Personality, learning styles and handedness

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Personality, learning styles and handedness: The use of the non-dominant hand in preclinical operative dentistry training

Abstract

This research was undertaken with the aim of using personality traits, learning styles and handedness to develop and evaluate a scale to measure a new concept in operative dentistry, symmetrization. An initial hypothesis was proposed, stating that handedness, personality trait and learning style could be used to predict symmetrization potential in the domain of operative dentistry. **Methods:** Participants completed three questionnaires: the Edinburgh handedness inventory assessment; the Keirsey Temperament Sorter-II (KTS-II); and the learning style assessment (VARK). Then, participants prepared a cavity on an artificial third molar tooth in the traditional phantom head using their non-dominant hand. For evaluation and comparison purposes, Standard Tessellation Language (STL) images were obtained from prepared teeth using a CAD/CAM scanner and then aligned against a reference 'unprepared' tooth image using a custom software developed by the authors based on the Iterative Closest Point algorithm (ICP). **Results:** Extroverts, intuitive and participants characterized as relying on their feelings were more accurate compared to introverts, sensory and toughminded participants, respectively. Extroverts were faster to complete the task compared to introverts. Participants with a preference for read/writing learning style produced more errors than any of the other groups. Handedness however did not show any significant association with performance. **Conclusions:** It was concluded that both, the Keirsey Temperament Sorter-II (KTS-II) and the learning style assessment (VARK) questionnaires possess potential as useful measures of symmetrization potential and the ability to use the non-dominant hand in operative dentistry, as well as platform for continuing research.

Keywords: Algorithm; Handedness; Personality; Operative dentistry

INTRODUCTION

Dental clinical education has undergone major changes toward a better instructional system in the past few decades and this is likely to continue to be the case as dental students now demand continuous support and expect appropriate training sessions that are tailored to fit the needs of the highly competitive dental care environment.

Awkward operative postures are a major part of dentists' everyday routine which would explain why special attention is paid to teach proper positioning and posture in the dental undergraduate curriculum.[1] Dentists, particularly the left handed, were found to have a higher risk of developing sensory and musculoskeletal problems as they are exposed to various work-related physical challenges which have been associated with the development of physical strains and psychological stresses.[2-4] Additionally, left-handed operators are more likely to develop injuries that lead them to physical deficit as compared to right-handed individuals.[5] It is seen in this sense how important the hand is to dentists from the economic point of view; an injury to the dominant hand can be detrimental to one's career. Therefore, left-handed dentists can face difficulties and sometimes uncertainties while executing their everyday clinical activities, negatively affecting treatment outcomes and representing a risk factor for musculoskeletal problems.[6]

In this sense, left-handed dental students have the stronger need and greater adaptability to learn to work with dental equipment designed for right-handed dentists using their left hands. However, in many cases, this may be at the expense of musculoskeletal complications.[6] It may have been better if this period of adaptation could be invested instead in training their right hands.[7] In doing so, as well as providing a supportive environment would help enhance the clinical potential of left-handed individuals and eliminate any discrimination and negative stereotyping.[8] Adjunctive clinical training for this ‘targeted’ group may, therefore, be viewed as an operant conditioning technique or an aid to the learning process.

In contrast to other high-skill domains (e.g. sports) dental schools do not have a tradition of testing prospective dental students for hand symmetrization that is now recognized as being important in improving high-skill task performance in terms of efficiency, quality and accuracy as well as in reducing the physical load on the dominant hand.[9] The concept of symmetrization is based on the process of equalizing the efficiency of the dominant and nondominant hands. The process itself can take place in a spontaneous, undirected manner, therefore, if the focus of symmetrization is introduced during the skill-acquiring stage, then it should employ a new method of instruction to potentially ‘able’ students.

However, a question may arise of whether it would not be beneficial to apply the process of symmetrization to all students, or at least to those who need it most, namely the left-handed students. Many left-handed students can achieve remarkable clinical skills without the need for any special or additional instructional measures.[8] This can be more fully understood if experiments exploiting such paradigm are conducted in dental schools.

Dental clinical skills can first be acquired in simulated learning environments during undergraduate dental training. Success in acquiring these skills is made up of several contributing factors, including personality traits and learning styles.[10, 11] The dental student's undergraduate grade-point average (GPA) has obvious relevance as a cognitive indicator for performance especially during the pre-clinical years of dental education.[12, 13] While during the clinical years, researchers have suggested that non-cognitive indicators, such as personality types and learning styles, better reflect performance and that there is a possible association between non-cognitive indicators and success in academic, clinical and professional education and practice.[14, 15]

In general, different personality traits are attracted differently to work environments depending on how compatible the environment is with the individual's own values and interests.[16, 17] According to that sense it would be right to say that dental students are expected to have personality traits that are different from other professional disciplines. This was not only proven to be statistically accurate,[18] but it could also be seen that students may differ in their performance throughout their dental education as a consequence of their individual personality trait.[10, 19]

Although the ability of personality variables to predict success in dental school has been of interest to dental educators and has informed the field, little has altered its learning processes and instructional methods.[12, 13] Measuring a student's 'fit' for a profession or study program is contributory to their persevering in the profession.[20] Instructors must identify students' learning style preferences and guide their students in their training to apply the right strategies to become better learners.[21, 22] Thus, non-cognitive screening of students would perhaps contribute to the identification of those who fulfil certain criteria.

An analysis of the acquired personality characteristics and skills will therefore be an integral part of the on-going attempt to more fully understand first the relationship between the structure and limits of human adaptations and the underpinning theories of learning and thereafter between personality traits, learning styles and symmetrization potential. An initial hypothesis was proposed stating that personality traits, learning styles and handedness could be used to predict symmetrization potential in the domain of operative dentistry.

In view of all the above, the aim of the work is to present: (a) the basic assumptions of a new concept in operative dentistry training (i.e. symmetrization) that is of particular interest to left-handed students, and (b) an experiment designed to aid in developing an understanding of who are (and who are not) the most eligible students.

METHODS

Experimental Design

The study protocol was approved by The Institutional Review Board (IRB) committee at Jordan University of Science and Technology. This was a laboratory-based quasi-experimental study. Participants performance on the task was assessed by examining reaction time and numbers of errors. The independent variables were handedness (right vs left), personality traits (Extroversion (E)/Introversion (I), Sensing (S)/ Intuiting (N), Thinking (T)/ Feeling (F), and Judging (J)/ Perceiving (P) as well as learning styles (visual, aural, read/write and kinesthetic).

Participants

Participants were 4^{th} year undergraduate dental students ($N = 70$). All left-handed students ($n = 36$) that fulfilled the selection criteria from one-year cohort were invited (ambidextrous students were not invited to participate). Right-handed participants ($n = 34$) were randomly selected from the same cohort and were then individually invited to participate; volunteer bias was therefore avoided. The final sample consisted of 70 students (34 right-handed and 36 left-handed).

Measures

Participants completed a series of self-reports prior to completing the task:

(1) The *Edinburgh Handedness Inventory* assessment to determine the dominant hand.[23] This instrument provides a self-reported quantitative measure of handedness.

(2) The *Keirsey Temperament Sorter-II* (KTS-II). The KTS-II instrument is a 70-item personality questionnaire that helps in identifying personality types for individuals.[24] The KTS-II had sufficiently high reliability and has been widely used.[25] There are four basic temperament pairs that describe the personality profile: Extroversion (E)/ Introversion (I), Sensing (S)/ Intuiting (N), Thinking (T)/ Feeling (F), and Judging (J)/ Perceiving (P).

(3) The *Visual Aural Read/write Kinesthetic* (VARK) learning preference questionnaire. The VARK instrument was designed to measure instructional preferences for giving and receiving information, where V is visual (prefer seeing), A is auditory (prefer hearing), R is read/write (prefer printed material), and K is kinesthetic (prefer practical experience).[26] The VARK was chosen in this study as it is a valid, reliable, and simple instrument to use.[27]

Task

Participants were asked to prepare a cavity, a common exercise in operative dentistry, on an artificial third molar tooth (Nissin Dental Prod. Inc, Tokyo, Japan) and in the traditional phantom head using their non-dominant hand. Thirty minutes prior to the experiment, participants attended a session where they received detailed instruction to ensure the correct execution of the exercise. Participants were informed that they would use their non-dominant hand to perform the exercise only after they had attended the instructional session.

Participants were instructed to follow ideal amalgam cavity preparation criteria. As for the outline, participants were asked to prepare the mesial and distal grooves with the inclusion of the mesial, central and distal pits. Ideal depth and width measurements were clearly provided (1.50 mm depth and 1.25 mm width). Extending the cavity into the secondary and developmental grooves was optional. Fulfilling the cavity convergence criterion was not requested.

Each participant performed the exercise twice with a resting period of five minutes in between. Each exercise was timed using a stopwatch. All participants used the same preparation bur (no. 330 bur, Komet, Lemgo, Germany) and were equipped with a standardized Williams graduated periodontal probe (Hu-Friedy, Chicago, IL, USA).

Evaluating performance on the task

After completing the task, the prepared teeth were collected and optically scanned using Ceramill Map400 (Amann Girrbach, Koblach, Austria). The Standard Tessellation Language (STL)images obtained from the CAD/CAM scanner were then aligned against a reference 'unprepared' tooth STL image using a custom software developed by the authors (AQ, RA & RA) (Figure 1). The alignment process is carried out by the software using an Iterative Closest Point (ICP) algorithm.[28] The alignment processes the surface information from two sets of 3D point vertices (i.e. reference tooth versus prepared tooth) to calculate the rigid body transformation using Singular Value Decomposition (SVD).[29] The ICP algorithm and the mean squared error of matching two point-sets are evaluated by measuring the 3D Euclidean distances between the closest surface points on the two images.[30] Part of the occlusal surface was excluded from the alignment calculation to prevent cavity preparation values from interfering with the initial alignment (figure 1-e).

Cavity preparations were assessed via a specially programmed algorithm software, developed by the authors, using Java Script language (software is open-source and available at https://cephcad.com/dentalign/). The software was programmed to measure cavity depth, width and extensions (mesio-distal). Measurements included three depth readings (mesial, middle and distal), two cavity isthmus width readings (mesial and distal), and two readings for the remaining tooth structure at the marginal ridge area (mesial and distal marginal ridge). The algorithm defined an error as a deviation from the ideal geometry of 0.25 mm and was given an error value of 1 for each (e.g. an error value of 1 for a cavity that is 0.25 mm short from including the mesial pit and an error value of 3 for a 2 mm wide distal cavity isthmus). The final score for each tooth was therefore calculated as the sum of the number of errors from 7 readings (figure2).

Data analysis

Data was analyzed using IBM SPSS software package for windows, version 25.0 (IBM Corp., Armonk, N.Y., USA). Firstly, to examine if there were significant differences in the reaction time and errors performed during the first and second trial, paired t-tests were conducted. Secondly, to examine the influence of the dominant hand (right vs left) and different personality traits (Extraverts vs Introverts, Sensing vs Intuitive, Thinking vs Feeling, Judging vs Perceiving) on participants performance of the task, a series of t-tests were performed for reaction time and errors performed. Finally, to examine the influence of learning style (visual, aural, read/write, kinesthetic) on participants performance on the task with regard to reaction time and errors performed, one-way analyses of variance (ANOVA) were conducted.

As there were no significant differences in errors performed in time-1 and time-2 ($p > 0.05$) and the lack of an a priori rationale for hypothesized differences between the two trials, data were averaged for error and reaction time for the two trials for subsequent analyses. Results for the average error and reaction time were descriptively analyzed and checked for normality and homoscedasticity. Assumptions of normality were met for the reaction time responses and error performed. Skewness and Kurtosis ranged from 0.63 to 0.78 and 0.58 to 1.16, for reaction time and numbers of errors performed, respectively. Additionally, the Kolmogorov-Smirnov and Shapiro-Wilk normality tests were both not significant ($p > 0.05$). Homogeneity of variance was also checked with the Levenes test which were not significant ($p > 0.05$). LSD post hoc test for the ANOVA are presented. The significance level adopted for all analyses was 5%.

RESULTS

Participants took an average of 6.87 (*SD* = 2.53) minutes to complete the task with the fastest student completing the task in 2 minutes and the slowest completing it in 14.5 minutes. The number of errors produced by students showed a broad range in variation from as low as 4 errors up to 23 errors with a mean of 10.18 (*SD* = 3.62) errors.

To examine the influence of the dominant hand (right vs left) and different personality traits (Extraverts vs Introverts, Sensory vs Intuitive, Thinking vs Feeling, Judging vs Perceiving) on participants performance of the task, a series of t-tests were performed for reaction time and errors performed. Results show (table 1) that overall extroverts were faster to complete the task compared to introverts. None of the other variables showed significant group differences with regard to time taken to complete the task. When examining group differences for errors performed (table 1), extroverts, intuitive and feeling individuals were more accurate compared to introverts, sensory and judging individuals respectively. Looking at the profile of the top performers 10% of the cohort who produced the least errors in table 2, five out of seven were left-handed. More interestingly, the only students who managed to complete the task with less than 5 errors were left-handed (table 2).

To examine the influence of learning style (visual, aural, read/write, kinesthetic) on participants performance on the task, one-way analyses of variance (ANOVA) showed that there was no effect for learning style, $F(3,69) = 0.47$, $p = 0.70$ for time taken to compete the task. There was however an effect of learning style $F(3,69) = 7.78$, $p < 0.01$ on number of errors performed. Post-hoc comparisons, show that participants with a preference for read/write learning style performed significantly more errors than any of the other groups (figure 3). No other differences between groups were found ($p > 0.05$).

DISCUSSION

Before commenting upon the findings of this work, a discussion of the rationale of this work is warranted. As there is evidence to support that dental clinical performance can be predicted by non-cognitive factors,[10, 13] we endeavored to ascertain whether there was an association between these factors and the innate skill of the non-dominant hand. However, there still may arise a question, of whether superior performance can be influenced by external factors and thus can be potentially 'engineered'.

Fine motor skills which includes bi-manual dexterity, depth perception and the ability to cope with reduced tactile feedback can be predicted during the very first training attempts.[31] These skills were found to correlate with operative skill and the ability to learn a new maneuver.[32] Hence the assumption herein that two attempts are enough to predict motor dexterity while using the non-dominant hand. A complex operative task was chosen which poses heavy demands on fine motor skills namely depth perception, and the ability to cope with reduced tactile feedback. The more complex the task, the more likely that any differences in performance will be spotted.[33]

Our hypothesis was partially confirmed, but contrary to prediction, the findings showed that symmetrization potential was not related with handedness. Better performance using the non-dominant hand was significantly associated with the personality profile and learning style but not the innate lateralization of manual dexterity. Regarding personality traits, the group with better performance and the least errors was clustered around three traits: extroversion, intuition and feeling. Students with these personality traits showed a better symmetrization potential than those with other personality traits. However, those with less symmetrization aptitude might require more training to achieve proficiency which requires consideration but goes beyond the scope of this paper. Regarding learning styles, individuals who demonstrated a preference for the read/write learning style, committed more errors compared to others with a different predominant learning style. So, it is likely that students with non-read/write learning style and a personality trait that combines extroversion, intuition and feeling can be the best candidates for symmetrization. This, however, will need a larger-scale study to confirm this preliminary finding.

Several studies, including ours, indicated that dental students are predominantly extroverted.[10, 34] We found a statistically significant relationship between increased symmetrization potential and extroversion. This coincides with researchers who found that extroversion was positively correlated with clinical performance.[10, 13, 14] Being extroverted means focusing on other people and objects and to be more open to others' thoughts.[24, 35] Extroversion contributes to student-instructor training and is fundamental in developing a successful dentistpatient relationship.[36] We also found that extroverted students were faster than introverts in performing the task. Interestingly, research has shown that extroverted students performed better in completing tasks under time pressure.[37] We believe that the level of engagement with the requested task, given the unfamiliarity that it entailed, could have potentially influenced performance on that task. This fact may explain our result that students with outgoing personalities made less errors and took less time to complete the task.

Intuitive individuals depend on inspiration, trust their hunches and value imagination. They try to change things rather than keeping them the way they are. They rely more heavily on their sixth sense and on their sense of direction.[24, 35] In contrast, feeling personality types tend to believe that any 'unfamiliar' concept can be validated whether it makes sense or not.[35] All of the above traits fall into the categories of imagination and open-mindedness and are closely related to educational advantage within a clinical skills context.[13]

Extroverted intuitive learners are action-oriented innovators that tend to be untraditional, experimental, and very open to new experiences, possibilities and challenges. Intuitive feelers (idealists) have the desire to be recognized as superior individuals making unique contributions. They listen carefully and intently to instruction because they are always motivated to succeed and have the talent for seeing how a weakness can be turned into an asset. They also tend to identify themselves as highly trained professionals.[35] These characteristics, collectively, may help enhance performance perhaps by the causal role of openness and confidence on the brain in the acquisition and the coordination of an 'unfamiliar' motor skill.[13, 38, 39] It is likely that other factors contributed to our findings, but it is certain that, in that case, those factors can still be explained within the context of the three discussed personality characteristics.

According to the theory of learning styles, students have different approaches to learning. Given a specific instruction method or environment, some students will learn more effectively than others due to their individual learning style.[40] Read/write learners prefer to see new information in writing via text. They learn new material by writing out notes in their own words or organizing tables and lists of information. This preference is confined largely to the left brain. An interesting finding in our study pertains to the significantly higher number of errors committed by the students who prefer the read/write learning style compared to that committed by students who prefer any other style. We can infer two reasons for this finding. First, the task itself was perhaps more meaningful to Aural- and kinesthetic-style learners. Second, aural-, kinesthetic-style learners may have more creative and imaginative potential than read/write-type learners, as such features are more strongly associated with the right-brain hemisphere.[41]

Even though we expected that there would be an association between handedness and task performance, we could not find any association. Our assumption, which was not borne out in this work, was based on several previous studies published in the literature indicating that left-handedness is associated with better performance in tasks that require fine motor skills,[38, 42] and that inter-hand performance differences were smaller in left-handed individuals.[43] Nevertheless, and as other researchers have suggested, it is possible for the non-dominant hand, regardless left or right, to be trained to perform as accurately as the dominant one.[44, 45]

A limitation of this study was the inability to achieve an adequate statistical power for a more detailed insight into specific personality subtypes or combinations of personality traits. An additional limitation was the use of self-reported questionnaires that are associated with subjectivity and social desirability bias. The study design focused on examining performance with the use of the non-dominant hand. It may be a good idea to have students perform the task using the dominant hand and examine how performance is affected. One strength of this study, was the fact that we were able to recruit a total of 36 left-handed students from a large single-year cohort of dental students (4th year; 364 students), a task that may be difficult or even impossible in a smaller cohort of students.

Conclusions

The read/write approach to learning, as measured with VARK, was significantly related to more errors while performing a fine motor skill in operative dentistry using the non-dominant hand. Better performance in performing the skill was significantly associated with three personality traits namely extroversion, intuition, and feeling. The extent to which each personality trait accounted for differences in performance is not clear, but the findings from this study can be taken as the basis for further reflection. The main goal of the current study was to open dialogue on an area where very little has been researched, especially via a quantitative method.

Conflict of Interest: The authors report no declarations of interest.

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TABLES

Groups	Time in minutes					Number of errors				
	N	Mean (SD)	F	t	p	N	Mean (SD)	F	t	p
Dominant Hand			0.24	1.13	0.26			0.31	-1.37	0.18
Right	34	7.20 (2.50)				34	9.61(3.65)			
Left	36	6.52 (2.54)				36	10.79 (3.53)			
Extravert Vs Introvert			1.64	-1.19	0.05			0.70	-2.70	0.00
Extroverts	40	6.36 (2.14)				40	9.22 (3.08)			
Introverts	30	7.55 (2.86)				30	11.47 (3.92)			
Sensing Vs Intuitive			0.19	-0.44	0.66			0.68	4.20	0.00
Sensory	44	6.77 (2.57)				44	11.43 (3.51)			
Intuitive	26	7.05 (2.50)				26	8.06 (2.74)			
Thinking Vs Feeling			0.15	0.61	0.54			3.22	2.06	0.04
Thinking	24	7.13 (2.83)				24	11.38 (4.38)			
Feeling	46	6.74 (2.38)				46	9.55 (3.01)			
Judging Vs Perceiving			0.02	0.92	0.36			0.02	-0.69	0.49
Judging	53	7.03 (2.60)				53	10.01 (3.67)			
Perceiving	17	6.38 (2.31)				17	10.71 (3.50)			

Table 1. Descriptive data and group differences for time in minutes taken to complete the task and the number of errors performed during the task.

Dominant Hand	**Learning Style** *'Highest raw score'*	**Personality Trait**				**Time (min)**	**Average Error**
		Extrovert-Introvert	*Sensing-Intuitive*	*Thinking-Feeling*	*Judging-Perceiving*		
Left	Aural	Extrovert	Intuitive	Feeling	Judging	5.50	**4.00**
Left	Kinesthetic	Introvert	Intuitive	Thinking	Judging	5.00	**4.30**
Left	Kinesthetic	Introvert	Intuitive	Feeling	Judging	9.00	**4.34**
Left	Aural	Extrovert	Intuitive	Feeling	*Perceiving*	11.00	**5.10**
Left	Aural	Extrovert	Sensing	Feeling	*Perceiving*	9.50	**5.30**
Right	Aural	Extrovert	Intuitive	Thinking	Judging	4.38	**5.50**
Right	Kinesthetic	Extrovert	Sensing	Feeling	Judging	3.88	**5.60**

Table 2. The top 10% performing students' dominant hand, learning style, personality trait, time taken to complete the task, and number of errors.

FIGURE LEGENDS

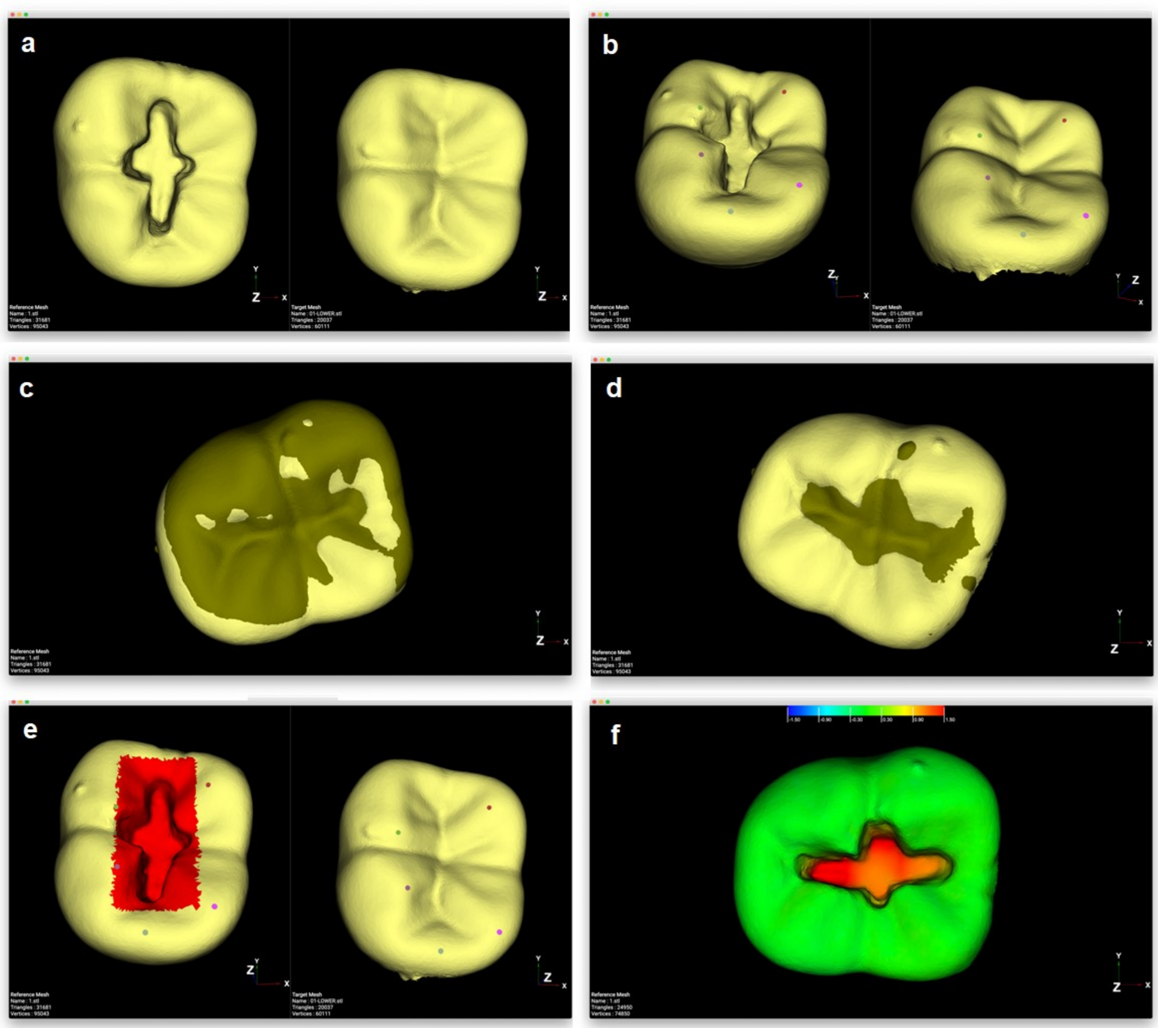

Figure 1. (a) Prepared- and reference-tooth Standard Tessellation Language (STL) images loaded using the custom software. **(b)** The initial registration was performed by selecting feature points (e.g. cusp tips) for both images. **(c)** The models were aligned using rigid body transformation (i.e. Singular Value Decomposition (SVD) technique). **(d)** Point-based registration was performed with an Iterative Closest Point (ICP) algorithm. **(e)** Measuring the 3D Euclidean distances between the closest surface points on the two images; with the area of concern being selected before running the algorithm. **(f)** The differences between the two images were evaluated using color-mapping methods.

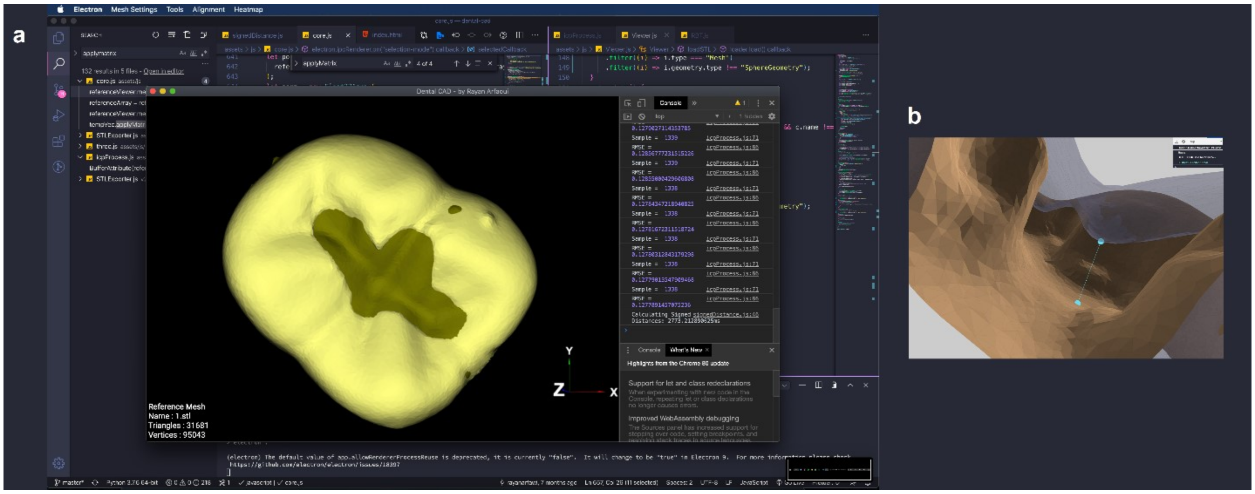

Figure 2. (a) Software developed by authors to grade cavity preparations (software is open-source and available at https://cephcad.com/dentalign/). **(b)** Demonstrative image from one sample referring to the process of measuring the depth of the cavity at one location. The depth was found to be 1.08 mm.

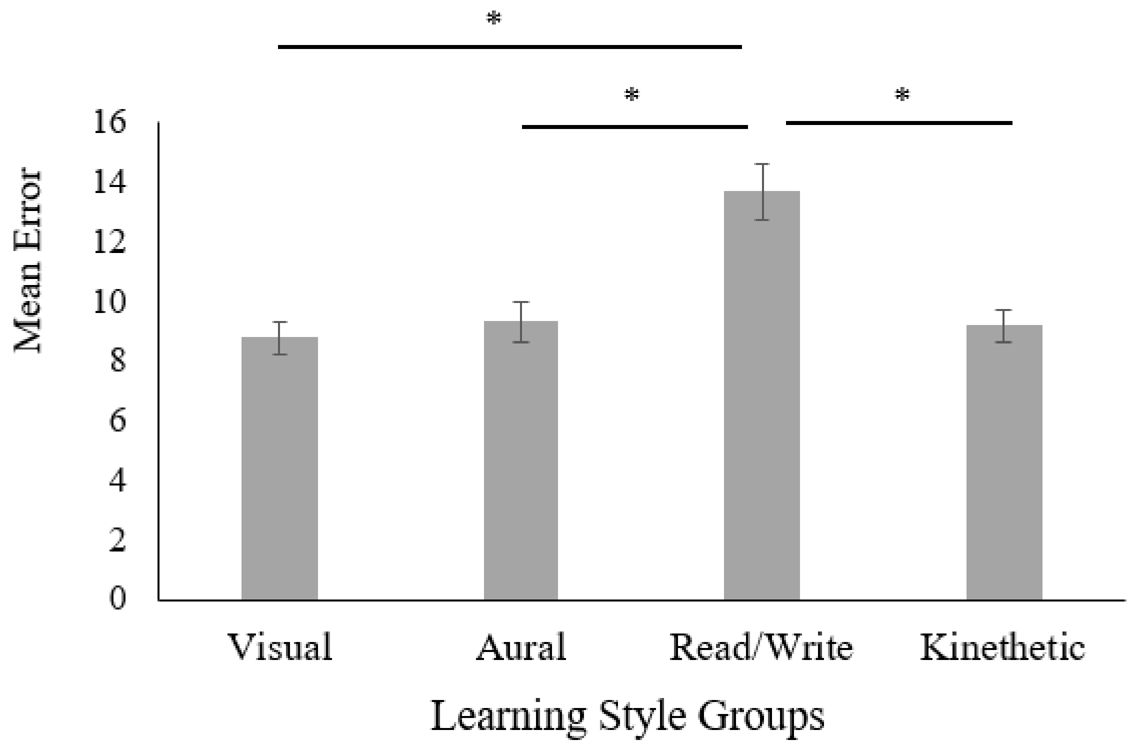

Figure 3. Mean error scores among learning style groups based on the highest raw score of the Visual Aural Read/write Kinesthetic (VARK) learning preference questionnaire. The asterisk sign (*) indicates a significant difference ($p < 0.05$).