The Validity of Cephalometric Landmark Identification on Cadavers

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ABSTRACT:

The validity of cephalometric landmark identification on cadavers

This study investigated landmark identification error in six commonly used cephalometric points on six lateral head films taken on cadavers at the Oregon Health Sciences University School of Dentistry. After initial radiographs were exposed, cadavers were dissected and implants placed at the anatomic landmarks being evaluated. Subsequent radiodraphs were taken and used for comparisons to twelve clinicians' estimates of the six landmarks on all pre-implant films.

Errors in landmark identification were assigned X, Y, and D coordinates relative to a parallel from Frankfort Horizontal. By combining all measures for a landmark and by identifying them by cadaver, scattergrams were developed which demonstrated the tracers' error from the implants as a group and by cadaver. Identification error was evaluated on the group in total, as well as, by operator experience.

Variation in the identification of landmarks was found to be affected by anatomic differences within each cadaver. As with earlier studies, no notable differences were witnessed relative to operator experience. Tracers repeated measures at least one week later on a randomly selected specimen and demonstrated no significant difference in reproducibility over time, again, supporting previous authors.

Agreement with previous studies was noted as each identified landmark tended to exhibit its own characteristic envelope of error. Statistically significant differences were found in 14/18 measures between implanted landmarks and the constructed means as used in other studies. Results would suggest that using a constructed mean as the true landmark in identification studies would tend to lead to increased error associated with results relying on such method. Clinical implications to these X and Y mean differences would likely only affect ANS and B Point, but yield potential suspicion to other points not identified in this study. Absolute mean distances located from the six landmarks all demonstrated statistically and, potentially, clinically significant deviations.

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INTRODUCTION

Orthodontics depends greatly upon the use of lateral cephalometric radiographs in examining patients both diagnostically and comparatively. Since its inception into the specialty, cephalometrics has been regarded as both an art and an exacting science by various followers. Current belief is that although cephalometrics and the use of cephalometric norms appear quite technical, they are in actuality filled with diagnostic error and constraints and thus, should only be used as an aid in diagnosis and treatment planning.[1]

To date, numerous researchers have examined cephalometry and various sources of error that are associated in its uses. The most common errors cited have been in terms of projection errors, identification/tracing errors, and measurement errors.[2] Currently, measurement errors may be addressed via either repeating measurements to alleviate mistakes or using computer generated measurements from a digitizer.[3,4,5,6] Conversely, tracing errors, or errors in landmark identification, cannot be readily corrected. Tracings will vary from individual to individual based on bias and interpretation of a definition of a particular landmark.[2,5,7] Thus far, landmark identification error has been suggested to be related to several possible features:[8]

1) Curvature of the line that the landmark is located

2) Film contrast

3) Image distortion or "noise"

4) Definition of the landmark

Finally, projection errors are recognized and can be mathematically adjusted for, but commonly no such activity is utilized due to standardization of cephalometrics.[4,9,10,11]

Research in landmark identification has demonstrated that various points used in cephalometrics are harder to reproduce or concur with than others.[3,4,5,7,8,12] Thus far, all such studies have involved reproduction of landmarks on either dried skulls or on live human subjects.[3,4,5,6,7,8,12,13] Validity of dry skull research must be questioned as connective tissues, organs, and integument are not available to provide blurring and artifaction of the image.[13,14] Likewise, human subject models rely solely on a group of "tracers" to locate a landmark and simply use the group mean for the actual point when, in fact, the actual point cannot be validated.

PURPOSE

The purpose of the study was to examine cephalometric landmarks from radiographs of human cadavers to determine the accuracy of landmark identification in a group of practitioners. Each structure was evaluated for its accuracy in relation to actual vs. operator identification. Additionally, a mean value for the operators was determined to compare to the actual in an effort to check the validity of assumptions made in previous studies.[3,4,5,6,7,8,12]

REVIEW OF THE LITERATURE

History

The compiled works of B. Holly Broadbent, Sr.[15,16,17] demonstrate that he was not only one of the first orthodontists to routinely take lateral head films of his patients, but was also instrumental in presenting the idea of standardizing lateral head plates. Prior to his efforts in spreading the benefits of cephalometric radiology, orthodontists achieved only gross clinical approximations of cranial measures which were deemed of little value and fraught with error. With this newly improving science, error was not only decreased, but radiographic measurement of intracranial landmarks was now possible. In May, 1929, Broadbent presented a paper to the Eastern Associations of Angle Graduates and with the help of Allan G. Brodie, demonstrated the cephalometer and the applications of serial cephalometrics to his colleagues. In 1931, he presented his adaptation of anthropologic methods to the profession of orthodontics.

Broadbent described the use of the craniostat for dried skulls and how recording craniometric data on growing children could be of interest. To be plausible, Broadbent discussed the need for reproducibility of head plates from person to person and lab to lab. His presentation then described the importance of a central beam, a sixty inch target-to-film distance, and the mechanics of magnification all in an effort to maintain consistency and decrease production errors. Additionally, Broadbent demonstrated reproducibility of radiographs and described the first superimpositional guidelines when evaluating changes in an individual. With the advent of the Broadbent-Bolton Cephalometer the current standards for cephalometric technique were originated.

Unfortunately, clinicians of the day began utilizing this new found tool with little regard or understanding as to its potential limitations. Bjork,[2] in 1947, described three potential sources for discrepancy in cephalometric measurement reproducibility. First, was difference between two films of the same subject, or "projection" error. Second, was observer difference in locating landmarks and points, or "identification/tracing" error. Third, and final, was the actual difference in measuring distances between two marked points, or "measurement" error.

Smith,[18] in a review of orthodontic radiology, later classified the errors associated with cephalometric technique as projection errors, positioning errors, and observer errors. His definitions of projection error and positioning errors combined were synonymous with Bjork's definition of projection error. His definition of observer error was comparable to Bjork's identification/tracing error.

Projection Errors

As the specialty began utilizing this tool more and more, clinicians and researchers began to examine the various types of error as noted by Bjork. Twenty years after Broadbent's introduction, both Thurow[9] and Franklin[11] described to the profession the inherent problems seen with the taking of cephalograms and solutions to minimizing error caused from these items of interest. Patient positioning, enlargement error, blurring of the image (either through motion or optical blurring), and distortion were noted to comprise the error in cephalometry itself.

Head holders and clinician accuracy can tend to minimize positional considerations. Enlargement errors are usually insignificant as long as radiographs are standardized through a constant subject-to-film distance. If the operator is not standardizing, or in need of absolute measures, the angular measures will not be affected by enlargement, however, linear measures must be corrected by using scales projected onto the film. Increasing kilovoltage power and milliamperes in conjunction with intensifying screens will decrease motion blurring. Optical blurring becomes minimized with a small focal spot, long target-to-subject distance, and a short subject-to-film distance. Conversely, screens have been shown to decrease image quality due to their blurring, however, the clinical significance has been debated by McWilliam and Welander.[19] Irrespective of the screens themselves, by reducing these blurring factors Thurow stated that identification accuracy could be improved to as little as 0.5mm. Distortion, generally due to anatomic structures in different planes superimposing, cannot be readily corrected for unless right and left image midpoints are used and, thus, makes certain landmark identification more difficult.

Broadbent,[15,17] had originally proposed a target-to-film distance of sixty inches and close positioning of the film to the subject to minimize errors as noted already. Franklin[11] also suggested a target-to-film distance of at least sixty inches. Thurow,[9] however, stated more specifically that a target-to-subject distance of sixty inches and a subject-to-film distance of eight to twelve centimeters would yield enlargement of the image by five to eight percent. Horowitz and Hixon[20] concurred by noting that with the placement of the subject-to-target distance at sixty inches and the subject-to-film distance at one inch, enlargement error could be decreased to between six and seven percent.

Hatton and Grainger[10] examined error as noted in cephalometrics and noted that error exists in the technique, however, when following the standards it is generally small and consistent so, therefore, negligible.

Landmark/Tracing and Measurement Errors

As cephalometrics progressed into a "science" and became more widely used, some clinicians began evaluating patients primarily via their cephalometric numbers as it was felt it was a panacea to the specialty. Steiner,[21] in describing the fundamental advantages of cephalometrics, was one of the first to comment on the circumstantial nature of cephalometric data and that it should be used only in conjunction with other evidence to be useful.

In 1956, Hixon[1] illustrated that critically evaluating patients via cephalometric measurements alone was inappropriate. His rationale was that the cephalometric norms established by clinicians such as Downs,[22] only describe or rank a patient's measurements in relation with the population used to construct the norms. Statistically, most norms as placed forth in various analyses were derived from small samples and therefore should be applied with caution to the evaluation of patients. If not, the use of these so called norms would, in themselves, introduce a variation of measurement error. He also pointed out that norms varied as per population race, age, and sex and further caution was warranted.

Hatton and Grainger[10] also demonstrated that error does exist in tracing, and thus most assumably measurement, but that the major source of distribution variation actually came from the real differences between individuals examined. This last conclusion corroborated the ideas of Hixon in that norms derived from small samples should be suspect.

As part of his earlier work, Bjork[2] was one of the first to really examine measurement error relative to the common practices of cephalometric measures. In evaluating both angular and linear measures on lateral cephalograms, he reported errors which could be of clinical significance. Described variations ranged from 0.26 - 2.43 degrees in angular measures and 0.27 - 2.84 millimeters in linear measures.

Hixon[1] had also questioned the reliability of both identification and measurement in the "science" of cephalometry. Results of nine clinicians each tracing the head plates of three patients showed varying degree of concurrence in measurements. Variation in angular measures ranged from 1.5 - 15.0 degrees difference and millimeter measures averaged approximately 4.2mm in difference. Some error was attributed to operator-protractor misreadings and when an operator repeated measures one week later, error was found to be minimized. Of note was that any specific landmark could not be located with equal reliability between different patients. This point was also supported by Hatton and Grainger[10] who cited that the reliability of a certain landmark will vary amongst individuals due to variations amongst the population.

To minimize errors derived in measurements and superimpositions, Hixon[23] suggested marking landmarks directly on the head film by means of piercing the emulsion with a fine pin. Theoretically, by having marked a landmark permanently the clinician could be certain from where a measure was to be taken and lead to less error in an analysis. Hixon felt that when superimpositioning measures were accomplished in such a manner, that this landmark registration process was advantageous for consistency in noting growth changes.

Conversely, as witnessed by Bjork and Solow,[24] emulsion marking can lead to increases in the correlation coefficients of measurement error. They found that by marking a landmark or plane on a film or acetate and then repeating measures from it could lead to several errors in analyzing a patient's radiograph. If a landmark or plane was identified incorrectly, this methodology would tend to propagate multiple errors in measurements taken from one erroneously identified landmark. Additionally, they recommended measuring all values directly from the radiograph rather than using additive/subtractive measures for achieving values such as the ANB angle. Their results showed inconsistency in trials where methods of indirect measure were accomplished. An indirect measurement method would tend to multiply error should one of the landmarks or initial measures be misrepresented.

Carrying some of these preliminary ideas forward, Richardson[7] evaluated identification variation in thirteen landmarks/points and nine planes on cephalograms of ten patients. He found, that depending on the point examined, the tendency was for certain landmarks to be more reproducible vertically than horizontally and vice versa. This idea has been graphically demonstrated and described as an envelope or an ellipse. Many other authors have validated these early landmark identification concepts over a span of numerous years.[3-6,8,12,13,20] van der Linden[13] found that not all landmarks were located with the same ease or amount of error. Examining both dried and living skulls he concluded that anatomic variation in the position of sutures and other landmark structures caused variation in image projection with wide variation of where structures may actually be located.

Additionally, Richardson's[7] observations cited that inter-observer measurement comparison varied with greater statistical significance than intra-observer comparison on repeated measures. Stabrun and Danielsen[5] also evaluated the intra-observer and inter-observer error witnessed in landmark identification. Like Richardson, they too noted a higher correlation in intra-observer registrations than inter-observer. Of interest was that despite a session to standardize methods with each observer, they noted variation in landmark definition between tracers which contributed to their reported identification error. Although repeated measures after an interval were not significantly different from first measures, a recommendation to repeat measures anyway after a time period was presented as a method to possibly decrease aberrant gross error caused by an isolated landmark misidentification.

Contrary to Richardson's and Stabrun and Danielsen's work, Midtgard, Bjork, and Linder-Aronson[25] related no significant differences between intra-observer and inter-observer landmark identification. They did, however, corroborate these other works when they noted no significant difference in repeated measures in identification accomplished one month later.

Work by Savage, Showfety, and Yancey[26] examined landmark identification of anatomic and constructed points on cephalograms. Additionally, they evaluated the impact of repeated measures and operator experience on landmark identification. As had been shown previously, their results showed that some landmarks are more easily repeated than others and that constructed points are no more variable than anatomic points in identification. Operator experience, divided by one, two , and three or more years experience, yielded no difference as all examiners identified landmarks similarly within and between the various groups.

Baumrind and Frantz[3,4] attempted to quantify both errors in landmark identification and the effects that those errors would have on subsequent angular and linear measures. Twenty lateral head films were each traced by five operators. Results were combined and compared to a mean constructed point. The outcome of identification accuracy concluded that the magnitude of error varied depending upon the landmark being evaluated. This was later supported further by Broch, Slagsvold, and Rosler,[6] Vincent and West,[8] and Tng et al.[12] Additionally, many landmarks tended to vary either vertically or horizontally as noted both earlier[7] and later[5,8,12] by other clinicians. Landmarks located along sharp edges or folds had overall better identification than those located in a gradual curve. Thus, landmarks similar to A-point, B-point, and gonion tended to demonstrated broader variation in hypothesized location. This was supported by Midtgard, Bjork, and Linder-Aronson[25] as well as Tng et al.[12]

A corollary factor related to the sharpness of the landmark's viewed edge. Those landmarks subjected to image distortion and poor contrast were also more difficult to identify. McWilliam and Welander[19] lent support to this in discussing how rare-earth screens can significantly affect reliability of landmark identification. Their data showed that the points most affected tended to be the ones which had the lowest standard deviations in previous reliability studies. Harder to identify points, however, did not seem to be adversely affected by this blurring. Thus, their conclusions were that although landmark reliability was compromised by rare-earth screens, the error introduced was of questionable clinical significance and was outweighed by the radiation exposure decrease to the patient.

Hurlburt[27] and Kimura, Langland, and Biggerstaff[28] also researched the area of image quality as related to screen usage. Hurlburt drew conclusions that screens were useful in orthodontic cephalometrics and produced adequate landmark visualization as determined by the viewing clinicians. Kimura et al tallied parallel conclusions after rating various film/screen combinations. Both studies, however, failed to evaluate landmark identification reliability as related to screens as they both, instead, had clinicians rate landmark clarity on films. Results in each report did support screen usage to decrease radiation dosage to patients.

In evaluating the effect that identification errors had on actual measures, Baumrind and Frantz[4] found that the magnitude of error varied widely and that it was improper to treat all measures with equal reliability. They suggested that linear measures demonstrated less variability in replicated estimates than angular measures. Most interesting was that statistics suggested that a cephalometric analysis with their sixteen points would have only a forty-four percent chance of having all points accurately placed. Finally, they discussed how such a single landmark identification error was projected into, on average, at least three measurement errors in their simple analysis. This evidence supported earlier presentations by Bjork and Solow.[24]

Tng et al[12] examined the differences between mean estimated landmarks and the actual landmark on human skulls. They too found that the validity depended greatly upon the landmarks involved. Estimated landmarks were shown to vary statistically from the actual in the majority of the points examined. They also evaluated angular and linear measurement errors as related to dental and skeletal components. Specifically, their evidence suggested that measurements based on skeletal landmarks tended to be more accurate than those based solely or partially on dental landmarks. This did not hold true, however, when a compounding effect in error was seen when more than three skeletal landmarks were needed for a measure.

Studies in landmark identifications have typically been conducted on either dried skulls or patient records. Although dried skulls afford the access to landmarks, van derLinden,[13] along with Jacobson and Jacobson,[14] both discussed problems in landmark identification associated with using them. Both studies cited that using live skulls with the corresponding integuments would make landmark identification more difficult. Areas of limited transverse bony dimensions, such as A-point and ANS, were specifically referenced as having their identification accuracy being greatly reduced due to overlying soft tissues. This problem, as noted, prompted both authors to either propose an alternative point or suggest a method for extrapolating A-point when its whereabouts was in question.

Similar remarks regarding ANS were noted in works by Sekiguchi and Savara.[29] They related that ANS is difficult to locate anteroposteriorly for several reasons:

1) Thin boney dimension not allowing it to be thick enough to be radioopaque

2) Image of the tip not being clear enough to be distinguished from the cartilage attached anterosuperiorly to it

3) Facial soft tissue image is too obscure with the cheek image sometimes overlapping ANS

4) X-rays are sometimes cut down with a lead screen in the anterior image to produce a better soft tissue image, thereby, decreasing ANS image

Similarly, Kalafa and Kronman[30] proposed a more reliable substitution for A-point after evaluating twenty-five dried skulls and fifteen lateral cephalograms of children. Through the course of labeling, radiographing, and evaluating the area of subspinale, or A-point, as defined by Downs,[22] it was claimed that no such point actually exists. The anatomic variation witnessed from ANS to prosthion varied in that some skulls had a curvature connecting the two points while others demonstrated no such curve where A-point was defined to be. It was, thus, suggested that anatomically A-point could not be located with any great correlation and that it only existed as a distortional image produced on a radiograph. Similar remarks were later made by van der Linden.[13]

Modern Technology - Digital Aids

In 1978, Oka and Trussall[31] described the digital enhancement of the cephalogram image. Their technique was presented in an effort to better define structures and landmarks previously approximated by clinicians. The process and its potential for its speed of measurements and power of analysis was further described by Houston.[32]

Along with digital technology comes computer based measurements and a decrease in related measurement error. Digital measurement error, as reported, was less than previously described measurement error accomplished via manual data collection. In a study comparing measurement of radiographs by hand versus direct digitization, Houston[33] concluded that manual measuring was slightly less precise than computer aided measures.

As digitization has progressed, two major methods have arisen. The original method was that of directly digitizing on the radiograph. The next generation of programs has allowed for the computer to capture an image of the radiograph for digitization via a cursor on the screen. Marci and Wenzel[34] evaluated the reliability of both techniques while also examining the effects of varying radiographic quality on digitizing. Results concluded that the directly digitized cephalograms were deemed more accurate than those digitized on a captured image. Significance in variation of reliability between the two methods along the x-axis was noted, whereas, the y-axis, demonstrated no appreciable differences. Lastly, radiographic image quality was shown to have little effect in this particular study.

Proper landmark identification, as related earlier, relies on several factors. One such factor is image quality. Digitizing has allowed great improvements in this area and, with it, the potential for more accurate identification of landmarks. Studies utilizing an electronic digitizer to register landmarks, such as that by Bondevik, Rosler, and Slagsvold[35] and Broch, Slagsvold, and Rosler[6] showed digitization error of points to be less than 0.1mm.

Most recently on the horizon in cephalometric digital usage has been the automatic landmarking of points accomplished via computer based algorithms. Studies by Levy-Mandel et al,[36] Parthasarathy et al,[37] and Tong et al[38] have described computer-aided landmark digitization. Programs utilizing this technology allow for partial analysis completion based on landmarks that can currently be artificially identified. Results in comparison of human versus computer located points yielded a high degree of agreement despite varying degrees in the quality of the radiographs. Research, thus, supports the use of computer generated landmarks as they continue to develop.

MATERIALS AND METHODS

Cadavers utilized for this study were made available through the Department of Biologic Structure and Function at the Oregon Health Sciences University School of Dentistry. Limitations as to the amount of dissection possible were in place as the cadavers were being used for anatomy lab course work and structures needed for curriculum purposes could not be sacrificed. Therefore, this study limited itself to evaluating points which could be easily accessible with minimal cadaver destruction. Additionally, due to ongoing anatomy coursework and the inability to sever the specimens' head/neck from their torsos, movement of the cadavers was limited. Logistics did not permit the transportation of specimens from the laboratory to a cephalometer so all radiology was carried out with a portable X-ray unit. Finally, once the laboratory portion of this study was completed the cadavers heads were altered thereby making reexamination impossible.

All fifteen cadavers present were evaluated as to whether they met a limited number of objective criteria. First, specimens used were required to have intact head and facial structures. Next, the presence of maxillary and mandibular incisors was deemed necessary as in edentulous cadavers/persons the evaluated landmarks would be altered and different from a characteristic orthodontic population. Six cadavers were found to have met the criteria. All specimens were geriatric Caucasians; four were females, two were males.

Since the cadavers could not be moved, a portable head/film holder was fabricated from wood and metal brackets (Photos 1and 2). As specimens head dimensions varied, the right ear rod holder was made to be adjustable transversely, and both ear rods were adjustable anteroposteriorly. One ear rod was imprinted with an amalgam core at its tip and the other was outlined with a strip of 0.024" brass wire. This allowed for radiological evaluation of the centering placement of the x-ray beam. Adjacent to the left ear rod holder, a slot was left that firmly accommodated an 8"x 10" screened film cassette encased in a plastic bag.

The procedure for each specimen was identical. The head/film holder was placed under the cadaver's head (Photo 3). A carpenters level was used to level the head and holder in both transverse and A-P dimensions. A portable Philips Oralix 65 X-ray unit was placed with its target at sixty inches to the subject. A floor to ear rod measurement was made with a tape measure and double checked. This measurement was then transferred to correspond with the height at which the X-ray target was set from the floor. Again, the carpenter's level was utilized along the long cone of the unit to check for beam parallelism with the subject. Additionally, with all overhead lights extinguished, a Mag-lite focusable flashlight was centered inside the cone to visualize the projection of the beam on the subject. Light and X-ray beam paths were aimed along the ear rod axis. Lastly, a soft tissue attenuator made from radiographic screen material was taped to the barrel of the cone to provide similar profile images produced in the clinical setting (Photo 4). The net result of specimen head position, the head/film holder, and the X-ray beam positioning was to mimic the radiographic standard set by Broadbent.

After achieving initial alignment, the Lanex Regular speed film cassette was placed and a film (Kodak TMatL) exposed.[28] Immediately after exposure, each film was developed in an automatic processor to check for quality contrast, proper beam alignment, and adequate soft tissue profile. Due to the varying degrees of specimen dehydration, constant kVp, milliamperes, and time settings could not be assumed and had to be evaluated on an individual basis. Beam alignment was found to be consistently acceptable and retakes were required only to adjust the attenuator or exposure settings. The process was continued until a satisfactory initial film was achieved for a specimen.

After production of an adequate pre-implant film, a minimal dissection was completed. The procedure called for incisions in soft tissue to expose the midline regions of Nasion, ANS, A-point, B-point, Pogonion, and Menton (Photo 5). After structure exposure, a Dremel with a small round bur was utilized to bore holes at the landmark points. Dental amalgam was condensed into each pit and smoothed to follow anatomic contours. Incisions were sutured to original position with 3-0 silk suture. During this landmark identification procedure, the cadaver was left in its original radiographic position. Care was given not to move the table and the head was left in the holder until completion of the final exposure. Initially, maxillary and mandibular central incisor tips were to be evaluated in conjunction with the other landmarks, however, cadaver stabilization and mandibular position could not be guaranteed with the amount of manipulation required to access the incisal edges in the specimens' state of rigor mortis. All attempts were made to minimize the incorporation of projection error which would alter the results in examining landmark identification error.

The X-ray unit was similarly left undisturbed during landmark identification. Once the dissection was completed, unit, beam, head, and, table position were all double checked for original position. A post-implant film was then exposed on the previously determined setting and processed. Ear rod marker locations were evaluated on the post-implant film for comparison to the pre-implant film to ascertain if any cadaver repositioning had occurred during dissection. All ear rod positioning suggested that little, if any, repositioning occurred.

Upon collection of all lateral head films, all radiographs were indexed for superimpositioning. Each set of pre- and post-implant exposure radiographs were superimposed and joined with adhesive tape. The sets were then placed under a 10"x12" sheet of 4.5mm Acrylite plastic and pin indexed (Photos 6 & 7) with fiducial points in all four corners at a known distance as described by McWilliam.[39]

Eight orthodontic residents, four with two years tracing experience and four with one year tracing experience, and four faculty orthodontists with at least six years of tracing experience were given the six indexed pre-implant radiographs and accompanying sheets of tracing acetate. In addition, a list of landmark definitions and verbal and written instructions were distributed (Figure 1). Using a 0.5mm thickness 2H lead pencil, the four pin indexes and each landmark were identified on the appropriate acetate for each specimen. The pre-implant acetates for each specimen were then superimposed over a master acetate of each corresponding post-implant specimen. Using a Boley gauge calibrated to 0.1mm (Photo 8), each "traced" point was measured in distance from the actual dissection-identified landmark. Hypothesized points were evaluated in both direct linear measure, termed D, and along an X/Y Cartesian coordinate superimposed over each master tracing's Frankfort horizontal plane.

Measurement error was minimized by all measurements being accomplished by the same investigator. As presented by Houston,[40] investigator error was evaluated by performing repeat measures of all previously collected points on a randomly selected specimen one week later. Intra-observer error was evaluated by having all participants repeat landmark identification on a randomly selected cadaver one week later.

RESULTS

Due to a rotation of the mandible during dissection of Cadaver #6, its mandibular points (B Point, Pogonion, and Menton) were excluded from the data set as superimposition of pre- and post-implant films in this area yielded obvious error. No such error was witnessed with any other points or in any other specimens.

Measurement Error/Reproducibility

Author measurement error was deemed insignificant as 214/216 repeated measures were in the range of 0.0 - 0.3mm in absolute difference to the initial measure. The remaining two measures were related coordinates of the same measure with both exhibiting a 0.4mm in difference to the originally measured points. Mean measurement error was calculated for all points as (-0.019)mm and as 0.089mm in absolute terms.

Tracer reproducibility of points at least one week later tended to vary slightly depending on the landmark being identified. Combined mean differences between repeated and original means of X, Y, and D measurements ranged from (-0.300) - (+0.291)mm (Table 1). No statistical differences, however, were found between original and repeated tracing groups.

Anatomic Variation/Experience Differences

Statistics were compiled using a two-way analysis of variance with repeated measures. Ranges and means for each point on each cadaver were determined relative to each specific implant in overall distance and in an X and Y direction (Table 2). Variation of points due to anatomic differences between cadavers was then determined using these ranges and means. Anatomic structures were found to potentially influence landmark identification variation from cadaver to cadaver and coordinate to coordinate.

Additionally, operator tracing experience was evaluated for differences on each point for each cadaver. Results yielded no differences between experience groups for all measures except two. Mean coordinate points "B Point - X" and "B Point - Y" were determined to be of slight significant difference ($p<0.05$) between tracers with six or more years experience vs. tracers with one or two years experience in which the more experienced tracers showed greater variation. Levels of significance between experience groups were very low suggesting chance error.

Since no real differences were exhibited between experience groups for all measures, interaction plots of each coordinate measured by cadaver and group illustrate the possible anatomic influence in landmark identification (Figures 2-19). Despite the variation noted between cadaver coordinates, no significance was detected thereby allowing grouping of individual results for a composite representation (Table 3).

Landmark Identification

Variation about each identified landmark as a group was determined by using overlay scattergram plots about a Cartesian coordinate centered on the implants and using the perpendicular and parallel to Frankfort Horizontal as the reference planes. Each cadaver was labeled independently to allow for evaluation from specimen to specimen and a combined mean for all cadavers was calculated and superimposed independently. In addition, a one-sample t-test was utilized to determine if the calculated mean varied from the anatomical zero centered at the implant for each landmark (Table 4).

Nasion (Figure 20): The group means in both the X and Y coordinates demonstrated very little difference from the actual implant centers. Despite having a larger mean, the range for the X coordinate tended to be quite a bit smaller than the Y coordinate range. Cadavers #2 and #4 both demonstrated outliers in both the vertical and horizontal directions with the vertical points demonstrating proportionately larger error. Both the X and D measure means showed significance from anatomic zero.

ANS (Figure 21): The group mean for the Y coordinate demonstrated a slightly inferior position to the actual implant location whereas the X coordinate mean yielded the largest horizontal variation of the landmarks examined. Typically, ANS was identified in a position more anterior and inferior to its actual location. Greatest variation in ANS was witnessed in Cadaver #3 as all twelve identifiers placed its ANS in a grouping independent of the other specimens. By coincidence, Cadaver #3 was the specimen repeated by all tracers at a later date and the group, again, identified similar positions for ANS. Comparison of pre-implant and post-implant films for Cadaver #3 yielded a marked demarcation of nasal cartilage that appeared similar to ANS radiographically. Recalculating the X and Y means for ANS minus specimen #3 yielded similar net results but to a slightly lesser magnitude. All three coordinate measures showed statistical significance from the implants.

A Point (Figure 22): Overall, the X coordinate mean was slightly posterior to the implant while the Y coordinate mean was close to two times further away in an inferior position. Evaluating coordinate marks by cadaver demonstrated a clustering effect for this landmark. Variation, for the most part, tended to be dependent upon which cadaver was being evaluated. X means varied by cadaver, however, the standard deviations tended to be very small. Y means varied similarly, but their standard deviations tended to be much larger accounting for the greater variability of vertical identification in this landmark. Similar to Nasion, both X and D coordinates were significantly different from zero.

B Point (Figure 23): Coordinate means placed the average point at slightly anterior to the implant and greater than one and one half millimeters superior to it. The Y coordinate value for this landmark demonstrated both the largest Y-mean and greatest standard deviations in the data set for X and Y. Similar results to those seen with A Point in relation to individual cadaver scattering was witnessed. All three mean measures were significant in relation to true zero.

Pogonion (Figure 24): Pogonion means placed the average point very close to the implant site with the X coordinate slightly more affected than the Y. Overall, however, Pogonion was similar to Nasion in that its standard deviations for X were comparatively small to those demonstrated by Y. Thus, the net outcome yielded greater variability about Y. Both X and D means were found to be significantly different from center.

Menton (Figure 25): Results seen with Menton were similar to those seen with A Point but reversing X and Y coordinates. Here, the group X mean and standard deviations were largest relative to those seen with Y, and both the Y and D coordinate means were statistically significant in relation to the implants.

DISCUSSION

Error

Reproducibility of measurements for this study were found to be statistically and clinically insignificant. An absolute range of 0.0 - 0.4mm, an absolute mean error value of 0.089mm, and an overall mean error value of (-0.019)mm were witnessed on repeated measures. This error, termed measurement error, in actuality is a combination of measurement and acetate positioning utilizing the discussed pin-index system. Comparisons of error using fiducial points as reported by McWilliam,[39] who utilized a computer rather than hand measures, demonstrated a mean orientation error on the order of 0.101mm which closely approximates the mean absolute "measurement error" of the present study. Additionally, the data's range of measurement error was comparable to the 0.25mm accuracy afforded by some models of digitizers[12] and better than that previously attributed to manual measures.[26]

Intra-observer reproducibility of landmark identification by tracers yielded very few exact replications of points. No statistical differences, however, were found between original and repeated tracings. This supported the findings of Stabrun and Danielsen[5] as well as those of Richardson.[7] This data set's reproducibility was also found to more reliable than data from Houston[32] in which the same acetates were digitized twice allowing for computer measures to be repeated. For similar reported points to this study, Houston listed median errors ranging from 0.6 - 1.0mm and eightieth percentile ranges of 0.9 - 1.9mm vs. mean differences of 0.0 - 0.291mm in this study.

Experience

Although a small difference was notable on two coordinates between experience groups, no remarkable separation of groups was evident. Net results of tracer experience thus support the findings of Savage, Showfety, and Yancey[26] in that operator experience yields no major difference in landmark identification. Additionally, no significances were noted in evaluating between experience groups for intra-observer reproducibility of landmarks.

Landmark Identification

Despite differences in means and standard deviations, agreement with previous studies was noted. Each identified landmark tended to exhibit its own characteristic envelope of error as seen from earlier researchers.[3,5,6,8,41] As shown previously, points tend to be more reproducible in one direction as opposed to the other. Specifically, the present study showed that Nasion, A Point, B Point, and Pogonion are more reproducible horizontally, while ANS and Menton are more reproducible vertically.

Constructed scattergrams have been marked to demonstrate the means for each landmark. Comparisons showed closest approximation of mean to actual for Nasion, Pogonion, and Menton. ANS and B Point demonstrated the worst approximations based on means due to great variation in the X and Y directions, respectively. The A Point mean was found to be of moderate approximation compared to the others. As reported in other studies,[3,8,12] landmarks on gradual curves tended to be more difficult in assessing the proper location along the curve thereby increasing the variability and the potential for error.

Notably, standard deviations for total errors were smaller in the present study than those seen in previous reports.[3,8] Additionally, standard deviations for X and Y coordinates were considerably smaller than those reported by Baumrind and Frantz[3] and similar, yet overall slightly less than, those reported by Vincent and West.[8] A large portion of the explanation for these differences lies within the experimental design. The present study utilized mean standard deviations of the distance from constructed means to anatomic zero. These other authors utilized the standard deviation of the distance of all points to the constructed mean. Additional explanation may lay with the fact that like the latter study, this investigation utilized Frankfort as its reference plane due to its independence from the evaluated points, whereas the former used the Sella-Nasion plane.

Tng et al[12] have, to date, done the most comparable study to the present one. The results that they achieved on dried skulls shared similar X coordinate means for Nasion, Pogonion, and Menton as well as a similar Y coordinate mean for ANS. Ranges for operator identification measures were larger in the present data set for three-forths of the coordinates evaluated. For the six points evaluated in this study, they found only ANS-Y, Pogonion-X, and Menton-Y to be significant statistically. Their results did not evaluate the overall distance, D, that estimates were from zero. Speculation as to the differences between the two studies could, in part, be due to the influence of soft tissue integuments and or a difference in the reference plane utilized for measures.

The present study demonstrated variation of identified points amongst the cadavers. This supports remarks by others[1,5,10,13] who reported differences alleged to variations in anatomy of individuals. Cadaver variation was suspected to be due to several possible factors or their combinations. These included: 1) the actual anatomical variation of the structure being examined 2) artifact caused by the age of the specimens (structure calcification) vs. average orthodontic patients 3) artifact resulting from the embalming and tissue changes witnessed in the specimens vs. a live population 4) variation associated with the tracers' orientation of landmarks to a Frankfort Horizontal which they constructed vs. a Frankfort Horizontal constructed and utilized by the investigator.

Of importance from this investigation was that the actual landmarks, with soft tissue interferences, were utilized to check identification error.

Notably, tracers remarked on the difficulty in determining some of the Frontonasal sutures as related to calcification in the area. This would tend to support the larger standard deviations seen in the Y coordinate for this structure, however, the mean standard deviation found was actually smaller than the comparable study by Tng et al[12] which utilized skulls of humans aged 20-40 years old. Conversely, the general consensus amongst tracers was that, overall, ANS presented more clearly on the cadavers than in the clinical setting. Suggestive support is offered with the large X coordinate mean for ANS being combined with the relatively narrow range. Further evidence would support this as the variation of ANS as seen here was smaller than in studies utilizing live patients of younger ages.[3,8]

Since this study was based upon the known landmark rather than a constructed mean landmark as in other reports, a comparison of actual vs. the mean was possible utilizing X and Y coordinates. Additionally, using absolute distances irrespective of direction, a computed average of the distance the tracers' points were from the implant was achieved. Simple t-tests were performed comparing landmark means to the anatomically placed implant. This data demonstrated that there was statistical significance between 14/18 coordinate distances as compared to their means. The outcome demonstrated would suggest that previous landmark studies utilizing means as their zero have potentially flawed comparative points.

This study evaluated only six points as compared to the numerous ones utilized in cephalometrics that may be similarly affected. The importance of the noted differences must be weighed, however, in its relationship to clinical orthodontics. Of the X and Y points examined herein, only ANS (X coordinate) and B Point (Y coordinate) yielded means greater than 1.0mm thereby leaning towards obvious clinical implications. The results found from the absolute means (D values) of the total distances that the estimated points were away from the implants demonstrated potentially more clinical significance. Mean D values for all six landmarks ranged from 0.70 - 3.04mm in distance, and with the exception of Nasion, all estimated landmarks were greater than 1.10mm away from their respective implant.

Bjork,[2] however, related that measures on the level of 0.27-2.84mm could be of clinical significance. Given the parameters of his data 13/18 means examined here could be of clinical significance.

CONCLUSIONS

The data presented herein suggested the following:

1) No difference exists between the three experience groups relative to tracing and the landmark identification of the six points examined.

2) Anatomic points and their identification demonstrate variation depending on the individual/specimen being evaluated.

3) Anatomic landmarks, when grouped together during identification, demonstrate characteristic envelopes or ellipses for each specific landmark. Some landmarks are more reproducible vertically than horizontally and vice versa.

4) Coordinate means in X, Y, and D dimensions can vary significantly from the true anatomic landmark and therefore, caution should be employed when using them to substitute for the true landmark in identification studies.

PHOTOS, FIGURES,

&

TABLES

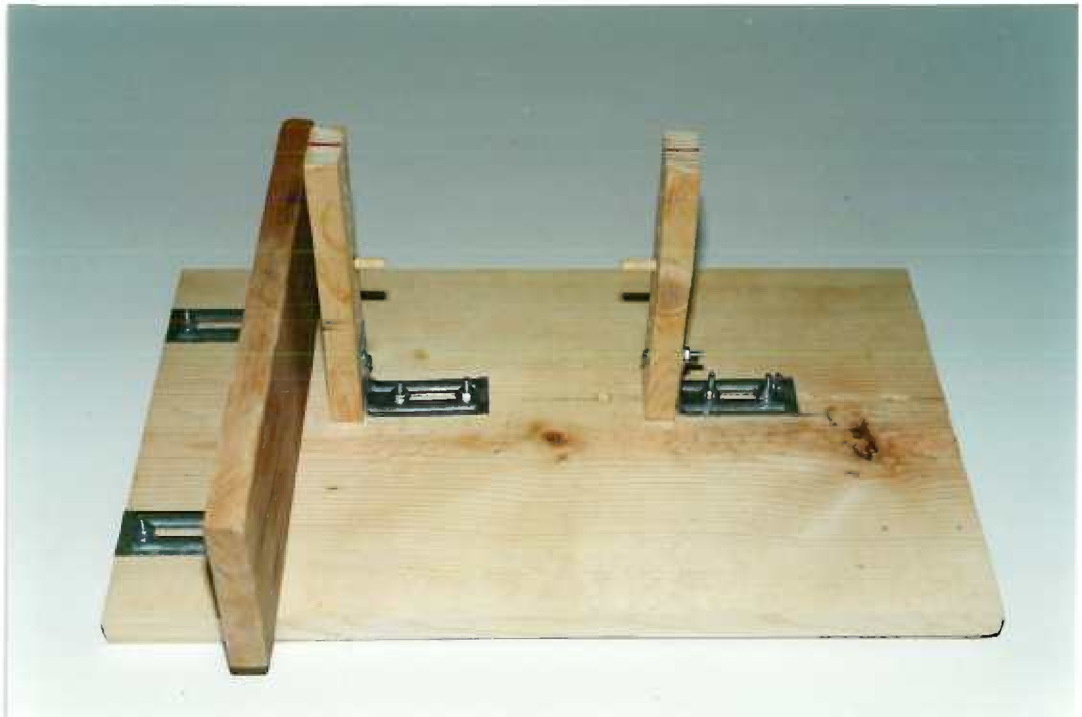


Photo 1

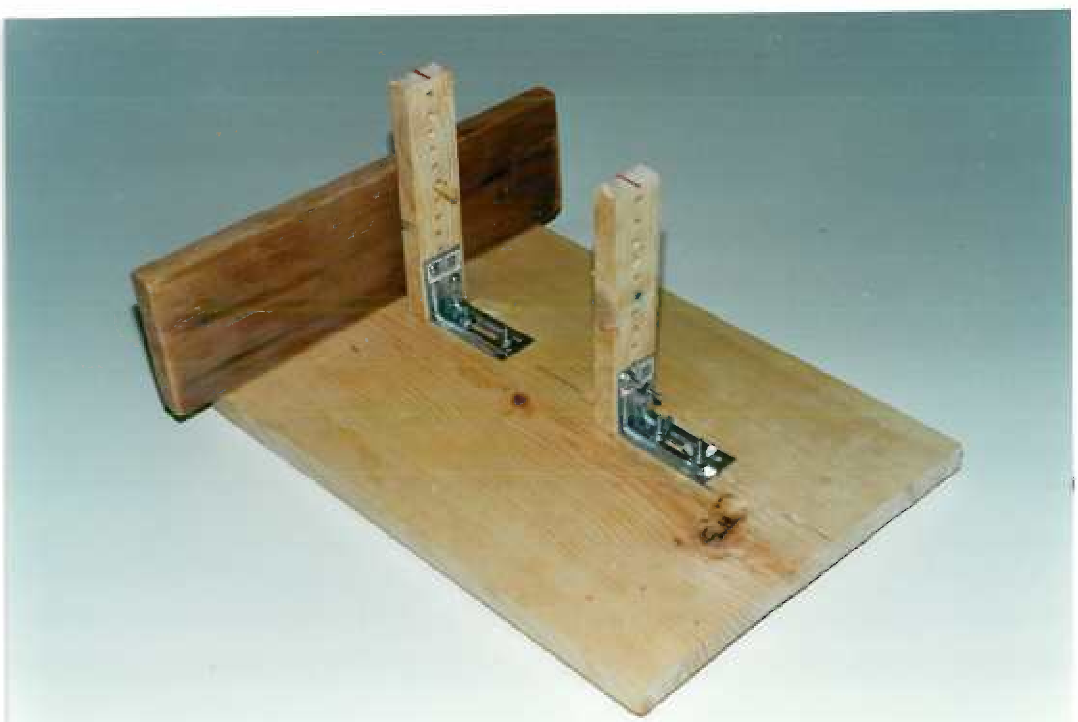


Photo 2

Photo 3

Photo 4

Photo 5

Photo 6

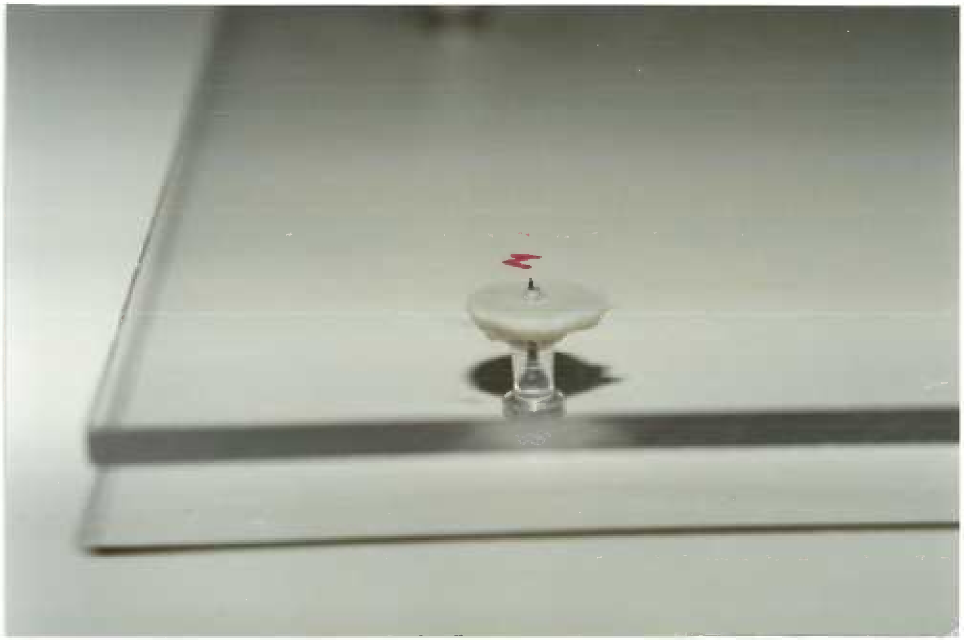


Photo 7

Photo 8

Figure 1

Definitions for Landmark Identification

Nasion: the most anterior point of the junction of the frontal and nasal bones

ANS: anterior most tip of maxilla projection at inferior base of nasal aperture

A Point: deepest point on the internal curvature between ANS and prosthion

B Point: deepest point on the internal curvature between pogonion and infradentale

Pogonion: most anterior point on the symphysis with head in Frankfort horizontal

Menton: most inferior aspect of the symphysis outline with head in Frankfort horizontal

Figure 2

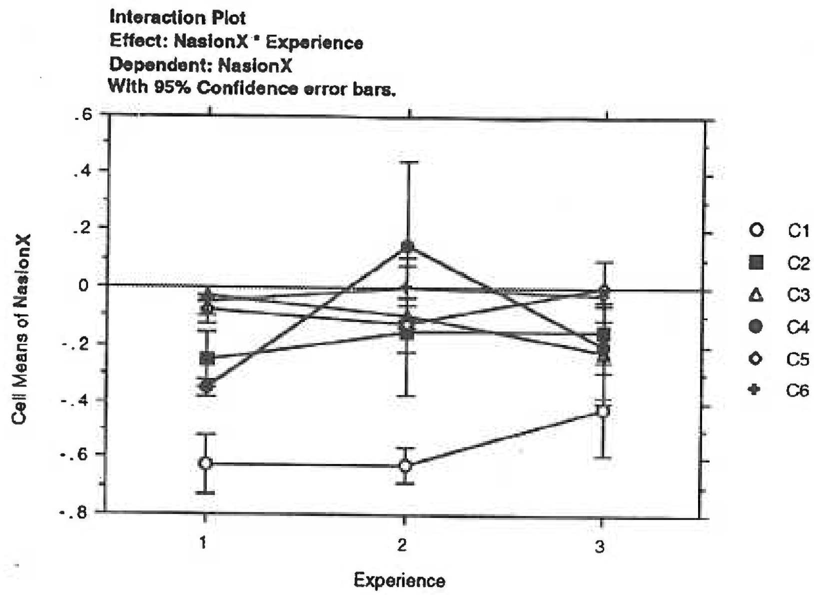


Figure 3

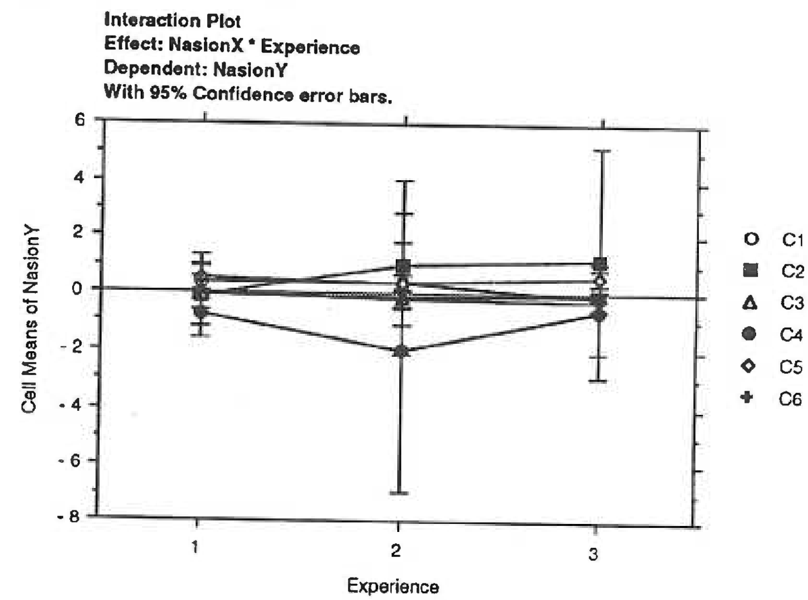


Figure 4

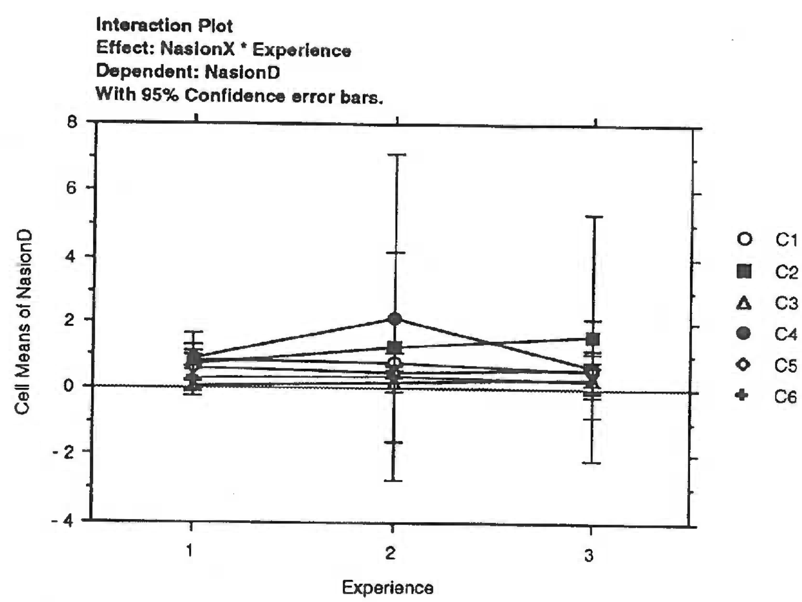
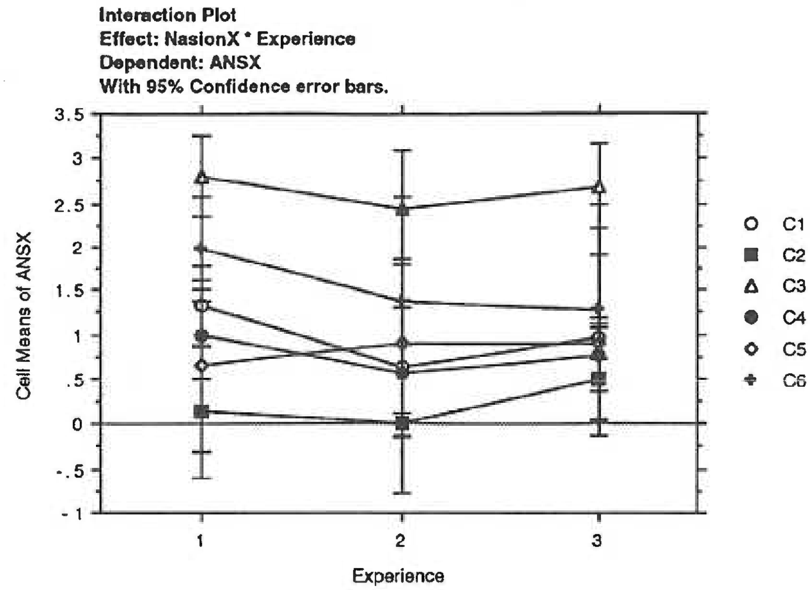


Figure 5



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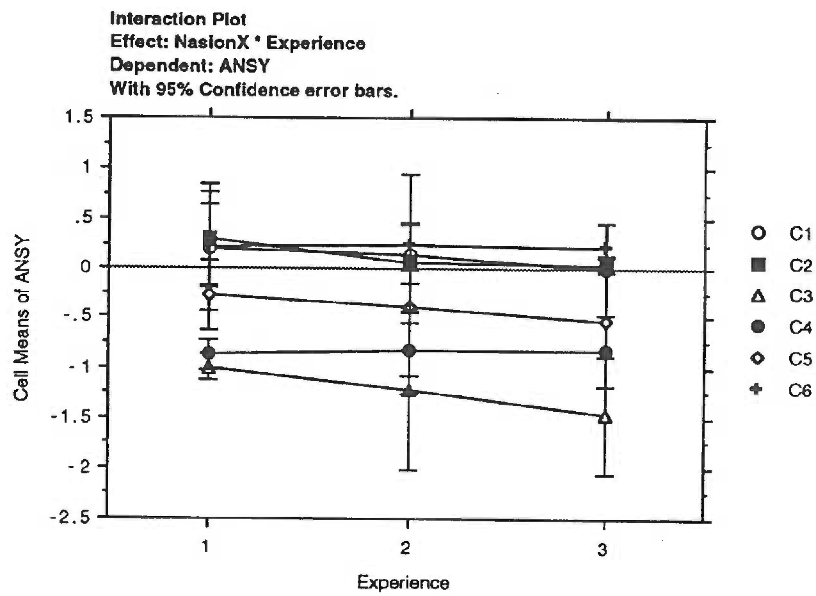

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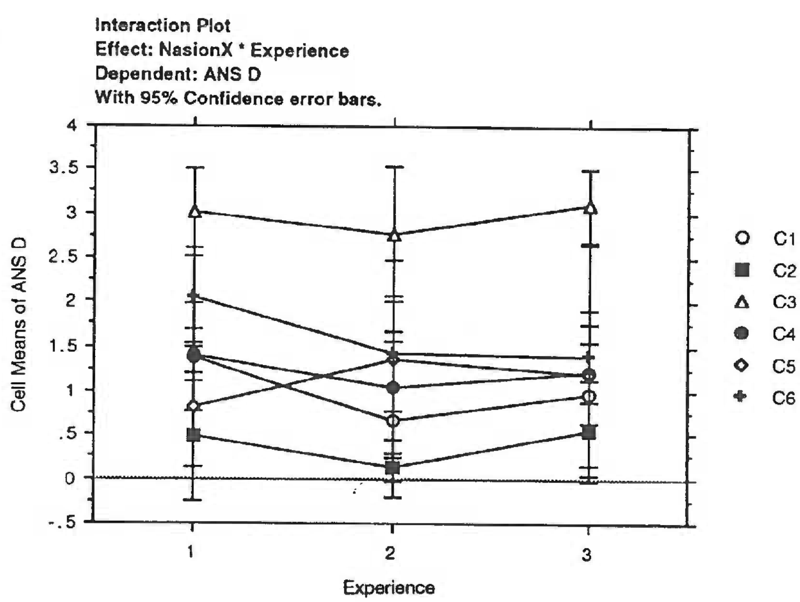

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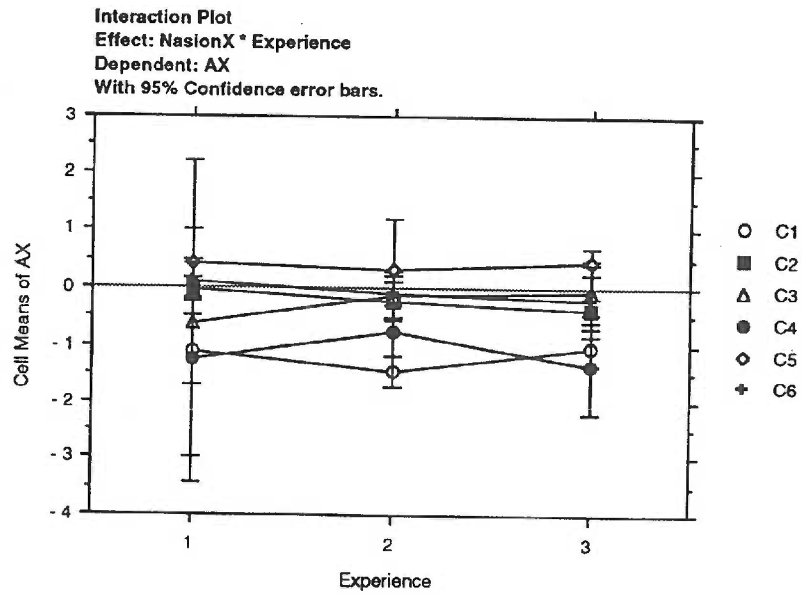

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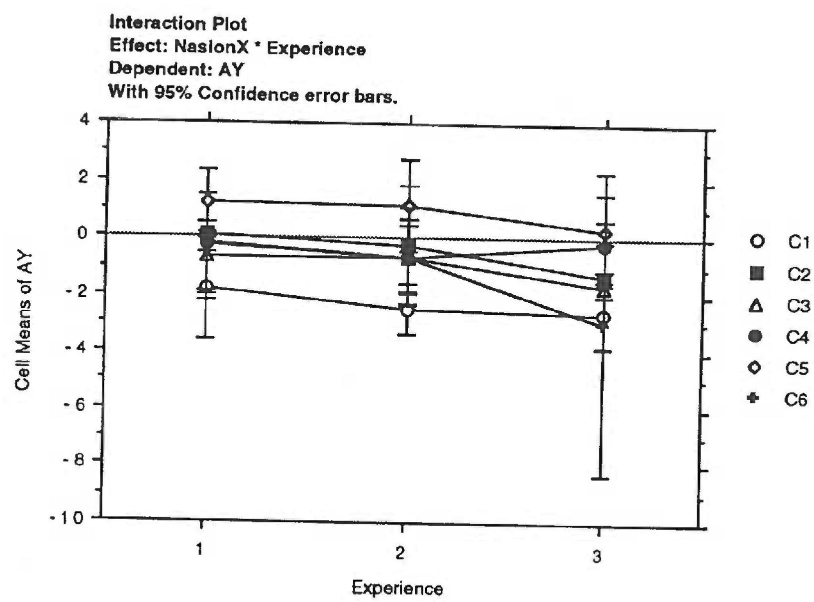

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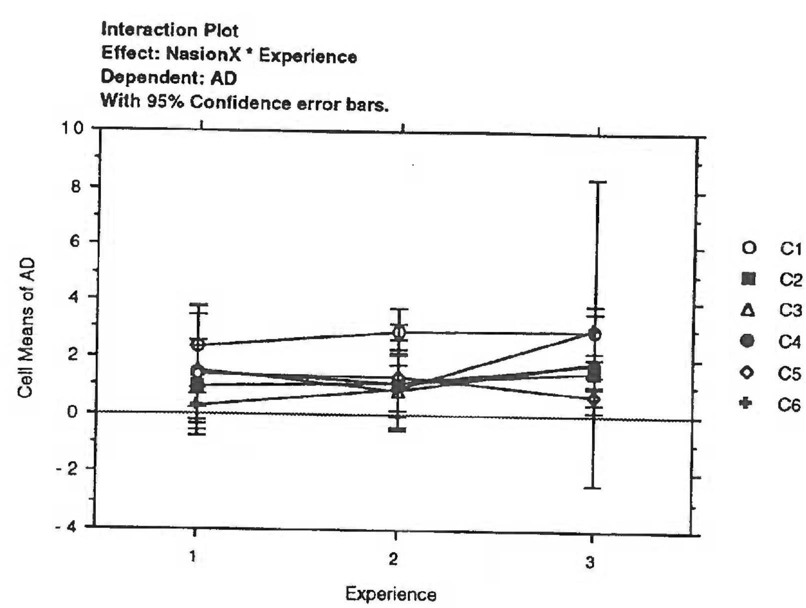

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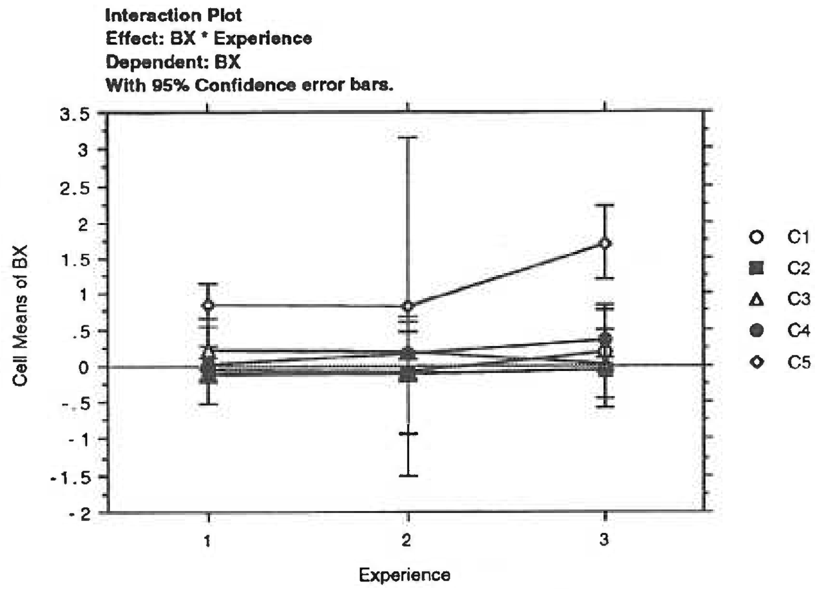

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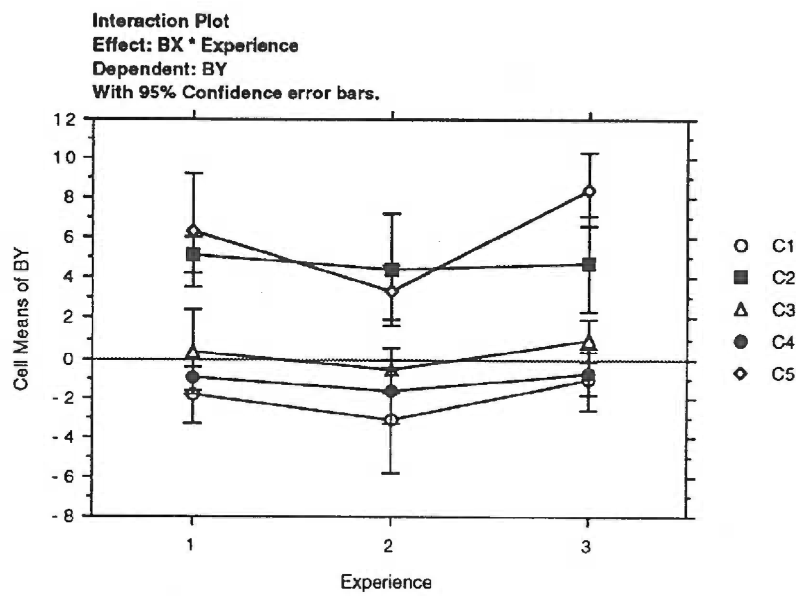

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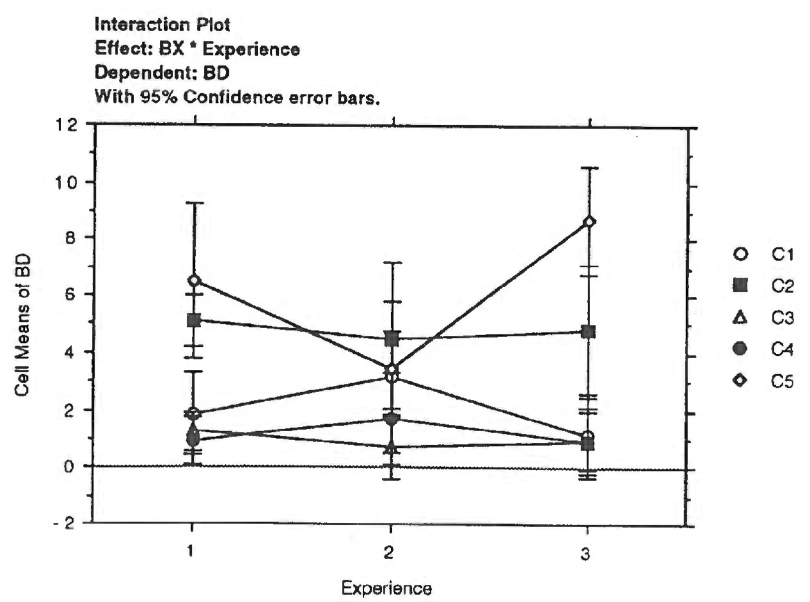


Figure 14

Interaction Plot
Effect: BX * Experience
Dependent: PogX
With 95% Confidence error bars.

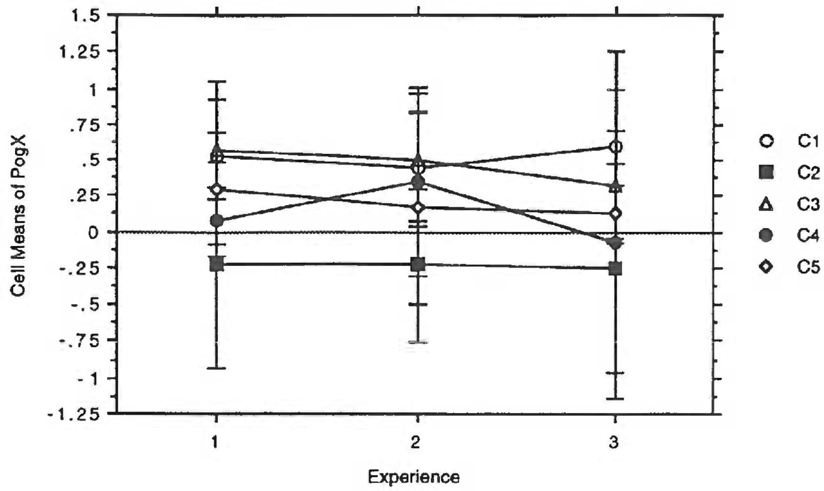


Figure 15

Interaction Plot
Effect: BX * Experience
Dependent: PogY
With 95% Confidence error bars.

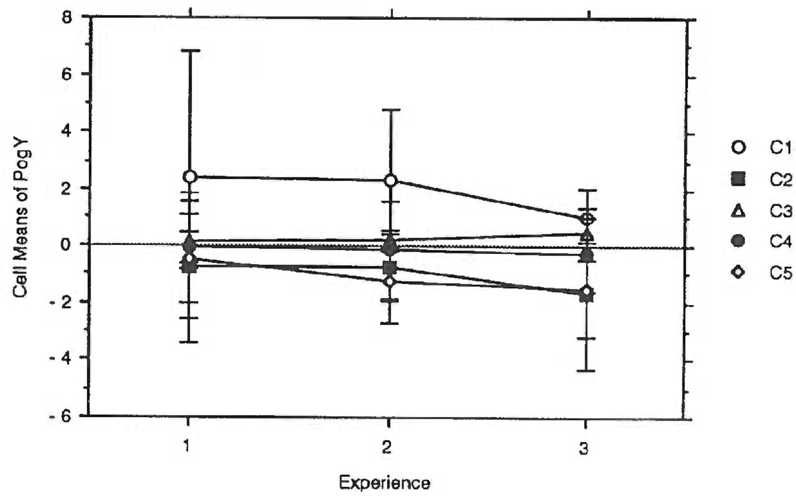


Figure 16

Interaction Plot
Effect: BX * Experience
Dependent: Pog D
With 95% Confidence error bars.

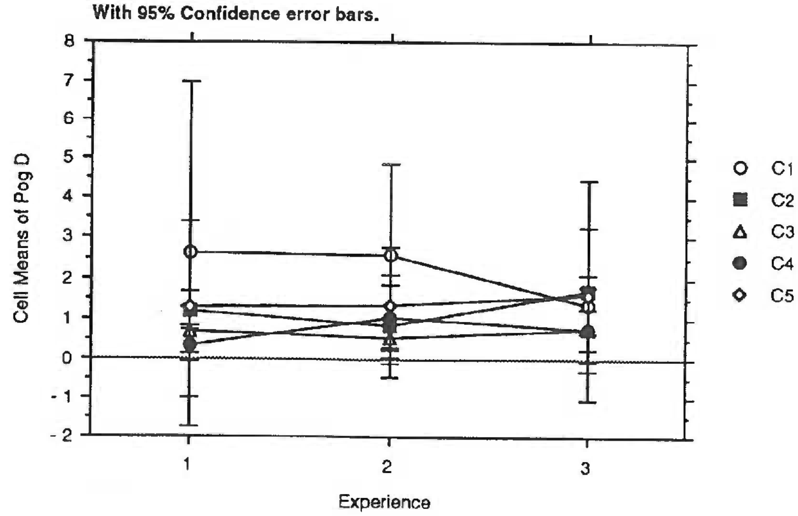


Figure 17

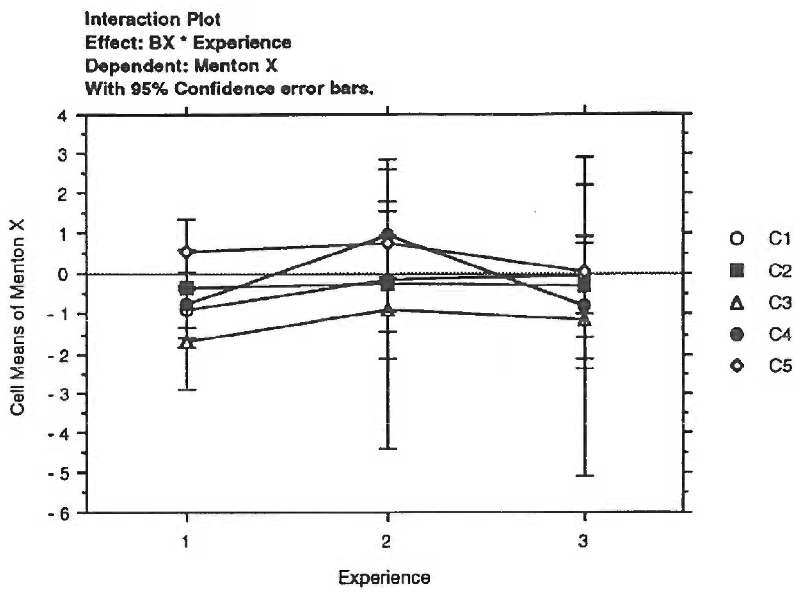
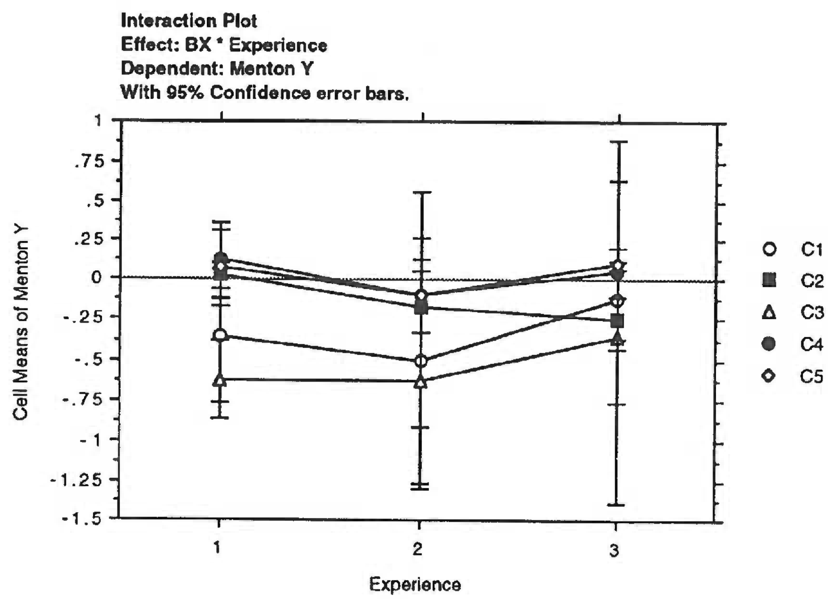


Figure 18



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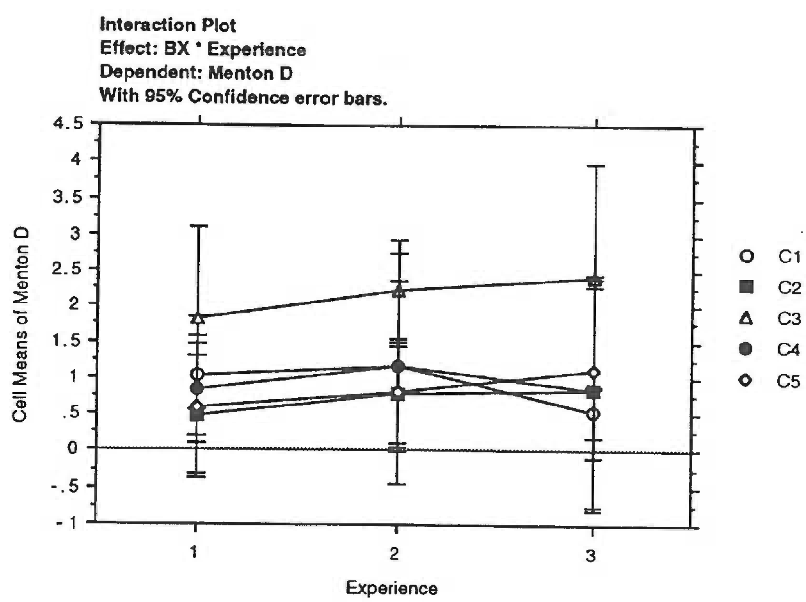


Figure 20

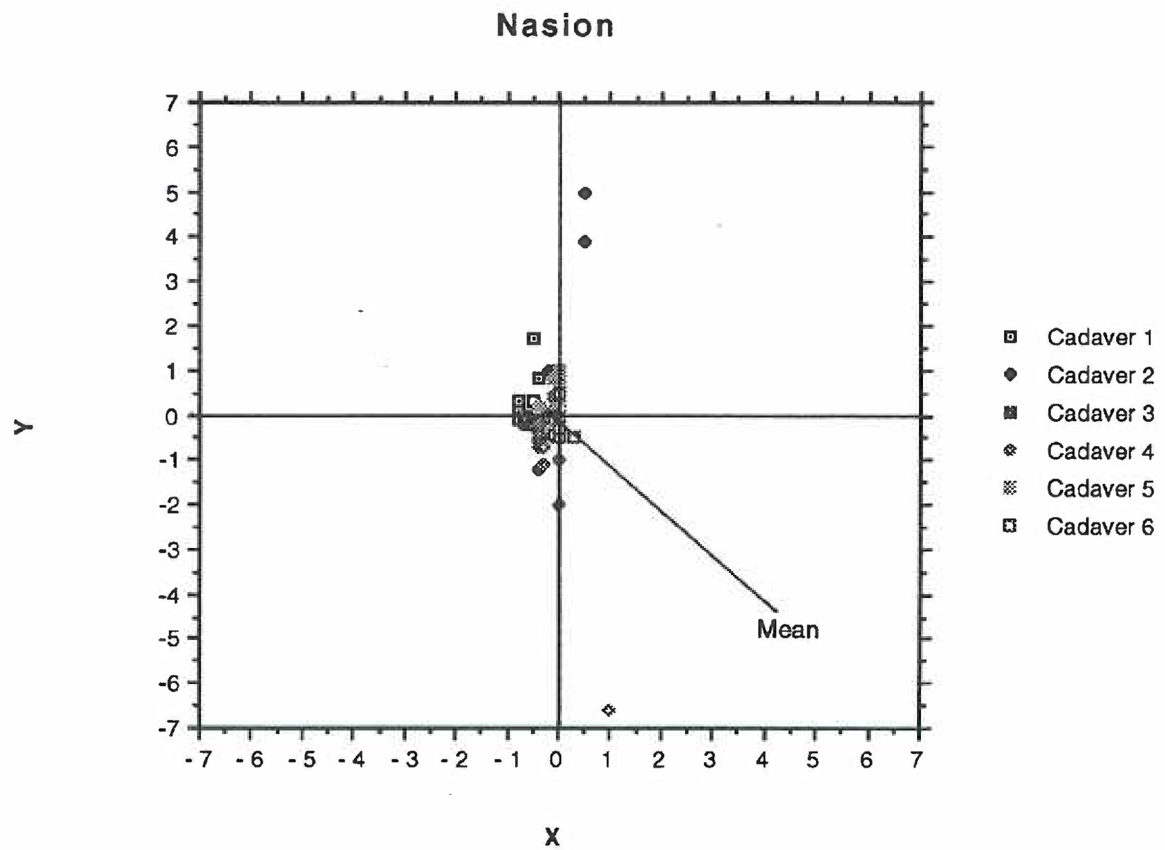


Figure 21

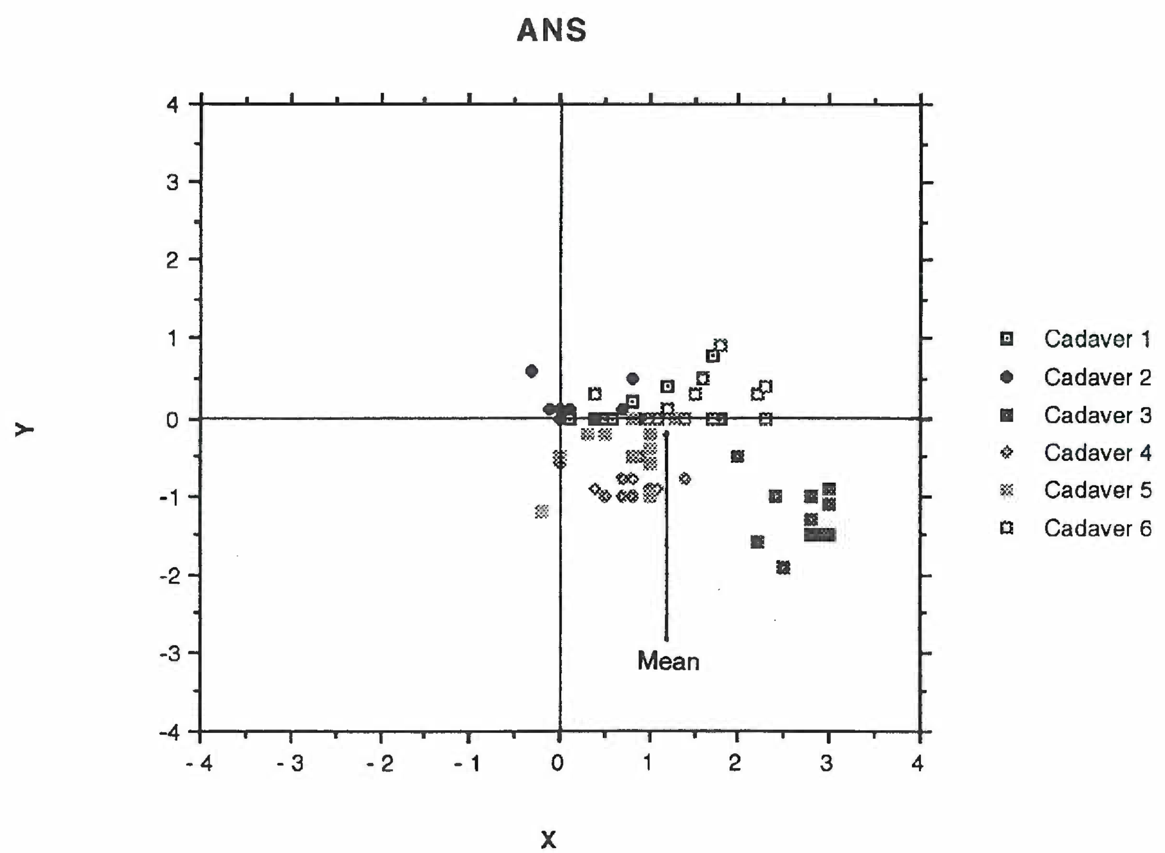
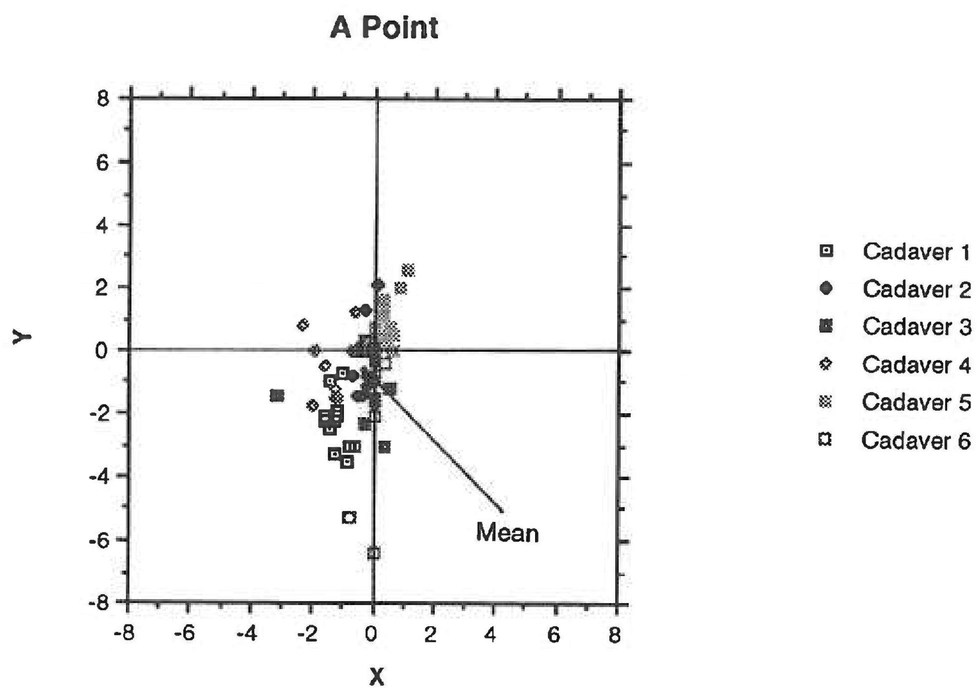


Figure 22



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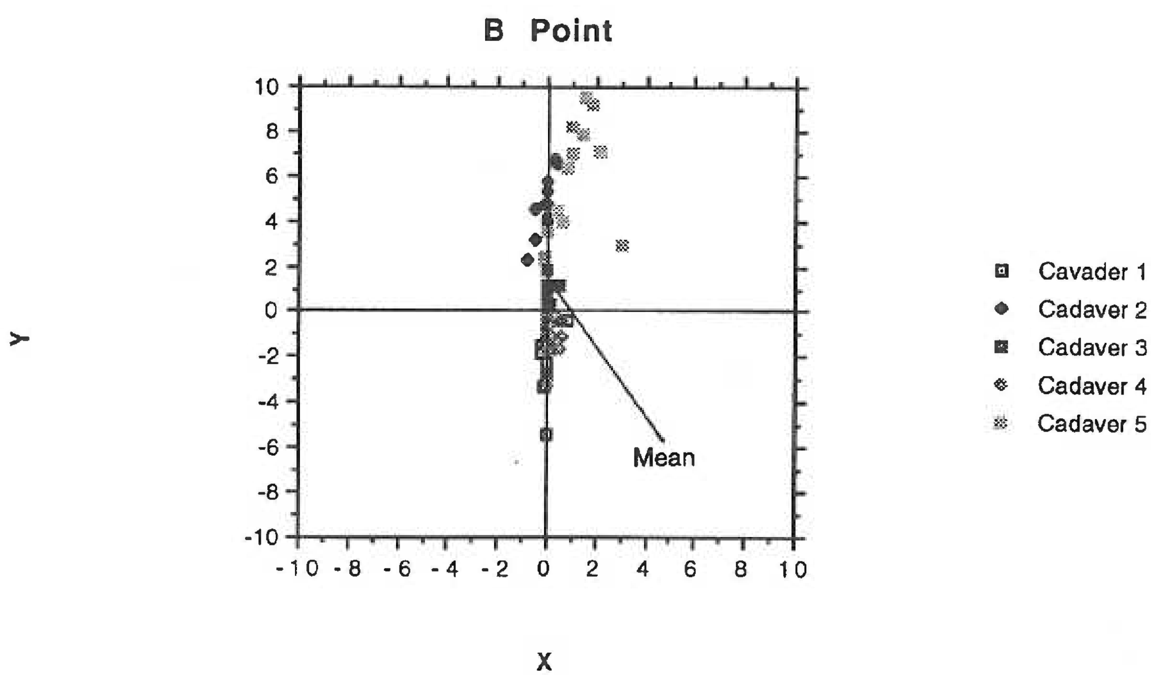

Figure 24

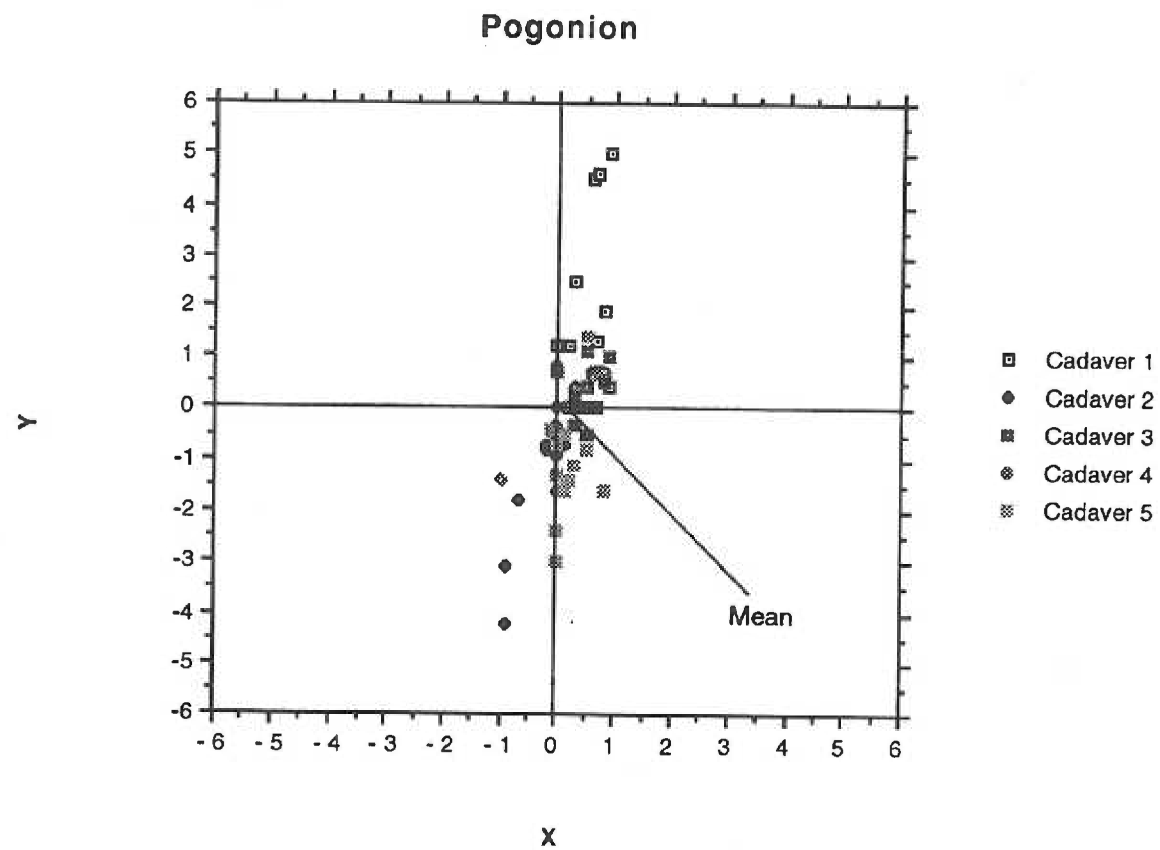

Figure 25

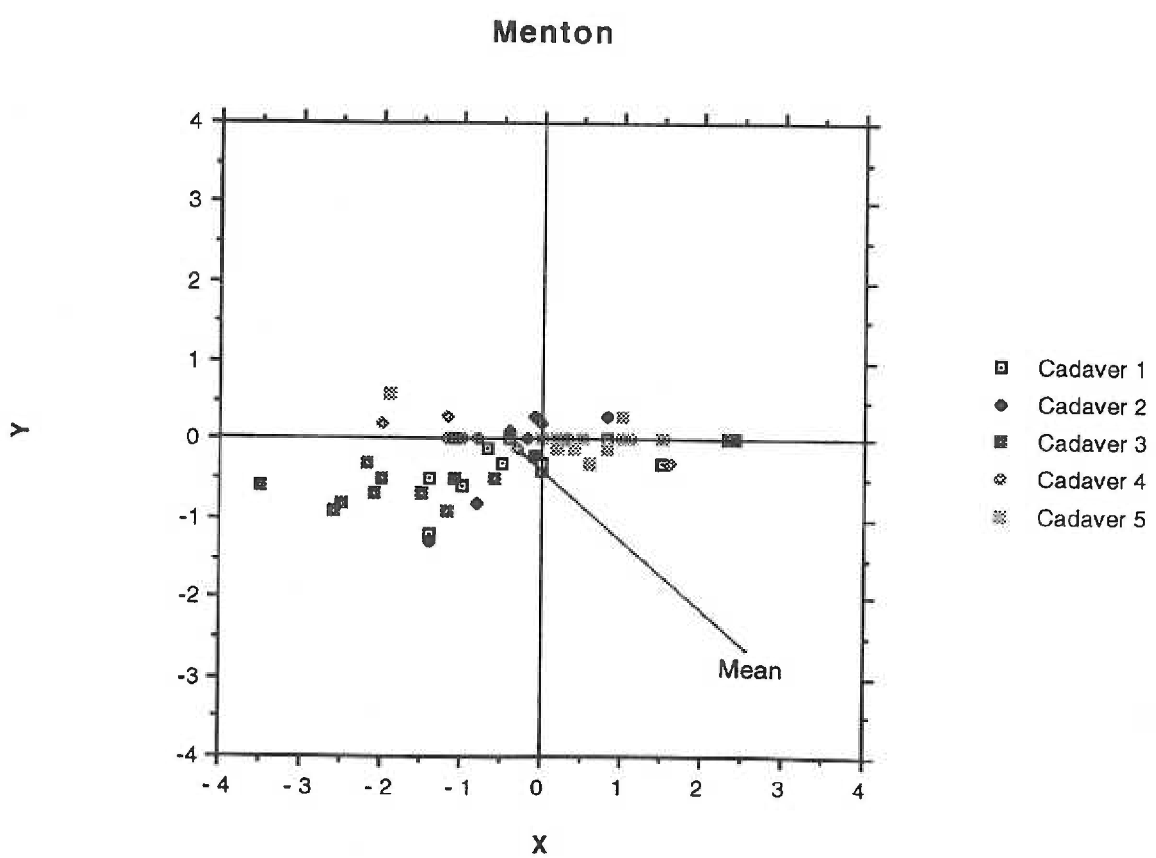

TABLE 1

Mean Comparisons on Intra-observer Reproducibility

Variable	Original Mean (mm)	Repeated Mean (mm)
Nasion X	-0.117	-0.167
Nasion Y	-0.067	-0.175
Nasion D	0.183	0.292
ANS X	2.650	2.675
ANS Y	-1.233	-1.517
ANS D	2.967	3.117
A Point X	-0.275	0.025
A Point Y	-0.992	-1.158
A Point D	1.383	1.667
B Point X	0.150	0.175
B Point Y	0.250	0.217
B Point D	0.975	1.258
Pogonion X	0.467	0.567
Pogonion Y	0.258	0.350
Pogonion D	0.667	0.958
Menton X	-1.217	-1.217
Menton Y	-0.533	-0.667
Menton D	2.158	2.208

TABLE 2

Outcome By Cadaver

Variable	Cadaver 1		Cadaver 2		Cadaver 3		Cadaver 4		Cadaver 5		Cadaver 6	
	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range
Nasion X	-0.558	-0.8-0.0	-0.183	-0.7-0.5	-0.117	-0.7-0.0	-0.133	-0.4-1.0	-0.067	-0.4-0.0	-0.025	-0.2-0.3
Nasion Y	0.183	-0.5-1.7	0.675	-1.2-5.0	-0.067	-0.4-0.1	-1.125	-6.6-0.0	0.492	0.1-1.0	-0.167	-0.5-0.5
Nasion D	0.725	0.0-1.0	1.200	0.0-5.1	0.183	0.0-0.8	1.258	0.2-6.8	0.550	0.3-1.0	0.300	0.0-0.7
ANS X	0.975	0.1-1.8	0.217	-0.3-0.9	2.650	2.0-3.0	0.783	0.0-1.4	0.817	-0.2-2.3	1.542	0.4-2.3
ANS Y	0.117	0.0-0.8	0.142	0.0-0.6	-1.233	-1.9--0.5	-0.842	-1.0--0.5	-0.400	-1.2-0.0	0.233	0.0-0.9
ANS D	1.008	0.1-1.9	0.383	0.0-1.0	2.697	2.1-3.4	1.225	0.6-1.6	1.125	0.4-2.3	1.625	0.6-2.4
A Point X	-1.192	-1.6--0.6	-0.217	-0.7-0.1	-0.275	-3.2-0.6	-1.117	-2.3-0.0	0.408	-0.1-1.1	-0.067	-0.8-0.4
A Point Y	-2.292	-3.5--0.7	-0.492	-1.7-2.1	-0.992	-3.0-0.3	-0.367	-1.8-1.2	0.892	0.0-2.6	-1.267	-6.4-0.3
A Point D	2.733	1.3-3.7	1.192	0.0-2.1	1.383	0.3-3.5	1.417	0.0-2.5	1.100	0.3-3.0	1.367	0.0-6.4
B Point X	0.025	-0.2-0.8	-0.100	-0.8-0.4	0.150	0.0-0.5	0.175	0.0-0.6	1.125	-0.1-3.0	Excluded	
B Point Y	-1.992	-5.4--0.4	4.750	2.3-6.8	0.250	-1.6-1.8	-1.117	-3.2--0.2	6.050	2.4-9.6	Excluded	
B Point D	2.025	0.5-5.4	4.792	2.5-6.8	0.975	0.1-1.8	1.192	0.2-3.2	6.208	2.4-9.9	Excluded	
Pogonion X	0.525	0.0-0.9	-0.233	-0.9-0.1	0.467	0.0-0.9	0.117	-1.0-0.8	0.200	-0.1-0.8	Excluded	
Pogonion Y	1.942	0.0-5.0	-1.067	-4.2-0.8	0.258	-0.5-1.1	-0.175	-1.6-0.7	-1.117	-3.0-1.4	Excluded	
Pogonion D	2.183	0.2-5.3	1.242	0.0-4.3	0.667	0.2-1.2	0.700	0.0-1.6	1.408	0.5-3.0	Excluded	
Menton X	-0.358	-1.4-1.5	-0.292	-1.4-0.8	-1.217	-3.5-2.4	-0.192	-2.0-2.3	0.450	-1.9-1.5	Excluded	
Menton Y	-0.325	-1.2-0.0	-0.133	-1.3-0.3	-0.533	-0.9-0.0	0.025	-0.3-0.3	0.025	-0.3-0.6	Excluded	
Menton D	0.908	0.3-2.0	0.692	0.0-2.3	2.158	0.8-3.7	0.933	0.0-2.3	0.825	0.0-2.1	Excluded	

TABLE 3

Mean Outcomes

Variable	Landmark Range (mm)	Mean (mm)	Mean Range (mm)	Mean Standard Deviation
Nasion X	-0.8 - 1.0	-0.181	-0.367 - 0.017	0.128
Nasion Y	-6.6 - 5.0	-0.001	-1.233 - 0.900	0.549
Nasion D	0.2 - 6.8	0.073	0.350 - 1.567	0.359
ANS X	-0.3 - 3.0	1.164	0.700 - 1.567	0.316
ANS Y	-1.9 - 0.9	-0.331	-0.533 - -0.150	0.151
ANS D	0.0 - 3.4	1.389	0.850 - 1.817	0.309
A Point X	-3.2 - 1.1	-0.410	-1.017 - 0.050	0.309
A Point Y	-6.4 - 2.6	-0.753	-2.367 - 0.300	0.866
A Point D	0.0 - 6.4	1.532	0.833 - 2.767	0.649
B Point X	-0.8 - 3.0	0.275	0.060 - 0.520	0.170
B Point Y	-5.4 - 9.6	1.588	0.120 - 3.100	1.055
B Point D	0.1 - 9.9	3.043	1.980 - 3.660	0.528
Pogonion X	-1.0 - 0.9	0.215	0.040 - 0.480	0.135
Pogonion Y	-4.2 - 5.0	-0.032	-1.300 - 1.480	0.820
Pogonion D	0.0 - 5.3	1.240	0.660 - 1.900	0.356
Menton X	-3.5 - 2.4	-0.322	-1.340 - 1.460	0.726
Menton Y	-1.3 - 0.6	-0.188	-0.600 - 0.000	0.161
Menton D	0.0 - 3.7	1.103	0.420 - 1.920	0.393

TABLE 4

Mean Differences From Anatomic Zero

Variable	Mean (mm)	t	P
Nasion X	-0.181	-4.89	.0005
Nasion Y	-0.001	-0.00	.9934
Nasion D	0.073	6.73	<.0001
ANS X	1.164	12.76	<.0001
ANS Y	-0.331	-7.59	<.0001
ANS D	1.389	15.56	<.0001
A Point X	-0.410	-4.59	.0008
A Point Y	-0.753	-3.01	.0118
A Point D	1.532	8.18	<.0001
B Point X	0.275	5.62	.0002
B Point Y	1.588	5.22	.0003
B Point D	3.043	19.95	<.0001
Pogonion X	0.215	5.50	.0002
Pogonion Y	-0.032	-0.13	.8960
Pogonion D	1.240	12.07	<.0001
Menton X	-0.322	-1.54	.1529
Menton Y	-0.188	-4.06	.0019
Menton D	1.103	9.72	<.0001

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APPENDICES

1. RAW SCORES
2. COORDINATE MEANS
3. MEASUREMENT ERROR DATA
4. INTRA-OBSERVER REPRODUCIBILITY DATA

APPENDIX 1

RAW SCORES

	Observer	Experience	NasionX						NasionY						Nasi		
			C1	C2	C3	C4	C5	C6	C1	C2	C3	C4	C5	C6	C1	C2	C3
Type:	String	Category	Real	Real	Real	Real	Real	Real	Real	Real	Real	Real	Real	Real	Real	Real	Real
Source:	User E...	User Ent...	User En...	User E...	User ...	User ...	User E...	User E...	User E...	User E...	User E...	User E...	User E...	User E...	User E...	User E...	User E...
Class:	Inform...	Nominal	Continu...	Contin...	Conti...	Conti...	Contin...	Contin...	Continu...	Contin...	Contin...	Contin...	Contin...	Contin...	Contin...	Contin...	Contin...
Format:	•	•	Free Fo...	Free F...	Free ...	Free ...	Free F...	Free F...	Free Fo...	Free F...	Free F...	Free F...	Free F...	Free F...	Free F...	Free F...	Free F...
Dec. Places:	•	•	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Mean:	•	•	-.558	-.183	-.117	-.133	-.067	-.025	.183	.675	-.067	-1.125	.492	-.167	.725	1.200	.183
Std. Deviation:	•	•	.235	.369	.195	.387	.123	.129	.575	1.842	.130	1.811	.257	.281	.277	1.628	.244
Std. Error:	•	•	.068	.106	.056	.112	.036	.037	.166	.532	.038	.523	.074	.081	.080	.470	.071
Variance:	•	•	.055	.136	.038	.150	.015	.017	.331	3.393	.017	3.278	.066	.079	.077	2.649	.060
Coeff. of Variation:	•	•	-42.148	-201....	-1.6...	-290...	-184....	-515....	313.627	272.889	-195.4...	-160....	52.366	-168....	38.173	135.6...	133.2...
Minimum:	•	1	-.800	-.700	-.700	-.400	-.400	-.200	-.500	-1.200	-.400	-6.600	.100	-.500	0.000	0.000	0.000
Maximum:	•	3	0.000	.500	0.000	1.000	0.000	.300	1.700	5.000	.100	0.000	1.000	.500	1.000	5.100	.800
Range:	•	2.000	.800	1.200	.700	1.400	.400	.500	2.200	6.200	.500	6.600	.900	1.000	1.000	5.100	.800
Count:	•	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
Missing Cells:	•	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sum:	•	•	-6.700	-2.200	-1.400	-1.600	-.800	-.300	2.200	8.100	-.800	-13.500	5.900	-2.000	8.700	14.400	2.200
Sum of Squares:	•	•	4.350	1.900	.580	1.860	.220	.190	4.040	42.790	.240	51.250	3.630	1.200	7.150	46.420	1.060

	Observer	Experience	NasionX						NasionY						Nasi		
			C1	C2	C3	C4	C5	C6	C1	C2	C3	C4	C5	C6	C1	C2	C3
1	MEL	3	0.000	-.100	-.100	0.000	0.000	-.100	0.000	0.000	-.100	-2.000	.300	-.400	0.000	.100	.200
2	AEG	3	-.800	-.300	0.000	-.300	0.000	0.000	.100	-.100	0.000	-.200	.500	0.000	.900	.400	0.000
3	RGK	3	-.400	-.700	-.700	-.400	0.000	0.000	-.500	-.200	-.100	-.200	1.000	-.500	.600	.800	.800
4	DLM	3	-.500	.500	-.100	-.100	0.000	0.000	-.100	5.000	.100	-.100	.500	-.100	.700	5.100	.200
5	PW	2	-.600	-.500	-.100	0.000	-.100	-.100	0.000	0.000	-.200	-1.000	.400	-.100	.600	.500	.200
6	WTM	2	-.500	.500	0.000	-.100	0.000	0.000	1.700	3.900	0.000	-.500	.600	-.300	1.000	4.000	0.000
7	DGD	2	-.600	-.400	-.200	1.000	0.000	.300	-.200	0.000	-.400	-6.600	.300	-.500	.700	.400	.500
8	FJS	2	-.800	-.200	-.100	-.300	-.400	-.200	-.100	0.000	0.000	0.000	.200	0.000	.800	.200	.100
9	JM	1	-.400	-.400	-.100	-.400	0.000	0.000	.800	-.300	-.100	-.700	.700	0.000	1.000	.500	.200
10	TWA	1	-.800	0.000	0.000	-.300	-.100	-.200	-.100	0.000	0.000	-1.100	.800	-.300	.800	0.000	0.000
11	TH	1	-.800	-.200	0.000	-.400	-.200	0.000	.300	1.000	0.000	-.400	.100	-.300	1.000	1.100	0.000
12	ALW	1	-.500	-.400	0.000	-.300	0.000	0.000	.300	-1.200	0.000	-.700	.500	.500	.600	1.300	0.000

	pnD			AX						AY						A		
	C4	C5	C6	C1	C2	C3	C4	C5	C6	C1	C2	C3	C4	C5	C6	C1	C2	C3
Type:	Real	Real	Real	Real	Real	Real	Real	Real	Real	Real	Real	Real	Real	Real	Real	Real	Real	Real
Source:	User ...	User E...	User E...	User E...	User E...	User E...	User E...	User E...	User E...	User ...	User E...	User E...	User E...	User E...	User E...	User E...	User En...	User E...
Class:	Contin...	Contin...	Contin...	Contin...	Contin...	Contin...	Contin...	Contin...	Contin...	Contin...	Contin...	Contin...	Contin...	Contin...	Contin...	Contin...	Continu...	Contin...
Format:	Free F...	Free F...	Free F...	Free F...	Free F...	Free F...	Free F...	Free F...	Free F...	Free F...	Free F...	Free F...	Free F...	Free F...	Free F...	Free F...	Free Fo...	Free F...
Dec. Places:	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Mean:	1.258	.550	.300	-1.192	-.217	-.275	-1.117	.408	-.067	-2.292	-.492	-.992	-.367	.892	-1.267	2.733	1.192	1.383
Std. Deviation:	1.828	.224	.213	.312	.248	.986	.764	.360	.277	.851	1.189	1.031	.949	.789	2.240	.702	.619	1.082
Std. Error:	.528	.065	.062	.090	.072	.285	.220	.104	.080	.246	.343	.298	.274	.228	.647	.203	.179	.312
Variance:	3.341	.050	.045	.097	.062	.973	.583	.130	.077	.724	1.414	1.063	.901	.623	5.019	.493	.383	1.171
Coeff. of Variation:	145.2...	40.656	71.067	-26.162	-114....	-358....	-68.397	88.273	-416....	-37.1...	-241....	-103....	-258....	88.495	-176....	25.697	51.910	78.213
Minimum:	.200	.300	0.000	-1.600	-.700	-3.200	-2.300	-.100	-.800	-3.500	-1.700	-3.000	-1.800	0.000	-6.400	1.300	0.000	.300
Maximum:	6.800	1.000	.700	-.600	.100	.600	0.000	1.100	.400	-.700	2.100	.300	1.200	2.600	.300	3.700	2.100	3.500
Range:	7.000	.700	.700	1.000	.800	3.800	2.300	1.200	1.200	2.800	3.800	3.300	3.000	2.600	6.700	2.400	2.100	3.200
Count:	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
Missing Cells:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sum:	15.100	6.600	3.600	-14.300	-2.600	-3.300	-13.400	4.900	-.800	-27.5...	-5.900	-11.900	-4.400	10.700	-15.200	32.800	14.300	16.600
Sum of Squares:	55.750	4.180	1.580	18.110	1.240	11.610	21.380	3.430	.900	70.990	18.450	23.490	11.520	16.390	74.460	95.080	21.250	35.840

	pnD			AX						AY						A		
	C4	C5	C6	C1	C2	C3	C4	C5	C6	C1	C2	C3	C4	C5	C6	C1	C2	C3
1	2.000	.300	.400	-1.200	-.400	0.000	-1.900	.300	0.000	-1.900	-1.400	-1.500	0.000	.500	-.100	2.300	1.500	1.500
2	.400	.500	0.000	-1.200	-.200	-.300	-.600	.400	0.000	-2.100	-1.100	.300	1.200	.200	-.100	2.700	1.100	.500
3	.500	1.000	.500	-.900	-.400	-.300	-1.600	.600	0.000	-3.500	-1.400	-2.300	-.500	.500	-6.400	3.700	1.600	2.300
4	.200	.500	.100	-.800	-.500	.400	-1.300	.600	-.800	-3.000	-1.400	-3.000	-1.500	0.000	-5.300	3.100	1.800	3.100
5	1.000	.500	.200	-1.600	-.700	-.500	-1.200	0.000	-.300	-2.100	-.800	0.000	-1.500	.700	.300	2.600	1.000	.500
6	.600	.600	.300	-1.300	0.000	-.100	-1.300	.300	0.000	-3.300	-1.700	-.900	-1.200	1.100	-2.100	3.700	1.700	.900
7	6.800	.300	.700	-1.600	-.300	0.000	-.500	1.100	0.000	-2.200	1.300	-.300	.100	2.600	-.800	2.700	1.400	.300
8	.300	.500	.200	-1.300	0.000	0.000	0.000	-.100	-.100	-2.200	.300	-1.600	0.000	.300	0.000	2.700	.300	1.600
9	.900	.700	0.000	-1.400	0.000	-3.200	-2.000	.500	0.000	-2.500	-1.000	-1.400	-1.800	.700	-.300	3.000	1.000	3.500
10	1.200	.900	.400	-.600	0.000	.600	0.000	.300	0.000	-3.000	0.000	0.000	0.000	1.600	0.000	3.200	0.000	.600
11	.600	.300	.300	-1.400	-.200	-.400	-2.300	0.000	0.000	-1.000	-.800	0.000	.800	.500	0.000	1.800	.800	.400
12	1.000	.500	.500	-1.000	.100	.500	-.700	.900	.400	-.700	2.100	-1.200	0.000	2.000	-.400	1.300	2.100	1.400

	D			BX					C6BX	BY					C6BY	BD		
	C4	C5	C6	C1	C2	C3	C4	C5		C1	C2	C3	C4	C5		C1	C2	C3
Type:	Real	Real	Real	Real	Real	Real	Real	Real	Real	Real	Real	Real	Real	Real	Real	Real	Real	Real
Source:	User E...	User ...	User E...	User E...	User E...	User E...	User E...	User E...	Use...	User E...	User E...	User E...	User E...	User E...	User...	User E...	User E...	User E...
Class:	Contin...	Contin...	Contin...	Contin...	Contin...	Contin...	Contin...	Contin...	Con...	Contin...	Continu...	Contin...	Contin...	Contin...	Cont...	Contin...	Contin...	Contin...
Format:	Free F...	Free F...	Free F...	Free F...	Free F...	Free F...	Free F...	Free F...	Fre...	Free F...	Free Fo...	Free F...	Free F...	Free F...	Free...	Free F...	Free F...	Free F...
Dec. Places:	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Mean:	1.417	1.100	1.367	.025	-.100	.150	.175	1.125	•	-1.992	4.750	.250	-1.117	6.050	•	2.050	4.792	.975
Std. Deviation:	.897	.812	2.205	.256	.341	.211	.222	.897	•	1.449	1.280	1.068	.817	2.499	•	1.411	1.237	.586
Std. Error:	.259	.235	.637	.074	.098	.061	.064	.259	•	.418	.369	.308	.236	.721	•	.407	.357	.169
Variance:	.805	.660	4.862	.066	.116	.045	.049	.804	•	2.101	1.637	1.141	.667	6.245	•	1.992	1.530	.344
Coeff. of Variation:	63.339	73.855	161.3...	1025....	-341....	140.7...	126.9...	79.696	•	-72.7...	26.938	427.253	-73.136	41.304	•	68.845	25.814	60.143
Minimum:	0.000	.300	0.000	-.200	-.800	0.000	0.000	-.100	•	-5.400	2.300	-1.600	-3.200	2.400	•	.500	2.500	.100
Maximum:	2.500	3.000	6.400	.800	.400	.500	.600	3.000	•	-.400	6.800	1.800	-.200	9.600	•	5.400	6.800	1.800
Range:	2.500	2.700	6.400	1.000	1.200	.500	.600	3.100	•	5.000	4.500	3.400	3.000	7.200	•	4.900	4.300	1.700
Count:	12	12	12	12	12	12	12	12	0	12	12	12	12	12	0	12	12	12
Missing Cells:	0	0	0	0	0	0	0	0	12	0	0	0	0	0	12	0	0	0
Sum:	17.000	13.200	16.400	.300	-1.200	1.800	2.100	13.500	•	-23.9...	57.000	3.000	-13.400	72.600	•	24.600	57.500	11.700
Sum of Squares:	32.940	21.780	75.900	.730	1.400	.760	.910	24.030	•	70.710	288.760	13.300	22.300	507.9...	•	72.340	292.3...	15.190

	D			BX					C6BX	BY					C6BY	BD		
	C4	C5	C6	C1	C2	C3	C4	C5		C1	C2	C3	C4	C5		C1	C2	C3
1	1.900	.600	.100	0.000	0.000	0.000	.500	2.100	•	-2.500	4.200	.500	-1.600	7.100	•	2.500	4.200	.500
2	1.400	.500	.100	0.000	0.000	0.000	0.000	1.400	•	-.500	4.800	1.100	-.200	7.900	•	.500	4.800	1.100
3	1.700	.900	6.400	.800	-.500	0.000	.600	1.500	•	-.400	3.200	1.800	-1.100	9.600	•	.900	3.400	1.800
4	2.000	.600	5.400	0.000	.300	.100	.300	1.800	•	-.600	6.800	.300	-.200	9.200	•	.600	6.800	.400
5	2.000	.700	.500	0.000	-.100	0.000	.400	0.000	•	-5.400	4.800	.100	-1.300	3.500	•	5.400	4.800	.100
6	1.800	1.200	2.100	0.000	.400	.300	0.000	.400	•	-2.300	6.500	-1.600	-3.200	4.400	•	2.300	6.600	1.700
7	.500	3.000	.800	-.100	-.800	0.000	0.000	3.000	•	-3.300	2.300	-.400	-1.000	3.000	•	3.400	2.500	.400
8	0.000	.300	.100	-.200	0.000	.500	.200	-.100	•	-1.500	4.000	-.400	-1.100	2.400	•	1.600	4.000	.700
9	2.500	1.000	.300	0.000	-.500	0.000	0.000	1.000	•	-1.500	4.500	.700	-.900	7.000	•	1.500	4.500	.700
10	0.000	1.700	0.000	0.000	0.000	.400	0.000	.600	•	-3.100	5.300	-1.500	-1.700	4.000	•	3.100	5.300	1.700
11	2.500	.500	0.000	0.000	0.000	.500	0.000	1.000	•	-1.000	5.800	1.200	-.500	8.200	•	1.000	5.800	1.400
12	.700	2.200	.600	-.200	0.000	0.000	.100	.800	•	-1.800	4.800	1.200	-.600	6.300	•	1.800	4.800	1.200

			C6BD	PogX					C6PogX	PogY					C6PogY	Pog D		
	C4	C5		C1	C2	C3	C4	C5		C1	C2	C3	C4	C5		C1	C2	C3
Type:	Real	Real	Real	Real	Real	Real	Real	Real	Real	Real	Real	Real	Real	Real	Real	Real	Real	Real
Source:	User E...	User E...	User...	User E...	User E...	User E...	User E...	User E...	User ...	User E...	User E...	User E...	User ...	User E...	User...	User E...	User E...	User E...
Class:	Contin...	Contin...	Cont...	Continu...	Contin...	Contin...	Contin...	Contin...	Conti...	Contin...	Contin...	Contin...	Contin...	Contin...	Cont...	Contin...	Contin...	Contin...
Format:	Free F...	Free F...	Free...	Free Fo...	Free F...	Free F...	Free F...	Free F...	Free ...	Free F...	Free F...	Free F...	Free F...	Free F...	Free...	Free F...	Free F...	Free F...
Dec. Places:	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Mean:	1.192	6.208	•	.525	-.233	.467	.117	.200	•	1.942	-1.067	.258	-.175	-1.117	•	2.183	1.242	.667
Std. Deviation:	.805	2.567	•	.308	.375	.253	.457	.273	•	1.815	1.379	.494	.752	1.099	•	1.754	1.287	.308
Std. Error:	.232	.741	•	.089	.108	.073	.132	.079	•	.524	.398	.143	.217	.317	•	.506	.372	.089
Variance:	.648	6.588	•	.095	.141	.064	.209	.075	•	3.295	1.901	.244	.566	1.207	•	3.076	1.657	.095
Coeff. of Variation:	67.557	41.343	•	58.638	-160....	54.313	391.6...	136.5...	•	93.493	-129....	191.396	-4.3E2	-98.3...	•	80.330	103.677	46.270
Minimum:	.200	2.400	•	0.000	-.900	0.000	-1.000	-.100	•	0.000	-4.200	-.500	-1.600	-3.000	•	.200	0.000	.200
Maximum:	3.200	9.900	•	.900	.100	.900	.800	.800	•	5.000	.800	1.100	.700	1.400	•	5.300	4.300	1.200
Range:	3.000	7.500	•	.900	1.000	.900	1.800	.900	•	5.000	5.000	1.600	2.300	4.400	•	5.100	4.300	1.000
Count:	12	12	0	12	12	12	12	12	0	12	12	12	12	12	0	12	12	12
Missing Cells:	0	0	12	0	0	0	0	0	12	0	0	0	0	0	12	0	0	0
Sum:	14.300	74.500	•	6.300	-2.800	5.600	1.400	2.400	•	23.300	-12.800	3.100	-2.100	-13.4...	•	26.200	14.900	8.000
Sum of Squares:	24.170	534.9...	•	4.350	2.200	3.320	2.460	1.300	•	81.490	34.560	3.490	6.590	28.240	•	91.040	36.730	6.380

			C6BD	PogX					C6PogX	PogY					C6PogY	Pog D		
	C4	C5		C1	C2	C3	C4	C5		C1	C2	C3	C4	C5		C1	C2	C3
1	1.800	7.300	•	0.000	.100	0.000	.600	.100	•	1.200	-.700	.700	.600	-.500	•	1.200	.700	.700
2	.200	8.100	•	.800	-.200	.300	-1.000	.300	•	1.900	-.800	-.300	-1.400	-1.100	•	2.000	.900	.500
3	1.300	9.900	•	.900	0.000	.500	.100	.100	•	.400	-.900	1.100	0.000	-1.600	•	1.000	.900	1.200
4	.500	9.500	•	.700	-.900	.500	0.000	0.000	•	.700	-4.200	.400	-.400	-3.000	•	1.200	4.300	.600
5	1.400	3.500	•	.600	-.200	.200	.800	0.000	•	4.500	-.700	0.000	.700	-.700	•	4.600	.800	.200
6	3.200	4.500	•	.700	0.000	.700	0.000	0.000	•	1.300	0.000	0.000	-1.600	-2.400	•	1.800	0.000	.700
7	1.000	3.200	•	.200	-.700	.300	0.000	.800	•	1.200	-1.800	.200	-.400	-1.600	•	1.300	1.900	.400
8	1.200	2.400	•	.300	0.000	.800	.600	-.100	•	2.500	-.600	.500	.700	-.400	•	2.600	.600	.900
9	.900	7.200	•	.200	-.900	.500	0.000	.500	•	0.000	-3.100	-.500	-.300	-.800	•	.200	3.200	.700
10	1.700	4.200	•	.700	0.000	.900	.300	.500	•	4.600	0.000	1.000	.400	1.400	•	4.700	0.000	1.200
11	.500	8.300	•	.300	0.000	.500	0.000	0.000	•	0.000	-.800	0.000	-.400	-1.300	•	.300	.800	.500
12	.600	6.400	•	.900	0.000	.400	0.000	.200	•	5.000	.800	0.000	0.000	-1.400	•	5.300	.800	.400

				Menton X						Menton Y							
	C4	C5	C6PogD	C1	C2	C3	C4	C5	C6MentonX	C1	C2	C3	C4	C5	C6MentonY	C1	C2
Type:	Real	Real	Real	Real	Real	Real	Real	Real	Real	Real	Real	Real	Real	Real	Real	Real	Real
Source:	User En...	User E...	User E...	User E...	User E...	User E...	User E...	User E...	User Ent...	User E...	User E...	User E...	User E...	User E...	User Ente...	User En...	User E...
Class:	Continu...	Contin...	Continu...	Contin...	Contin...	Contin...	Contin...	Contin...	Continuous	Contin...	Contin...	Contin...	Contin...	Contin...	Continuous	Continu...	Contin...
Format:	Free Fo...	Free F...	Free Fo...	Free F...	Free F...	Free F...	Free F...	Free F...	Free For...	Free F...	Free F...	Free F...	Free F...	Free F...	Free Form...	Free Fo...	Free F...
Dec. Places:	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Mean:	.700	1.408	•	-.358	-.292	-1.217	-.192	.450	•	-.325	-.133	-.533	.025	.025	•	.908	.692
Std. Deviation:	.539	.753	•	.873	.661	1.835	1.210	.860	•	.339	.462	.306	.154	.226	•	.568	.646
Std. Error:	.156	.217	•	.252	.191	.530	.349	.248	•	.098	.133	.088	.045	.065	•	.164	.186
Variance:	.291	.566	•	.763	.437	3.369	1.464	.739	•	.115	.213	.093	.024	.051	•	.323	.417
Coeff. of Variation:	77.051	53.433	•	-243....	-226.7...	-150....	-631....	191.0...	•	-104.2...	-346....	-57.282	617.9...	904.534	•	62.535	93.384
Minimum:	0.000	.500	•	-1.400	-1.400	-3.500	-2.000	-1.900	•	-1.200	-1.300	-.900	-.300	-.300	•	.300	0.000
Maximum:	1.600	3.000	•	1.500	.800	2.400	2.300	1.500	•	0.000	.300	0.000	.300	.600	•	2.000	2.300
Range:	1.600	2.500	•	2.900	2.200	5.900	4.300	3.400	•	1.200	1.600	.900	.600	.900	•	1.700	2.300
Count:	12	12	0	12	12	12	12	12	0	12	12	12	12	12	0	12	12
Missing Cells:	0	0	12	0	0	0	0	0	12	0	0	0	0	0	12	0	0
Sum:	8.400	16.900	•	-4.300	-3.500	-14.6...	-2.300	5.400	•	-3.900	-1.600	-6.400	.300	.300	•	10.900	8.300
Sum of Squares:	9.080	30.030	•	9.930	5.830	54.820	16.550	10.560	•	2.530	2.560	4.440	.270	.570	•	13.450	10.330

				Menton X						Menton Y							
	C4	C5	C6PogD	C1	C2	C3	C4	C5	C6MentonX	C1	C2	C3	C4	C5	C6MentonY	C1	C2
1	.900	.500	•	.800	-1.400	-2.200	-2.000	-1.900	•	0.000	-1.300	-.300	.200	.600	•	.800	2.300
2	1.600	1.200	•	-.400	.500	-3.500	-1.200	.800	•	0.000	0.000	-.600	0.000	-.100	•	.400	.500
3	.100	1.700	•	-.500	-.100	2.400	0.000	1.100	•	-.300	.300	0.000	0.000	0.000	•	.600	.300
4	.400	3.000	•	-.100	-.200	-1.100	0.000	.200	•	-.200	0.000	-.500	0.000	-.100	•	.300	.200
5	1.100	.700	•	0.000	-.800	-2.600	1.600	.600	•	-.400	0.000	-.900	-.300	-.300	•	.400	.800
6	1.600	2.400	•	-.700	-.100	-2.100	.300	.500	•	-.100	-.200	-.700	0.000	0.000	•	.700	.200
7	.400	1.800	•	-1.400	-.800	-1.200	-.300	1.500	•	-1.200	-.800	-.900	-.100	0.000	•	2.000	1.200
8	1.000	.500	•	1.500	.800	2.300	2.300	.400	•	-.300	.300	0.000	0.000	-.100	•	1.600	.900
9	.300	.900	•	-1.100	-.400	-1.500	-1.000	1.000	•	0.000	.100	-.700	0.000	0.000	•	1.100	.500
10	.600	1.500	•	-1.400	-1.200	-.600	-.800	0.000	•	-.500	0.000	-.500	0.000	0.000	•	1.500	1.200
11	.400	1.300	•	-1.000	0.000	-2.000	-1.200	.200	•	-.600	0.000	-.500	.300	0.000	•	1.200	0.000
12	0.000	1.400	•	0.000	.200	-2.500	0.000	1.000	•	-.300	0.000	-.800	.200	.300	•	.300	.200

	Menton D			C6MentonD	ANSX						ANSY						
	C3	C4	C5		C1	C2	C3	C4	C5	C6	C1	C2	C3	C4	C5	C6	C1
Type:	Real	Real	Real	Real	Real	Real	Real	Real	Real	Real	Real	Real	Real	Real	Real	Real	Real
Source:	User E...	User E...	User E...	User Ente...	User E...	User E...	User E...	User E...	User E...	User E...	User E...	User ...	User E...	User E...	User E...	User E...	User E...
Class:	Contin...	Contin...	Contin...	Continuous	Contin...	Contin...	Contin...	Contin...	Contin...	Contin...	Contin...	Contin...	Contin...	Contin...	Contin...	Contin...	Contin...
Format:	Free F...	Free F...	Free F...	Free For...	Free F...	Free F...	Free F...	Free F...	Free F...	Free F...	Free F...	Free F...	Free F...	Free F...	Free F...	Free F...	Free F...
Dec. Places:	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Mean:	2.158	.933	.825	•	.975	.217	2.650	.783	.817	1.542	.117	.142	-1.233	-.842	-.400	.233	1.008
Std. Deviation:	.750	.805	.591	•	.519	.388	.340	.369	.649	.573	.248	.198	.385	.156	.388	.277	.557
Std. Error:	.217	.232	.171	•	.150	.112	.098	.106	.187	.165	.072	.057	.111	.045	.112	.080	.161
Variance:	.563	.648	.349	•	.269	.151	.115	.136	.422	.328	.062	.039	.148	.024	.151	.077	.310
Coeff. of Variation:	34.754	86.240	71.640	•	53.227	179.1...	12.822	47.089	79.499	37.155	212.5...	139.4...	-31.1...	-18.585	-97.118	118.900	55.211
Minimum:	.800	0.000	0.000	•	.100	-.300	2.000	0.000	-.200	.400	0.000	0.000	-1.900	-1.000	-1.200	0.000	.100
Maximum:	3.700	2.300	2.100	•	1.800	.900	3.000	1.400	2.300	2.300	.800	.600	-.500	-.500	0.000	.900	1.900
Range:	2.900	2.300	2.100	•	1.700	1.200	1.000	1.400	2.500	1.900	.800	.600	1.400	.500	1.200	.900	1.800
Count:	12	12	12	0	12	12	12	12	12	12	12	12	12	12	12	12	12
Missing Cells:	0	0	0	12	0	0	0	0	0	0	0	0	0	0	0	0	0
Sum:	25.900	11.200	9.900	•	11.700	2.600	31.800	9.400	9.800	18.500	1.400	1.700	-14.8...	-10.100	-4.800	2.800	12.100
Sum of Squares:	62.090	17.580	12.010	•	14.370	2.220	85.540	8.860	12.640	32.130	.840	.670	19.880	8.770	3.580	1.500	15.610

	Menton D			C6MentonD	ANSX						ANSY						
	C3	C4	C5		C1	C2	C3	C4	C5	C6	C1	C2	C3	C4	C5	C6	C1
1	2.300	2.100	2.100	•	.600	.700	2.500	.400	.800	1.500	0.000	.100	-1.900	-.900	-.500	.300	.600
2	3.700	1.200	.900	•	1.000	.900	2.900	1.000	1.000	1.000	0.000	0.000	-1.500	-.900	-.600	0.000	1.000
3	2.400	0.000	1.100	•	.500	0.000	2.400	.900	.800	.400	0.000	.100	-1.000	-.500	0.000	.300	.500
4	1.300	0.000	.300	•	1.800	.400	3.000	.800	1.000	2.200	0.000	0.000	-1.500	-1.000	-1.000	.300	1.800
5	2.700	1.700	.700	•	1.200	0.000	2.800	1.100	2.300	1.800	.400	0.000	-1.500	-.900	0.000	.900	1.400
6	2.300	.300	.500	•	.400	.100	2.000	0.000	.500	1.200	0.000	.100	-.500	-.600	-.200	.100	.400
7	1.600	.300	1.500	•	.100	-.100	2.200	.500	1.000	1.400	0.000	.100	-1.600	-1.000	-.200	0.000	.100
8	2.300	2.300	.500	•	.800	0.000	2.800	.700	-.200	1.100	.200	.100	-1.300	-.800	-1.200	0.000	.800
9	1.700	1.000	1.000	•	1.700	0.000	3.000	1.400	1.000	2.300	.800	0.000	-1.100	-.800	-.400	0.000	1.900
10	.800	.800	0.000	•	1.300	.100	2.800	.700	1.300	1.700	0.000	.100	-1.000	-1.000	0.000	0.000	1.300
11	2.100	1.300	.200	•	1.300	.800	3.000	1.100	0.000	2.300	0.000	.500	-.900	-.900	-.500	.400	1.300
12	2.700	.200	1.100	•	1.000	-.300	2.400	.800	.300	1.600	0.000	.600	-1.000	-.800	-.200	.500	1.000

	ANS D					Input Column
	C2	C3	C4	C5	C6	
Type:	Real	Real	Real	Real	Real	Real
Source:	User E...	User E...	User E...	User E...	User E...	User Entered
Class:	Contin...	Contin...	Contin...	Contin...	Contin...	Continuous
Format:	Free F...	Free F...	Free F...	Free F...	Free F...	Free Format Fi...
Dec. Places:	3	3	3	3	3	3
Mean:	.383	2.967	1.225	1.125	1.625	•
Std. Deviation:	.366	.358	.290	.526	.586	•
Std. Error:	.106	.103	.084	.152	.169	•
Variance:	.134	.128	.0[illegible]4	.277	.344	•
Coeff. of Variation:	95.580	12.054	23.640	46.748	36.086	•
Minimum:	0.000	2.100	.600	.400	.600	•
Maximum:	1.000	3.400	1.600	2.300	2.400	•
Range:	1.000	1.300	1.000	1.900	1.800	•
Count:	12	12	12	12	12	•
Missing Cells:	0	0	0	0	0	•
Sum:	4.600	35.600	14.700	13.500	19.500	•
Sum of Squares:	3.240	107.0...	18.930	18.230	35.470	•

	ANS D					Input Column
	C2	C3	C4	C5	C6	
1	.800	3.000	1.100	1.000	1.600	
2	.900	3.200	1.400	1.500	1.000	
3	.100	2.800	1.000	.800	.600	
4	.400	3.400	1.400	1.500	2.400	
5	0.000	3.200	1.500	2.300	2.000	
6	.200	2.100	.600	.600	1.200	
7	.200	2.800	1.200	1.200	1.400	
8	.100	3.000	.900	1.300	1.100	
9	0.000	3.200	1.600	1.100	2.300	
10	.200	3.000	1.200	1.300	1.700	
11	1.000	3.300	1.500	.500	2.400	
12	.700	2.600	1.300	.400	1.800	

APPENDIX 2

COORDINATE MEANS

	Avg Nasion X	Avg Nasion Y	Avg Nasion D	Avg A Point X	Avg A Point Y	Avg A Point D	Avg B Point X	Avg B Point Y	Avg B Point D	Avg Pog X
Type:	Real	Real	Real	Real	Real	Real	Real	Real	Real	Real
Source:	Static Formula	Static Formula	Static Formula	User Entered	User Entered	Static Formula	Static Formula	Static Formula	Static Formula	Static Form...
Class:	Continuous	Continuous	Continuous	Continuous	Continuous	Continuous	Continuous	Continuous	Continuous	Continuous
Format:	Free Format ...	Free Format ...	Free Format Fi...	Free Forma...	Free Forma...	Free Format F...	Free Format Fi...	Free Format Fi...	Free Format Fi...	Free Format...
Dec. Places:	3	3	3	3	3	3	3	3	3	3
Mean:	-.181	-.001	.703	-.410	-.753	1.532	.275	1.588	3.043	.215
Std. Deviation:	.128	.549	.359	.309	.866	.649	.170	1.055	.528	.135
Std. Error:	.037	.159	.104	.089	.250	.187	.049	.304	.152	.039
Variance:	.016	.302	.129	.096	.750	.421	.029	1.112	.279	.018
Coeff. of Variation:	-70.830	-39553.554	51.053	-75.463	-115.023	42.338	61.643	66.403	17.344	62.982
Minimum:	-.367	-1.233	.350	-1.017	-2.367	.833	.060	.120	1.980	.040
Maximum:	.017	.900	1.567	.050	.300	2.767	.520	3.100	3.660	.480
Range:	.383	2.133	1.217	1.067	2.667	1.933	.460	2.980	1.680	.440
Count:	12	12	12	12	12	12	12	12	12	12
Missing Cells:	0	0	0	0	0	0	0	0	0	0
Sum:	-2.167	-.017	8.433	-4.918	-9.033	18.383	3.300	19.060	36.520	2.580
Sum of Squares:	.571	3.320	7.343	3.068	15.046	32.790	1.224	42.510	114.207	.756

	Avg Nasion X	Avg Nasion Y	Avg Nasion D	Avg A Point X	Avg A Point Y	Avg A Point D	Avg B Point X	Avg B Point Y	Avg B Point D	Avg Pog X
1	-.050	-.367	.500	-.533	-.733	1.317	.520	1.540	3.260	.160
2	-.233	.050	.367	-.317	-.267	1.050	.280	2.620	2.940	.040
3	-.367	-.083	.700	-.433	-2.267	2.767	.480	2.620	3.460	.320
4	-.033	.883	1.067	-.400	-2.367	2.667	.500	3.100	3.560	.060
5	-.233	-.150	.500	-.717	-.567	1.217	.060	.340	3.040	.280
6	-.017	.900	1.083	-.400	-1.350	1.900	.220	.760	3.660	.280
7	.017	-1.233	1.567	-.217	.117	1.450	.420	.120	2.100	.120
8	-.333	.017	.350	-.250	-.533	.833	.080	.680	1.980	.320
9	-.217	.067	.550	-1.017	-1.050	1.883	.100	1.960	2.960	.060
10	-.233	-.117	.550	.050	-.233	.917	.200	.600	3.200	.480
11	-.267	.117	.550	-.717	-.083	1.000	.300	2.740	3.400	.160
12	-.200	-.100	.650	.033	.300	1.383	.140	1.980	2.960	.300

	Avg Pog Y	Avg Pog D	Avg Menton X	Avg Menton Y	Avg Menton D	Avg ANS X	Avg ANS Y	Avg ANS D	Avg ANS X-C2	Avg ANS Y-C3
Type:	Real	Real	Real	Real	Real	Real	Real	Real	Real	Real
Source:	Static Form...	Static Form...	Static Formula	Static Formula	Static Formula	Static Form...	Static Formula	Static Formula	Static Formula	Static Formula
Class:	Continuous	Continuous	Continuous	Continuous	Continuous	Continuous	Continuous	Continuous	Continuous	Continuous
Format:	Free Format...	Free Format...	Free Format Fi...	Free Format Fi...	Free Format Fi...	Free Format...	Free Format ...	Free Format ...	Free Format Fi...	Free Format Fi...
Dec. Places:	3	3	3	3	3	3	3	3	3	3
Mean:	-.032	1.240	-.322	-.188	1.103	1.164	-.331	1.389	.867	-.150
Std. Deviation:	.820	.356	.726	.161	.393	.316	.151	.309	.323	.138
Std. Error:	.237	.103	.209	.046	.113	.091	.044	.089	.093	.040
Variance:	.672	.127	.527	.026	.155	.100	.023	.096	.104	.019
Coeff. of Variation:	-2588.487	28.696	-225.593	-85.372	35.629	27.141	-45.598	22.270	37.228	-92.113
Minimum:	-1.300	.660	-1.340	-.600	.420	.700	-.533	.850	.440	-.340
Maximum:	1.480	1.900	1.460	0.000	1.920	1.567	-.150	1.817	1.280	.080
Range:	2.780	1.240	2.800	.600	1.500	.867	.383	.967	.840	.420
Count:	12	12	12	12	12	12	12	12	12	12
Missing Cells:	0	0	0	0	0	0	0	0	0	0
Sum:	-.380	14.880	-3.860	-2.260	13.240	13.967	-3.967	16.667	10.400	-1.800
Sum of Squares:	7.403	19.844	7.034	.710	16.308	17.353	1.561	24.201	10.158	.480

	Avg Pog Y	Avg Pog D	Avg Menton X	Avg Menton Y	Avg Menton D	Avg ANS X	Avg ANS Y	Avg ANS D	Avg ANS X-C2	Avg ANS Y-C3
1	.260	.800	-1.340	-.160	1.920	1.083	-.483	1.350	.800	-.200
2	-.340	1.240	-.760	-.140	1.340	1.300	-.500	1.500	.980	-.300
3	-.200	.980	.580	0.000	.880	.833	-.183	.967	.520	-.020
4	-1.300	1.900	-.240	-.160	.420	1.533	-.533	1.817	1.240	-.340
5	.760	1.480	-.240	-.380	1.260	1.533	-.183	1.733	1.280	.080
6	-.540	1.300	-.420	-.200	.800	.700	-.183	.850	.440	-.120
7	-.480	1.160	-.440	-.600	1.320	.850	-.450	1.150	.580	-.220
8	.540	1.120	1.460	-.020	1.520	.867	-.500	1.200	.480	-.340
9	-.940	1.060	-.600	-.120	1.060	1.567	-.250	1.683	1.280	-.080
10	1.480	1.600	-.800	-.200	.860	1.317	-.317	1.450	1.020	-.180
11	-.500	.660	-.800	-.160	.960	1.417	-.233	1.667	1.100	-.100
12	.880	1.580	-.260	-.120	.900	.967	-.150	1.300	.680	.020

	Avg ANS D-C3	Avg Meas Error	Input Column
Type:	Real	Real	Real
Source:	Static Formula	Static Formula	User Entered
Class:	Continuous	Continuous	Continuous
Format:	Free Format Fl...	Free Format Fl...	Free Format Fi...
Dec. Places:	3	3	3
Mean:	1.073	-.019	•
Std. Deviation:	.311	.039	•
Std. Error:	.090	.011	•
Variance:	.097	.002	•
Coeff. of Variation:	28.980	-205.242	•
Minimum:	.600	-.106	•
Maximum:	1.500	.033	•
Range:	.900	.139	•
Count:	12	12	•
Missing Cells:	0	0	•
Sum:	12.880	-.228	•
Sum of Squares:	14.889	.021	•

	Avg ANS D-C3	Avg Meas Error	Input Column
1	1.020	-.039	
2	1.160	.017	
3	.600	-.044	
4	1.500	-.044	
5	1.440	-.028	
6	.600	-.011	
7	.820	-.106	
8	.840	-.033	
9	1.380	-.011	
10	1.140	.011	
11	1.340	.033	
12	1.040	.028	

APPENDIX 3

MEASUREMENT ERROR
DATA

	MEC2NasX	MEC2NasY	MEC2NasD	MEC2AX	MEC2AY	MEC2AD	MEC2BX	MEC2BY	MEC2BD	MEC2PogX	MEC2PogY	MEC2PogD	MEC2MeX
Type:	Real	Real	Real	Real	Real	Real	Real	Real	Real	Real	Real	Real	Real
Source:	User Enter...	User Ente...	User Ente...	User Ent...	User Ent...	User Ent...	User Ente...	User Ente...	User Ent...	User Enter...	User Ente...	User Enter...	User Ente...
Class:	Continuous	Continuous	Continuous	Continuous	Continuous	Continuous	Continuous	Continuous	Continuous	Continuous	Continuous	Continuous	Continuous
Format:	Free Form...	Free Form...	Free Form...	Free For...	Free For...	Free For...	Free For...	Free For...	Free For...	Free Form...	Free Form...	Free Form...	Free Form...
Dec. Places:	3	3	3	3	3	3	3	3	3	3	3	3	3
Mean:	-.208	.675	1.250	-.183	-.433	1.208	-.033	4.817	4.842	-.175	-1.075	1.225	-.267
Std. Deviation:	.406	1.870	1.629	.237	1.210	.562	.299	1.247	1.255	.339	1.354	1.287	.654
Std. Error:	.117	.540	.470	.068	.349	.162	.086	.360	.362	.098	.391	.372	.189
Variance:	.164	3.498	2.654	.056	1.464	.315	.090	1.554	1.575	.115	1.833	1.657	.428
Coeff. of Variation:	-194.663	277.097	130.320	-129.148	-279.244	46.476	-898.484	25.883	25.924	-193.589	-125.941	105.068	-245.297
Minimum:	-.700	-1.200	0.000	-.600	-1.700	0.000	-.500	2.400	2.500	-.900	-4.100	0.000	-1.500
Maximum:	.600	5.100	5.200	.200	2.000	2.100	.500	7.000	7.000	.100	.700	4.200	.700
Range:	1.300	6.300	5.200	.800	3.700	2.100	1.000	4.600	4.500	1.000	4.800	4.200	2.200
Count:	12	12	12	12	12	12	12	12	12	12	12	12	12
Missing Cells:	0	0	0	0	0	0	0	0	0	0	0	0	0
Sum:	-2.500	8.100	15.000	-2.200	-5.200	14.500	-.400	57.800	58.100	-2.100	-12.900	14.700	-3.200
Sum of Squares:	2.330	43.950	47.940	1.020	18.360	20.990	1.000	295.500	298.630	1.630	34.030	36.230	5.560

	MEC2NasX	MEC2NasY	MEC2NasD	MEC2AX	MEC2AY	MEC2AD	MEC2BX	MEC2BY	MEC2BD	MEC2PogX	MEC2PogY	MEC2PogD	MEC2MeX
1	-.100	0.000	.100	-.300	-1.400	1.500	0.000	4.300	4.300	.100	-.700	.700	-1.500
2	-.200	-.200	.300	-.200	-1.300	1.300	0.000	4.800	4.800	-.100	-.800	.800	.500
3	-.500	-.100	.600	-.200	-1.200	1.400	-.300	3.300	3.300	0.000	-.700	.700	0.000
4	.600	5.100	5.200	-.600	-1.400	1.600	.400	7.000	7.000	-.800	-4.100	4.200	0.000
5	-.700	-.200	.700	-.600	-.600	.900	0.000	4.900	4.900	0.000	-.700	.700	-.600
6	.500	3.900	4.000	0.000	-1.700	1.700	.500	6.500	6.700	0.000	0.000	0.000	-.100
7	-.300	.200	.500	-.100	1.500	1.500	-.500	2.400	2.500	-.400	-1.700	1.900	-.500
8	-.500	0.000	.500	0.000	.600	.600	0.000	4.300	4.300	0.000	-1.000	1.000	.700
9	-.500	-.400	.700	-.200	-.900	1.000	-.500	4.600	4.600	-.900	-3.200	3.300	-.500
10	0.000	0.000	0.000	0.000	0.000	0.000	0.000	5.200	5.200	0.000	0.000	0.000	-1.300
11	-.300	1.000	1.000	-.200	-.800	.900	0.000	5.600	5.600	0.000	-.700	.700	0.000
12	-.500	-1.200	1.400	.200	2.000	2.100	0.000	4.900	4.900	0.000	.700	.700	.100

	MEC2MeY	MEC2MeD	MEC2ANSX	MEC2ANSY	MEC2ANSD	Nasion Diff X	Nasion Diff Y	Nasion Diff D	A Diff X	A Diff Y	A Diff D	B Diff X
Type:	Real	Real	Real	Real	Real	Real	Real	Real	Real	Real	Real	Real
Source:	User Enter...	User Ente...	User Enter...	User Ente...	User Enter...	Static Form...	Static For...	Static For...	User Ent...	User Ente...	Static For...	Static For...
Class:	Continuous	Continuous	Continuous	Continuous	Continuous	Continuous	Continuous	Continuous	Continuous	Continuous	Continuous	Continuous
Format:	Free Form...	Free Form...	Free Form...	Free Form...	Free Form...	Free Format...	Free Forma...	Free Forma...	Free For...	Free Form...	Free Form...	Free For...
Dec. Places:	3	3	3	3	3	3	3	3	3	3	3	3
Mean:	-.150	.625	.242	.158	.392	.025	6.776E-21	-.050	-.033	-.058	-.017	-.067
Std. Deviation:	.472	.636	.399	.178	.360	.142	.104	.145	.115	.144	.147	.098
Std. Error:	.136	.183	.115	.051	.104	.041	.030	.042	.033	.042	.042	.028
Variance:	.223	.404	.159	.032	.130	.020	.011	.021	.013	.021	.022	.010
Coeff. of Variation:	-314.627	101.680	165.007	112.525	92.030	568.890	1.541E21	-289.200	-346.410	-247.436	-880.083	-147.710
Minimum:	-1.300	0.000	-.300	0.000	0.000	-.200	-.200	-.300	-.200	-.300	-.300	-.300
Maximum:	.200	2.200	.900	.500	1.000	.300	.200	.200	.200	.200	.200	0.000
Range:	1.500	2.200	1.200	.500	1.000	.500	.400	.500	.400	.500	.500	.300
Count:	12	12	12	12	12	12	12	12	12	12	12	12
Missing Cells:	0	0	0	0	0	0	0	0	0	0	0	0
Sum:	-1.800	7.500	2.900	1.900	4.700	.300	8.132E-20	-.600	-.400	-.700	-.200	-.800
Sum of Squares:	2.720	9.130	2.450	.650	3.270	.230	.120	.260	.160	.270	.240	.160

	MEC2MeY	MEC2MeD	MEC2ANSX	MEC2ANSY	MEC2ANSD	Nasion Diff X	Nasion Diff Y	Nasion Diff D	A Diff X	A Diff Y	A Diff D	B Diff X
1	-1.300	2.200	.900	.300	1.000	0.000	0.000	0.000	-.100	0.000	0.000	0.000
2	0.000	.500	.800	0.000	.800	-.100	.100	.100	0.000	.200	-.200	0.000
3	.200	.200	0.000	.300	.300	-.200	-.100	.200	-.200	-.200	.200	-.200
4	0.000	0.000	.500	0.000	.500	-.100	-.100	-.100	.100	0.000	.200	-.100
5	.100	.600	0.000	0.000	0.000	.200	.200	-.200	-.100	-.200	.100	-.100
6	-.300	.300	.100	.100	.200	0.000	0.000	0.000	0.000	0.000	0.000	-.100
7	-.900	1.000	0.000	.200	.200	-.100	-.200	-.100	-.200	-.200	-.100	-.300
8	.200	.700	0.000	0.000	0.000	.300	0.000	-.300	0.000	-.300	-.300	0.000
9	.200	.600	0.000	0.000	0.000	.100	.100	-.200	.200	-.100	0.000	0.000
10	0.000	1.300	.100	.100	.200	0.000	0.000	0.000	0.000	0.000	0.000	0.000
11	0.000	0.000	.800	.500	.900	.100	0.000	.100	0.000	0.000	-.100	0.000
12	0.000	.100	-.300	.400	.600	.100	0.000	-.100	-.100	.100	0.000	0.000

	B Diff Y	B Diff D	Pog Diff X	Pog Diff Y	Pog Diff D	Me Diff X	Me Diff Y	Me Diff D	ANS Diff X	ANS Diff Y	ANS Diff D	Input Column
Type:	Real	Real	Real	Real	Real	Real	Real	Real	Real	Real	Real	Real
Source:	Static Fo...	Static For...	Static Form...	Static For...	Static For...	Static For...	Static For...	Static Fo...	Static For...	Static For...	Static For...	User Entered
Class:	Continuous	Continuous	Continuous	Continuous	Continuous	Continuous	Continuous	Continuous	Continuous	Continuous	Continuous	Continuous
Format:	Free For...	Free Form...	Free Format...	Free Forma...	Free Form...	Free Form...	Free Form...	Free For...	Free Forma...	Free Forma...	Free Forma...	Free Format Fi...
Dec. Places:	3	3	3	3	3	3	3	3	3	3	3	3
Mean:	-.067	-.050	-.058	.008	.017	-.025	.017	.067	-.025	-.017	-.008	•
Std. Deviation:	.130	.138	.100	.151	.153	.142	.072	.123	.075	.111	.108	•
Std. Error:	.038	.040	.029	.043	.044	.041	.021	.036	.022	.032	.031	•
Variance:	.017	.019	.010	.023	.023	.020	.005	.015	.006	.012	.012	•
Coeff. of Variation:	-195.402	-276.340	-170.778	1806.050	916.515	-568.890	430.644	184.637	-301.511	-668.785	-1300.350	•
Minimum:	-.300	-.300	-.300	-.200	-.400	-.300	-.100	-.100	-.200	-.200	-.200	•
Maximum:	.200	.200	0.000	.400	.200	.100	.100	.200	.100	.200	.100	•
Range:	.500	.500	.300	.600	.600	.400	.200	.300	.300	.400	.300	•
Count:	12	12	12	12	12	12	12	12	12	12	12	•
Missing Cells:	0	0	0	0	0	0	0	0	0	0	0	•
Sum:	-.800	-.600	-.700	.100	.200	-.300	.200	.800	-.300	-.200	-.100	•
Sum of Squares:	.240	.240	.150	.250	.260	.230	.060	.220	.070	.140	.130	•

	B Diff Y	B Diff D	Pog Diff X	Pog Diff Y	Pog Diff D	Me Diff X	Me Diff Y	Me Diff D	ANS Diff X	ANS Diff Y	ANS Diff D	Input Column
1	-.100	-.100	0.000	0.000	0.000	.100	0.000	.100	-.200	-.200	-.200	
2	0.000	0.000	-.100	0.000	.100	0.000	0.000	0.000	.100	0.000	.100	
3	-.100	.100	0.000	-.200	.200	-.100	.100	.100	0.000	-.200	-.200	
4	-.200	-.200	-.100	-.100	.100	-.200	0.000	.200	-.100	0.000	-.100	
5	-.100	-.100	-.200	0.000	.100	-.200	-.100	.200	0.000	0.000	0.000	
6	0.000	-.100	0.000	0.000	0.000	0.000	.100	-.100	0.000	0.000	0.000	
7	-.100	0.000	-.300	-.100	0.000	-.300	.100	.200	-.100	-.100	0.000	
8	-.300	-.300	0.000	.400	-.400	.100	.100	.200	0.000	.100	.100	
9	-.100	-.100	0.000	.100	-.100	.100	-.100	-.100	0.000	0.000	0.000	
10	.100	.100	0.000	0.000	0.000	.100	0.000	-.100	0.000	0.000	0.000	
11	.200	.200	0.000	-.100	.100	0.000	0.000	0.000	0.000	0.000	.100	
12	-.100	-.100	0.000	.100	.100	.100	0.000	.100	0.000	.200	.100	

APPENDIX 4

INTRA-OBSERVER REPRODUCIBILITY DATA

	Observer	Experience	Repeat Nasion X		Repeat Nasion Y		Repeat Nasion D		Repeat AX		Repeat AY		Repe
			Remeasure	Original	Remeasure	Original	Remeasure	Original	Remeasure	Original	Remeasure	Original	Remeasure
Type:	String	Category	Real	Real	Real	Real	Real	Real	Real	Real	Real	Real	Real
Source:	User E...	User Ent...	User Ente...	User Ent...	User Enter...	User Enter...	User Enter...	User Ente...	User Entered	User Ent...	User Enter...	User Ente...	User Ente...
Class:	Inform...	Nominal	Continuous	Continuous	Continuous	Continuous	Continuous	Continuous	Continuous	Continuous	Continuous	Continuous	Continuous
Format:	•	•	Free Form...	Free For...	Free Form...	Free Form...	Free Form...	Free For...	Free Form...	Free For...	Free Form...	Free For...	Free Form...
Dec. Places:	•	•	3	3	3	3	3	3	3	3	3	3	3
Mean:	•	•	-.167	-.117	-.175	-.067	.292	.183	.025	-.275	-1.158	-.992	1.667
Std. Deviation:	•	•	.187	.195	.191	.130	.268	.244	.521	.986	1.407	1.031	.957
Std. Error:	•	•	.054	.056	.055	.038	.077	.071	.150	.285	.406	.298	.276
Variance:	•	•	.035	.038	.037	.017	.072	.060	.271	.973	1.981	1.063	.915
Coeff. of Variation:	•	•	-112.492	-166.821	-109.307	-195.402	91.834	133.271	2082.830	-358.685	-121.504	-103.951	57.398
Minimum:	•	1	-.500	-.700	-.600	-.400	0.000	0.000	-1.300	-3.200	-2.900	-3.000	.100
Maximum:	•	3	0.000	0.000	0.000	.100	.700	.800	.600	.600	1.000	.300	3.100
Range:	•	2.000	.500	.700	.600	.500	.700	.800	1.900	3.800	3.900	3.300	3.000
Count:	•	12	12	12	12	12	12	12	12	12	12	12	12
Missing Cells:	•	0	0	0	0	0	0	0	0	0	0	0	0
Sum:	•	•	-2.000	-1.400	-2.100	-.800	3.500	2.200	.300	-3.300	-13.900	-11.900	20.000
Sum of Squares:	•	•	.720	.580	.770	.240	1.810	1.060	2.990	11.610	37.890	23.490	43.400

	Observer	Experience	Repeat Nasion X		Repeat Nasion Y		Repeat Nasion D		Repeat AX		Repeat AY		Repe
			Remeasure	Original	Remeasure	Original	Remeasure	Original	Remeasure	Original	Remeasure	Original	Remeasure
1	MEL	3	-.500	-.100	-.200	-.100	.700	.200	.200	0.000	-2.400	-1.500	2.400
2	AEG	3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-.300	1.000	.300	1.000
3	RGK	3	0.000	-.700	0.000	-.100	0.000	.800	.400	-.300	-1.900	-2.300	2.000
4	DLM	3	0.000	-.100	0.000	.100	0.000	.200	.200	.400	-2.400	-3.000	2.400
5	PW	2	-.100	-.100	-.100	-.200	.200	.200	0.000	-.500	-.100	0.000	.100
6	WTM	2	-.100	0.000	-.100	0.000	.200	0.000	0.000	-.100	-2.000	-.900	2.000
7	DGD	2	-.400	-.200	-.600	-.400	.700	.500	.600	0.000	.700	-.300	.900
8	FJS	2	0.000	-.100	-.300	0.000	.300	.100	.300	0.000	-1.400	-1.600	1.400
9	JM	1	-.200	-.100	0.000	-.100	.200	.200	-1.300	-3.200	-2.400	-1.400	3.000
10	TWA	1	-.400	0.000	-.400	0.000	.600	0.000	0.000	.600	.700	0.000	.700
11	TH	1	-.300	0.000	-.300	0.000	.500	0.000	.500	-.400	-.800	0.000	1.000
12	ALW	1	0.000	0.000	-.100	0.000	.100	0.000	-.600	.500	-2.900	-1.200	3.100

	at AD	Repeat BX		Repeat BY		Repeat BD		Repeat Pog X		Repeat Pog Y		Repea
	Original	Remeasure	Original	Remeasure	Original	Remeasure	Original	Remeasure	Original	Remeasure	Original	Remeasure
Type:	Real	Real	Real	Real	Real	Real	Real	Real	Real	Real	Real	Real
Source:	User Enter...	User Enter...	User Ente...	User Enter...	User Enter...	User Enter...	User Enter...	User Ente...	User Ente...	User Entered	User Enter...	User Enter...
Class:	Continuous	Continuous	Continuous	Continuous	Continuous	Continuous	Continuous	Continuous	Continuous	Continuous	Continuous	Continuous
Format:	Free Form...	Free Form...	Free Form...	Free Form...	Free Form...	Free Form...	Free Form...	Free Form...	Free Form...	Free Form...	Free Form...	Free Form...
Dec. Places:	3	3	3	3	3	3	3	3	3	3	3	3
Mean:	1.383	.175	.150	.217	.250	1.258	.975	.567	.467	.350	.258	.958
Std. Deviation:	1.082	.245	.211	1.496	1.068	.889	.586	.271	.253	.870	.494	.664
Std. Error:	.312	.071	.061	.432	.308	.257	.169	.078	.073	.251	.143	.192
Variance:	1.171	.060	.045	2.238	1.141	.790	.344	.073	.064	.757	.244	.441
Coeff. of Variation:	78.213	140.236	140.705	690.440	427.253	70.631	60.143	47.788	54.313	248.633	191.396	69.282
Minimum:	.300	0.000	0.000	-3.300	-1.600	.200	.100	0.000	0.000	-.900	-.500	.100
Maximum:	3.500	.800	.500	1.600	1.800	3.600	1.800	1.000	.900	2.000	1.100	2.200
Range:	3.200	.800	.500	4.900	3.400	3.400	1.700	1.000	.900	2.900	1.600	2.100
Count:	12	12	12	12	12	12	12	12	12	12	12	12
Missing Cells:	0	0	0	0	0	0	0	0	0	0	0	0
Sum:	16.600	2.100	1.800	2.600	3.000	15.100	11.700	6.800	5.600	4.200	3.100	11.500
Sum of Squares:	35.840	1.030	.760	25.180	13.300	27.690	15.190	4.660	3.320	9.800	3.490	15.870

	at AD	Repeat BX		Repeat BY		Repeat BD		Repeat Pog X		Repeat Pog Y		Repea
	Original	Remeasure	Original	Remeasure	Original	Remeasure	Original	Remeasure	Original	Remeasure	Original	Remeasure
1	1.500	0.000	0.000	-.600	.500	.600	.500	0.000	0.000	-.100	.700	.100
2	.500	.200	0.000	1.200	1.100	1.200	1.100	.500	.300	-.400	-.300	.700
3	2.300	.500	0.000	1.000	1.800	1.200	1.800	1.000	.500	1.200	1.100	1.700
4	3.100	0.000	.100	-.200	.300	.200	.400	.200	.500	0.000	.400	.200
5	.500	0.000	0.000	1.300	.100	1.300	.100	.600	.200	1.700	0.000	1.900
6	.900	0.000	.300	.300	-1.600	.300	1.700	.500	.700	0.000	0.000	.500
7	.300	.200	0.000	.900	-.400	.900	.400	.700	.300	-.900	.200	1.100
8	1.600	.800	.500	-3.300	-.400	3.600	.700	.700	.800	.700	.500	1.000
9	3.500	.200	0.000	-1.900	.700	1.900	.700	.800	.500	0.000	-.500	.800
10	.600	.100	.400	1.300	-1.500	1.300	1.700	.500	.900	2.000	1.000	2.200
11	.400	.100	.500	1.600	1.200	1.600	1.400	.500	.500	0.000	0.000	.500
12	1.400	0.000	0.000	1.000	1.200	1.000	1.200	.800	.400	0.000	0.000	.800

	Pog D	Repeat Me X		Repeat Me Y		Repeat Me D		Repeat ANS X		Repeat ANS Y		Repeat
	Original	Remeasure	Original	Remeasure	Original	Remeasure	Original	Remeasure	Original	Remeasure	Original	Remeasure
Type:	Real	Real	Real	Real	Real	Real	Real	Real	Real	Real	Real	Real
Source:	User Enter...	User Entered	User Enter...	User Ente...	User Ent...	User Enter...	User Enter...	User Entered	User Enter...	User Entered	User Enter...	User Ente...
Class:	Continuous	Continuous	Continuous	Continuous	Continuous	Continuous	Continuous	Continuous	Continuous	Continuous	Continuous	Continuous
Format:	Free Form...	Free Forma...	Free Form...	Free Form...	Free For...	Free Form...	Free Form...	Free Forma...	Free Form...	Free Forma...	Free Form...	Free Form...
Dec. Places:	3	3	3	3	3	3	3	3	3	3	3	3
Mean:	.667	-1.217	-1.217	-.667	-.533	2.208	2.158	2.675	2.650	-1.517	-1.233	3.117
Std. Deviation:	.308	1.834	1.835	.385	.306	.624	.750	.296	.340	.276	.385	.180
Std. Error:	.089	.529	.530	.111	.088	.180	.217	.085	.098	.080	.111	.052
Variance:	.095	3.363	3.369	.148	.093	.390	.563	.088	.115	.076	.148	.032
Coeff. of Variation:	46.270	-150.735	-150.857	-57.683	-57.282	28.276	34.754	11.058	12.822	-18.184	-31.180	5.778
Minimum:	.200	-3.300	-3.500	-1.300	-.900	1.400	.800	2.200	2.000	-2.000	-1.900	2.900
Maximum:	1.200	2.900	2.400	0.000	0.000	3.400	3.700	3.200	3.000	-1.100	-.500	3.500
Range:	1.000	6.200	5.900	1.300	.900	2.000	2.900	1.000	1.000	.900	1.400	.600
Count:	12	12	12	12	12	12	12	12	12	12	12	12
Missing Cells:	0	0	0	0	0	0	0	0	0	0	0	0
Sum:	8.000	-14.600	-14.600	-8.000	-6.400	26.500	25.900	32.100	31.800	-18.200	-14.800	37.400
Sum of Squares:	6.380	54.760	54.820	6.960	4.440	62.810	62.090	86.830	85.540	28.440	19.880	116.920

	Pog D	Repeat Me X		Repeat Me Y		Repeat Me D		Repeat ANS X		Repeat ANS Y		Repeat
	Original	Remeasure	Original	Remeasure	Original	Remeasure	Original	Remeasure	Original	Remeasure	Original	Remeasure
1	.700	-2.500	-2.200	-1.000	-.300	2.800	2.300	2.200	2.500	-1.900	-1.900	2.900
2	.500	-3.300	-3.500	-.500	-.600	3.400	3.700	3.200	2.900	-1.700	-1.500	3.500
3	1.200	-2.100	2.400	-.200	0.000	2.100	2.400	2.800	2.400	-1.100	-1.000	3.100
4	.600	-1.300	-1.100	-.600	-.500	1.500	1.300	2.800	3.000	-1.400	-1.500	3.200
5	.200	2.000	-2.600	-.200	-.900	2.000	2.700	2.900	2.800	-1.500	-1.500	3.400
6	.700	-1.300	-2.100	-.800	-.700	1.500	2.300	2.200	2.000	-2.000	-.500	3.000
7	.400	-1.000	-1.200	-1.300	-.900	1.400	1.600	2.800	2.200	-1.500	-1.600	3.000
8	.900	2.900	2.300	0.000	0.000	2.900	2.300	2.800	2.800	-1.500	-1.300	3.200
9	.700	-1.500	-1.500	-.800	-.700	1.800	1.700	2.700	3.000	-1.300	-1.100	3.000
10	1.200	-2.100	-.600	-.700	-.500	2.200	.800	2.500	2.800	-1.100	-1.000	3.000
11	.500	-2.400	-2.000	-.900	-.500	2.600	2.100	2.800	3.000	-1.600	-.900	3.100
12	.400	-2.000	-2.500	-1.000	-.800	2.300	2.700	2.400	2.400	-1.600	-1.000	3.000

	ANS D Original	Input Column
Type:	Real	Real
Source:	User Ente...	User Entered
Class:	Continuous	Continuous
Format:	Free Form...	Free Format Fi...
Dec. Places:	3	3
Mean:	2.967	•
Std. Deviation:	.358	•
Std. Error:	.103	•
Variance:	.128	•
Coeff. of Variation:	12.054	•
Minimum:	2.100	•
Maximum:	3.400	•
Range:	1.300	•
Count:	12	•
Missing Cells:	0	•
Sum:	35.600	•
Sum of Squares:	107.020	•

	ANS D Original	Input Column
1	3.000	
2	3.200	
3	2.800	
4	3.400	
5	3.200	
6	2.100	
7	2.800	
8	3.000	
9	3.200	
10	3.000	
11	3.300	
12	2.600	