 2011). Suksudaj et al., 2012, also utilized the SMDT to assess psychomotor skills of dental students with regard to operative dentistry.

Methods

All applicants for the entering dental hygiene class of 2005, who were granted an interview, were asked participate in a "hands-on" portion of the interview. All three assessments were administered by trained occupational therapists and dental hygienists. These are all standardized tests and require specific guidelines and training. From 2005- 2014, the UMMC dental hygiene program records scores for all three assessments for the applicants each year. Since it was hypothesized these tests would give a better clinical assessment of the applicants, data will be compared to clinical board scores, instrumentation (pre-clinic) grades, and a faculty summation score.

Testing directions

Upon completing a face to face interview, subjects are seated at a table with the O'Connor Tweezer Dexterity Test (Model 32022) placed in front of them. The following directions recommended by the test distributer, Lafayette Instrument are read to the applicant (O'Connor Tweezer Dexterity Test: User Instruction, 2004):

1. "The board in front of you consists of 100 holes each large enough to hold one pin."
2. "Using your dominant hand, pick up one pin at a time with the tweezers and fill the holes, placing one pin in each as fast as you can."

248

3. "It is easiest to start in the farthest corner and work toward you. There are enough extra pins in the tray so that if you drop one or two on the floor you will still have enough left. Do not stop to pick them up."
4. Applicants are allowed to practice placing 10 pins to complete the top row.
5. The applicants then remove the 10 pins and place them back on the designated area of the board. They are allowed to rest for a moment.
6. Once applicants are instructed to begin, a stopwatch is used to accurately time the number of seconds required to fill the board from placing the first pin to the placing the last.

Along with completing the O'Connor Tweezer Dexterity Test, applicants are also asked to take the Grooved Pegboard Test (Model 32025). The applicants are seated at a table with the Pegboard in front of them. The following directions recommended by the test distributer (Grooved Pegboard Test: User Instructions, 2003) were read to the applicant:

1. "This is a pegboard and these are the pegs. All pegs are the same."
2. "We will begin with a practice round, when I say go, begin here placing the pegs into the board as fast as you can, using only your dominant hand. Fill the top row completely from this side to this side."
3. After returning the pegs to the well the applicants are directed "When I say go, begin here placing the pegs into the board as fast as you can, using only your dominant hand. Fill the top row completely from this side to this side. Do not skip any; fill each row the same way you filled the top row. Any questions? Ready, as fast as you can, go"
4. Once applicants are instructed to "go," a stopwatch is used to record the length of time in seconds it takes the applicant to completely fill the pegboard.

As with the other dexterity tests, the SMDT is administered after the applicants complete their admissions interview. The applicants are seated at a table with the SMDT and pens in front of them. The following directions recommended by the test distributer, Western Psychological Services (Smith, 2002) are read to the applicant:

1. Applicants are asked to "Please look at these boxes on the top of the page. You can see that each box in the upper row has a little mark in it. Now look at the boxes in the row just underneath the marks. Each of the boxes under the marks has a number. Each of the marks in the top row is different, and under each mark in the bottom row is a different number. You are to fill each empty box with the number that should go there according to the way they are paired in the key at the top of the page.
2. Applicants are allowed to practice until they reach the double line.
3. After the practice portion, applicants receive further instructions, " Now, when I say go write in the numbers just like you have been doing as fast as you can until I say stop. When you come to the end of the first line, go quickly to the next line

without stopping, and so on. If you make a mistake, do not erase, just write the correct answer over your mistake. Do not erase as you will waste time. Just write the correct answer over your mistake. Do not skip any boxes and work as quickly as you can. Ready? Go."
4. Exactly 90 seconds from starting, the examiner says: "Stop"

Comparisons

The majority of graduating UMMC dental hygiene students eligible for clinical testing (2005-2014) and planning to work in MS opted to take CITA as their clinical board. The Council of Interstate Testing Agency (CITA) provides psychometric, technical and administrative services in the administration and delivery of clinical licensure examinations in dentistry and dental hygiene. CITA is recognized for licensure in 24 states. The testing instrument was deemed valid in 2006 after careful data analysis, focus groups, surveys, a pilot study, and CITA committee review (AERA, 1999). Performance (patient assessment including probing, scaling, and treatment) is evaluated on a live patient (which must meet certain criteria) by calibrated licensed dental professionals. To be eligible for licensure, The Mississippi State Board of Dental Educators (MSBDE) requires a minimum score of 75 out of 100. Through the years (2005-2014) options for clinical testing have improved, and CITA is no longer the only option for licensure. Similarly, other recognized tests also require a minimum score of 75 for passing. These are later coded into a pass/fail. Since faculty felt that the standardized clinical testing was not always accurate in the prediction of *clinical* assessment, two other methods are also used in comparisons. First, course grades from students' first hands-on course in the UMMC dental hygiene program were recorded. Dental Hygiene Instrumentation, DH305 (pre-clinic) focuses on the development and application of the fundamentals of instrumentation. Students learn to apply principles of instrumentation of probes and scalers in this course (position, grasp, hold, fulcrum, adapt, angle, apply pressure, and use control). This course is the foundation for hand skill development in dental hygiene. The final grade in this course incorporates three practical examinations, where faculty directly observe and score the students on their performance of these principles. At the completion of this preclinic course, the student should be prepared to provide basic dental hygiene care to patients with relatively healthy oral conditions. Students must pass the course with a 75 out of 100 to move forward in the curriculum. It is in this course where most faculty identify those clinically awkward students. Since this course is offered during the first semester, faculty also developed a means for assessing the students' hands-on abilities at a later point in their clinical training. Faculty were asked to rank the students on a scale of 3 (above average), 2 (average), and 1(below average, still struggles) on their clinical or hands-on ability. This summation score was averaged by 10 of the dental and dental hygiene faculty that work with the students in clinic on a daily basis.

Analysis

The selected dental hygiene students for the UMMC classes of 2007 through 2014 were evaluated as part of this study. Once ethical clearance was obtained from the Institutional Review Board and the MSBDE shared the *clinical* examination scores, analysis began. The data collected included O'Conner Tweezer Dexterity test, Grooved Pegboard, Symbol Digit modalities as the 3 independent variables and clinical board, DH instrumentation final grade, and faculty summation scores as the dependent variables. Data was evaluated in SPSS (version 19) program with the level of significance set at 0.05.

Results

A simple Pearson's correlation matrix (Table 1) of 174 applicants, approximately 20 students each year, reveals correlation between the pre-clinic course grade and the faculty summation score upon graduation (P=0.000). There is also significant correlation of the pre-clinic grades with the Symbol Digit Modalities test (0.004) and the O'Conner Tweezer dexterity test (0.029).   Due to some parallels among the three assessments themselves, one must take significance into consideration in the regression model that includes all three of these assessments. When compared to passing or failing the *clinical* boards, the pre-clinic course grade and the O'Conner Tweezer Dexterity test divulge some correlation. Although there are many correlations, when each of the three assessments was looked at individually through regression analyses, significance dwindles, and not all models were significant (Tables 2 and 3). It appears the best indicator of passing the clinical boards is the pre-clinic course grade (Table 6) and the best indicators of success in the pre-clinic course are the O'Conner Tweezer Dexterity and Symbol Digits Modalities assessment tests (Tables 4 and 5).

Discussion:

The correlation between the pre-clinic grade and, upon graduation, the faculty summation score indicates that there is not much improvement in hands-on ability through the progression of the dental hygiene program. This displays some rationale for selecting a student with better-hands on ability prior to starting the program. An article written by Italian dentists and published in the British Dental Journal in 2003 contradicts this thought. Giuliani et al., 2007 report that basic manual dexterity is not essential in the selection of dental students, and students who could follow training significantly improved in their manual dexterity. It is important to note that the exercises performed to demonstrate hands-on ability were Montessori-type exercises such as threading a needle. This study was conducted over a five year period and observed only dental students. Although dental students do perform much with their hands, dental hygiene students perform intricate repetitious movements that differ from those of dental students. Since the symbol digit, O'Conner Tweezer, and Grooved Pegboard demonstrate some correlation between the assessments, the interpretation of the significant model (.008) is interpreted with caution. The model reveals *Symbol Digits Modalities* is the most predictive of pre-clinic grades; however, O'Conner and Grooved Pegboard cannot be ruled out due to the similarities among the assessments.

An additional model (.047) reveals that the O'Conner is significant with pre-clinic grades at the 0.038 level.

Conclusions

Hands-on ability is a strength that should be valued during the dental hygiene admissions process since a clinical board exam is given to obtain licensure. Although some skill sets are teachable, those intricate dental hygiene movements are best performed by clinicians that have some natural ability when it comes to hands-on dexterity. Dental hygiene schools can evaluate this natural hands-on ability using one or more of the aforementioned assessments. O'conner Tweezer dexterity and Symbol digit modalities assessments are significant predictors in clinical success of our dental hygiene applicants.

Figure 1: O'Conner Tweezer Dexterity

Figure 2: Grooved Pegboard

Figure 3: The Symbol Modalities Test (SMDT)
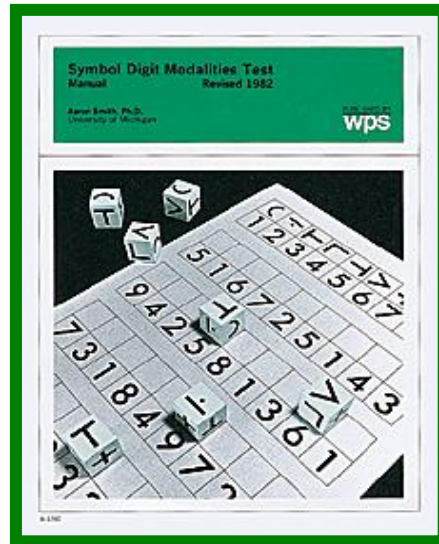
Table 1: Pearson's correlation matrix
 Correlations

		CITA (raw scores)	Faculty Sum	preClinic Grade	Symbol Digit Modalities	OConne rTweez	Groov edPeg	Clinical Board P/F
CITA (raw scores)	Pearson Correlation Sig. (2-tailed)	1	-.140 .137	.097 .301	.034 .724	.134 .158	-.014 .880	-.915** .000
Faculty Sum Of Hands-on	Pearson Correlation Sig. (2-tailed)	-.140 .137	1	.495** .000	.058 .452	-.018 .813	-.042 .582	.011 .900
preClinicGrade	Pearson Correlation Sig. (2-tailed)	.097 .301	.495** .000	1	.232** .004	.177* .029	-.015 .853	-.173* .039
Symbol Digit Modalities	Pearson Correlation Sig. (2-tailed)	.034 .724	.058 .452	.232** .004	1	.208** .006	.189* .013	-.082 .332
OConnerTweez	Pearson Correlation Sig. (2-tailed)	.134 .158	-.018 .813	.177* .029	.208** .006	1	.257** .001	-.162 .054
GroovedPeg	Pearson Correlation Sig. (2-tailed)	-.014 .880	-.042 .582	-.015 .853	.189* .013	.257** .001	1	-.018 .834
Clinical Board P/F	Pearson Correlation Sig. (2-tailed)	-.915** .000	.011 .900	-.173* .039	-.082 .332	-.162 .054	-.018 .834	1

**. Correlation is significant at the 0.01 level (2-tailed).
 *. Correlation is significant at the 0.05 level (2-tailed).

Table 2: ANOVA model of symbol digit modalities compared to clinical board, faculty summation, and pre-clinic grade (P= 0 .173); not a significant model

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	30.859	13.751		2.244	.026
	Clinical Board P/F	-1.444	2.697	-.046	-.535	.593
	Faculty Summation	-2.005	1.980	-.097	-1.012	.313
	Pre-Clinic Grade	.333	.165	.197	2.025	.045

a. Dependent Variable: syDigmod

Table 3: ANOVA model of Grooved Pegboard compared to clinical board, faculty summation, and pre-clinic grade (P= 0 .998) ; not a significant model

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	64.763	16.066		4.031	.000
	Clinical Board P/F	-.470	3.151	-.013	-.149	.882
	Faculty Summation	.194	2.314	.008	.084	.933
	Pre-Clinic Grade	.010	.192	.005	.050	.960

a. Dependent Variable: GroovedPeg

Table 4: ANOVA model of O'Conner Tweezer Dexterity compared to clinical board, faculty summation, and pre-clinic grade (P= 0 .047)

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-40.292	52.312		-.770	.443
	Clinical Board P/F	-14.706	10.259	-.122	-1.434	.154
	Faculty Summation	-9.927	7.534	-.125	-1.318	.190
	Pre-Clinic Grade	1.309	.626	.201	2.090	.038

a. Dependent Variable: OConnerTweez

Table 5: ANOVA model of pre-clinic grade compared to Symbol Digit Modalities, Grooved Pegboard, and O'Conner Tweezer Dexterity (P= 0 .008)

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	81.900	3.639		22.507	.000
	syDigmod	.128	.050	.215	2.592	.011
	GroovedPeg	-.057	.047	-.101	-1.211	.228
	OConnerTweez	.025	.014	.150	1.771	.079

a. Dependent Variable: preClinicGrade

Table 6: Anova model of the clinical board exam compared O'Conner Tweezer Dexterity, faculty summation score, and pre-clinic grade (P= 0 .044)

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.950	.402		4.857	.000
	OConnerTweez	-.001	.001	-.122	-1.434	.154
	Faulty summation	.067	.063	.101	1.066	.288
	preClinicGrade	-.011	.005	-.207	-2.157	.033

a. Dependent Variable: Clinical Board P/F

References:

[1]. Al-Johany, S., AlShaafi, M., Alshahrani, F., Alazmah, A., Aldhuwayhi, S., & Almaflehi, N. (2011) Correlation between handwriting, drawing skills, and dental skills of junior dental students. J Contemp Dent Pract , 12, 327-332.

[2]. American Dental Association Survey Center, 2010-2011 Survey of Dental Education.

[3]. American Educational Research Association (AERA), American Psychological Association (APA), & National Council on Measurement in Education (NCME). (1999). Standards for education and psychological testing. Washington, DC: American Educational Research Association.

[4]. Ashendorf, L., Vanderslice-Barr, J.L. & McCaffrey, R.J. (2009). Motor Test and Cognition in Healthy Older Adults. Applied Neuropsychology, 16, 171-176.

[5]. Austin, L.D. (2011). Predicting national dental hygiene board examiniation success based on specific admission factors. Journal of Dental hyiene, 85, 335-339.

[6]. Bauchmoyer, S. M., Carr, M.P. & Hoberty, P.D. (2004). Predicting academic and National Board Dental Hygiene Examination performance based on academic factors. J Dent Hyg, 78, 39-45.

[7]. Bohnen, N.I., Kuwabara, H., Constatine, G.M., Mathis, C.A., & Moore, R.Y. (2007). Grooved pegboard test as a biomarker of nigrostriatal denervation in Parkinson's disease. Neuroscience Letters, 424,   185-189.

[8]. Byrden, P.J. & Roy, E.A. (2005). A new method of administering the Grooved Pegboard Test: National Performance as a function of handedness and sex. Brain and Cognition, 58, 258-268.

[9]. Chambers, D.W., & Glassman, P.(1997). A primer on compentency-based evaluation. J Dent Educ, 61(8), 651-656.

[10]. Downey, M.C., Collins, M.A., & Browning, W.D. (2004). Predictors of success in dental hygiene education: a six year review. J Dent Educ., 66, 1269-73.

[11]. Downing, S.M., & Haladyna, T.M. (2006). Handbook of Test Development, Lawrence Erlbaum Associates, Publishers, Mahwah, New Jersey.

[12]. Fleishman, E.A. (1953). A Modified Administration Procedure for the O'Connor Finger Dexterity Test. J Of Applied Psychology, 37(3), 191-194.

[13]. Forn, C., Belloch, V., Bustamamante, J.C., Garbin, G. Parcet-Ibars, M.A., Sanjaun, A., Ventura, N., & Ávila, C. (2009). A Symbol Digit Modalities Test version suitable for functional MRI Studies. Neuroscience Letters, 456, 11-14.

[14]. Gabrieli, J.D.E., (1996). Memory systems analyses of mnemonic disorders in aging and age-related Diseases. Proc. Natl. Acad. Sci. USA. 93, 13534-13540.

[15]. Gansky, S.A, Pritchard, H., Kahl, E., Mendorza, D., Bird, M., Miller, A.J. & Graham, D. (2004). Reliability and vaiildity of a manual desterity test to predict preclinical grades. J Dent Educ., 68, 985-94.

[16]. Giuliani, M. Lajolo, C., Clemente, L., Querqui, A., Viotti, R. & Miani, C.M. (2007). Is manual dexterity essential in the selection of dental students? Br Dent J., 203, 149-55.

[17]. Golderberg. A.E., Neifeld, J.P., Wolfe, L.G., & Goldbergm, S.R. (2008). Correlation of Manual Dexterity With USMLE Scores and Medical Student Class Rank. J Surgical Research, 147, 212-215.

[18]. Grooved Pegboard Test: User Instructions (2003). Lafayette,IN: Lafayette Instrument.

[19]. Hauser, A.M., & Bowen, D.M. (2009). Primer on preclinical instruction and evaluation. J Dent Educ, 73(3), 390-398.

[20]. Hines, M. & O'Connor, J. (1926). A Measure of Finger Dexterity. Personnel Journal, 4, 379-382.

[21]. Jorm, A.F., Christensen, H., Henderson, A.S., Jacomb, P.A., Korten, A.E., & Mackinnon, A. (1996). Informant Ratings on cognitive Decline of Elderly People: Relationship of Longitudinal Change on Cognitive Tests. Age and Ageing, 25, 125-129.

[22]. Kirby, T.J. (1979). Dexterity Testing and Residents' Surgical Performance. TR.AM.OPHTH.SOC., 27, 294-307.

[23]. Kløve,H. (1963). Clinical Neurosphychological Assessment 3rd Edition. Oxford University Press.

[24]. O'Connor Tweezer Dexterity Test: User Instruction. (2004). Lafayette,IN: Lafayette Instrument.

[25]. Levine, A.J., Hinkin, C.H., Miller, E/N., Becker, J.T., Selnes, O.A., & Cohen B.A. for the Multicenter AIDS Cohort Study (MACS). (2007). The generalizability of neurocognitive test/retest data derived From a nonclinical sample for detecting change among two HIV+ cohorts. J of Clinical and Experimental Neurosphychology, 29(6), 669-678.

[26]. Lezak, M. (1995). Neurosphychological Assessment 3rd Edition. Oxford University Press.

[27]. Lundergan, W.P., Soderstrom, E.J., & Chambers, D.W. (2007). Tweezer Dexterity Aptitude of Dental Students. J Dent Educ, 71(8), 1090-1097.

[28]. Morgan, S.F., & Wheelock, J. (1992). Digit Symbol and Symbol Digit Modalities Tests: Are They Directly Interchangeable? Neuropsychology, 6(4), 327-330.

[29]. Ryan, J., Stanczyk, F., Dennerstein, L., Mack, W.J., Clark, M.S., Clark, M.S.,Szoeke, C., & Henderson, V.W. (2011). Executive functions in recently postmenopausal women: Absence of strong association Serum gonadal steroids. Brain Research, 1379, 199-205.

[30]. Schmidt, B. & MacWilliams, B. (2011). Admission criteria for undergraduate nursing programs: a Systematic review. Nurse Educ, 36, 171-174.

[31]. Sheridan, L.K., Fitzgerald, H.E., Adams, K.M., Nigg, J.T., Martel, M.M., Puttler, L.I., Wong, M.M., & Zucker, R.A. (2006). Normative Symbol Digit Modalities Test Performance in a community-based sample. Archives of Clinical Neuropsychology, 21, 23-28.

[32]. Smith, A. Symbol Digit Modalities Test Manual. (9th Printing). Michigan: Western Psychological Services, 2002.

[33]. Suksudaj, N., Townsend, G.C., Kaidonis, J., Lekkas, D., & Winning, T.A. (2012). Acquiring psychomotor skills in operative dentistry: do innate ability and motivation matter? Eur J Dent Educ, 16, e187-e194.

[34]. Waldermann, B.W., Dickson, A.L., Monahan, M.C., & Kaselskis, R. (1992). The Relationship Between Intellectual Ability and Adult Performance On The Trail Making Test and The Symbol Digit Modalities Test. J Clinical Psychology, 48(3), 360-363.

[35]. Ward, S. T., Downey, M. C., Thompson, A. L., Collins, M. A. (2010). Predictors of success in dental hygiene education: a follow-up study. Journal of Dental Hygiene, 84, 24-8.

[36]. Wang, Y.C., Magasi, S.R., Bohannon, R.W., McCreath, H.E., Bubela, D.J., Gershon, R.C., & Rymer, W.Z. (2011). Assessing Dexterity Function: A Comparison of Two Alternative for the NIH Toolbox. J HAND THER, 24, 313-321.

[37]. Yancosek, K.E., & Howell, D. (2009). A Narrative Review of Dexterity Assessments. J HAND THER, 22, 258-270.

[38]. Zullo, T.G. (1971). Patterns of Perceptual Motor Skills in First and Fourth Year Dental Students. Paper Presented at the annual meeting of the American Educational Research Association, New York,Feb 1971.