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นางสาวรุจณีย์ เหลืองวัฒนากิจ

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COLOR STABILITY OF RESIN CEMENTS AFTER ULTRAVIOLET ARTIFICIAL AGING

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อ. ที่ปรึกษาวิทยานิพนธ์หลัก: รศ.ทพ.ดร.แมนสรวง อักษรนุกิจ, 73 หน้า.

บทนำ พอร์ซเลนลามิเนตวีเนียร์เป็นที่นิยมในการบูรณะฟันเพื่อความสวยงาม อย่างไรก็ตามเรซินซีเมนต์ที่ใช้ในการยึดติดชิ้นงานมีการเสื่อมสภาพตามเวลา ทำให้เกิดความบกพร่องของขอบชิ้นงานและการเปลี่ยนสีตามมา เสถียรภาพของสีของวัสดุบูรณะฟันนั้นมาการศึกษาอย่างแพร่หลาย แต่การศึกษาในเรซินซีเมนต์นั้นยังมีน้อยมาก ดังนั้นวัตถุประสงค์ของการศึกษานี้เป็นการประเมินเสถียรภาพของสีเรซินซีเมนต์ภายหลังการเร่งให้วัสดุเก่าด้วยรังสีอัลตราไวโอเลต

วัสดุและวิธีการ เรซินซีเมนต์ทั้ง 4 ยี่ห้อที่ใช้ในการทดสอบประกอบด้วย รีลายเอกซ์วีเนียร์ วาริโอลิงค์วีเนียร์ วาริโอลิงค์ทู และเอนเอกซ์ทรี เตรียมชิ้นตัวอย่างด้วยแบบอะคริลิก จากนั้นนำชิ้นตัวอย่างไปเร่งให้วัสดุเก่าด้วยรังสีอัลตราไวโอเลตเอความเข้ม 62 วัตต์ต่อตารางเมตร โดยวัดสีทั้งก่อนและหลังจากเร่งให้วัสดุเก่าเป็นเวลา 1 3 5 และ 7 วัน และ 2 3 4 8 และ 12 สัปดาห์ด้วยเครื่องวัดสีสเปคโตรโฟโตมิเตอร์ตามระบบซีไออีแอลเอบี นำค่าที่ได้มาคำนวณหาค่าการเปลี่ยนสี วิเคราะห์ทางสถิติโดยใช้สถิติการวิเคราะห์ความแปรปรวนแบบสองทางเมื่อมีการวัดซ้ำและใช้การทดสอบตูกีที่ระดับความมีนัยสำคัญทางสถิติ .05

ผลการศึกษา หลัง 12 สัปดาห์กลุ่มควบคุมมีค่าการเปลี่ยนสี 1.07 ถึง 5.30 กลุ่มทดลองมีค่าการเปลี่ยนสี 1.66 ถึง 6.31 ค่าเดลตาแอลเป็นลบยกเว้นรีลายเอกซ์วีเนียร์สีเอสามและสีโปร่งแสง ค่าเดลตาเอเป็นบวกยกเว้นเอนเอกซ์ทรีสีเหลือง ค่าเดลตาบีมีความแตกต่างกันไปในแต่ละยี่ห้อและสี จากการวิเคราะห์ทางสถิติพบว่าสภาวะในการเร่งให้วัสดุเก่าและเวลาส่งผลต่อการเปลี่ยนสีของวัสดุอย่างมีนัยยะสำคัญทางสถิติยกเว้นรีลายเอกซ์วีเนียร์สีเอสามที่ไม่มีความแตกต่างทางสถิติระหว่างสภาวะ ส่วนปฏิสัมพันธ์ทั้งหมดมีนัยยะสำคัญทางสถิติ

สรุปผลการศึกษา รังสีอัลตราไวโอเลตสามารถเร่งให้เกิดการเปลี่ยนสีของเรซินซีเมนต์ได้ โดยทำให้มีความสว่างลดลงและมีสีแดงมากขึ้น ภายหลังการเร่งให้วัสดุเก่าเรซินซีเมนต์ทั้งหมดมีการเปลี่ยนสีที่สามารถสังเกตเห็นได้ โดยวาลิโอลิงค์วีเนียร์มีการเปลี่ยนสีมากที่สุดและรีลายเอกซ์วีเนียร์มีการเปลี่ยนสีน้อยที่สุด

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สาขาวิชา ทันตกรรมประดิษฐ์ ลายมือชื่อ อ.ที่ปรึกษาวิทยานิพนธ์หลัก.................................
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RUJJANEE LUEANGWATTANAKIJ: COLOR STABILITY OF RESIN CEMENTS AFTER ULTRAVIOLET ARTIFICIAL AGING.
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Introduction: Porcelain laminate veneers are popular for use in achieving an esthetic outcome. However, resin cements gradually degrade overtime, resulting in marginal defects and discoloration. The color stability of restorative materials, especially the indirect composite resins, is well documented. But only a few studies have focused on resin cements with conflicting results. Therefore, this study was to evaluate the color stability of resin cements after accelerated aging by ultraviolet irradiation.

Material and methods: Three shades of four commercial resin cements were tested in this study (RelyX Veneer, Variolink Veneer, VariolinkII, and NX3). Specimens were prepared using acrylic split molds and subjected to artificial aging with a UVA intensity of 62 W/m^2. Color measurement was done before and after accelerated aging for 1, 3, 5, and 7 days, and 2, 3, 4, 8 and 12 weeks. Color was measured using the CIE L*a*b* system with a spectrophotometer. ΔL^*, Δa^*, Δb^*, and ΔE^* were calculated between baseline values and subsequent measurements. Statistical analysis was performed using Two ways repeated measures ANOVA and Tukey post hoc test ($P<0.05$).

Results: After 12 weeks, the ΔE values ranged from 1.07 to 5.30 for control groups and from 1.66 to 6.31 for the artificial aging groups. ΔL^* values were negative except for RelyX Veneer A3 and Translucent. Δa^* values for the exposed groups were positive except for NX3 Yellow. Δb^* values were different among brands and shades. Statistical analysis showed that the aging conditions and times significantly influenced the color change of each material except for RVA3 which there was no significant difference between the aging conditions. All interactions were significant.

Conclusion: Ultraviolet light can induce resin cements to become darker and more reddish in color. All of the resin cements tested in this study exhibited perceptible color changes after artificial aging. Variolink Veneer exhibited the greatest ΔE^* values and RelyX Veneer exhibited the lowest ΔE^* values after artificial aging.

Department: Prosthodontics .... Student's Signature…………………………
Field of Study: Prosthodontics .... Advisor's Signature………………………...
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LIST OF ABBREVIATIONS

ABBREVIATIONS	DESCRIPTIONS
UV	Ultraviolet
UVA	Ultraviolet A
mW/cm^2	milliwatt per square centimeter
W/m^2	watt per square meter
%	percent
wt%	weight percent
°C	degree in Celsius
mm	millimeter
nm	nanometer
ISO	International Organization of Standardization
ADA	American Dental Association
mm^3	cubic millimeter
mg	milligram

s	second
i.e.	id est (that is)
et al	et alii (and others)
fig	figure
ANOVA	analysis of variance
SD	standard deviation
α	alpha

CHAPTER I

INTRODUCTION

With the current dental practice of conservative tooth restoration, porcelain laminate veneers are popular for use in achieving an esthetic outcome. Porcelain laminate veneers have become the preferred option over other types of restorations because of their natural appearance, conservation of tooth structure in preparation, color stability, wear and stain resistance, and ease of placement (1, 2). The marked improvements in available bonding systems have contributed to the success and widespread use of porcelain laminate veneers. Resin cements are generally used in esthetic restorations and have become popular because of their properties of less solubility and better adhesion compared to conventional cements (3). Currently, no commercially available resin cement is ideal for all situations. There have been considerable discussions on the properties and performance of these cements. Unlike porcelain which is durable and color-stable, resin cements gradually degrade overtime, resulting in marginal defects and discoloration. A six-year clinical study by Fradeani (4) demonstrated that 7.2% of all porcelain laminate veneer cases had marginal discoloration by using visual determination. A prospective ten-year clinical trial by Peumans et al (5) reported that the number of restorations showing marginal discoloration increased dramatically from 5 to 10 years using visual assessment by two evaluators. Nineteen percent of the restorations were clinically unacceptable due to marginal discoloration and 40% exhibited superficial discoloration.

The color instability of dental composites results from both exogenous and endogenous sources. Exogenous changes in color come from staining food and/or drink (e.g. coffee or red wine) (6-9). These external color changes can be eliminated by polishing the composite’s surface. Endogenous sources are chemical changes in the material’s composition due to the amine (10, 11), photo-initiator (12), inhibitor (13) content as well as the mode and time-span of light activation (14, 15). These can all cause color change of the material. However, this internal color change cannot be eliminated by polishing.

Many methods are currently used to assess tooth color ranging from visual comparisons (16) to instrumental measurements (17, 18). Visual color determination is a subjective process. Multiple variables such as external light conditions, the observer's experience, age, and eye fatigue can lead to inconsistency and bias. Spectrophotometers, generating objective measurements, are designed to produce the most accurate color measurements by recording the reflectance or transmittance of an object at wavelength in the visible range. There are two color specification systems which are widely used in dentistry; the Munsell System (19) and the CIE system (Commission Internationale de l'Eclairage or International Commission on Illumination) (20). CIELAB is the most complete color space developed by the CIE in 1976. Values from the CIE color system can be calculated to determine a color difference between two colors (20).

The color stability of restorative materials, especially the indirect composite resins, is well documented and most of them are clinically acceptable (9, 21, 22). But only a few studies have focused on resin cements with conflicting results. Lu and Power (18) reported that the color changes of the resin cements tested were perceptible and clinically unacceptable when ΔE was greater than 3.3. However, Noie et al (17) found that the ΔE values of most resin cements tested were lower than 3.3 and considered these acceptable color changes. Furthermore, a new amine-reduced formula and an innovative initiator were introduced. But there is no study on the color stability of these cements.

The evaluation of properties changes of composite resins may take a long period of time. Therefore, many artificial aging methods have been used to accelerate the degradation process of the materials such as boiling, thermocycling, and immersion in solvent. For resin cements, the esthetic should be concerned. Ultraviolet irradiation is one method recommended for the accelerated aging of the resin cements.

Objective

To evaluate the color stability of three shades of four commercial resin cements after accelerated aging by ultraviolet irradiation.

Research scope

This was an experimental research in vitro. Three shades of four commercial resin cements were tested. Each shade was divided in 2 subgroups of eight specimens each. Subgroup 1 was stored in an incubator at 37ºC in dark and dry condition as a control group, subgroup 2 was artificially aged in a custom-made ultraviolet chamber under water, respectively for 3 months. Color measurement was performed using a spectrophotometer at day 0, 1, 3, 5, and 7 and week 2, 3, 4, 8, and 12. The color changes of the resin cements tested were determined using ΔE values.

Agreements

This was an in vitro experimental study which did not represent intra-oral situation. The entire study was conducted within Chulalongkorn University facilities by one researcher using the same instruments.

Research limitations

This experimental research was conducted in the laboratory which could not simulate the real condition of the entire oral cavity. Since the color change of resin cement in vivo was time consuming. Therefore, the ultraviolet chamber was used to accelerate the degradation of the resin cements which was not the actual process in the oral cavity.

Type of research

Experimental research

Proposed benefits

1. To assess the color change of resin cements tested after accelerated aging. This result provided information of the commercial resin cement for restorative dentists.
2. To provide basic information for future studies to develop the properties of dental materials.

Hypothesis

The null hypothesis was that ultraviolet irradiation accelerated aging has no influence on color of resin cements.

CHAPTER II

LITERATURE REVIEW

Porcelain laminate veneers

Porcelain laminate veneers were first made in 1938 by Dr. Charles Pincus to enhance the appearance of Hollywood actors. They were retained by a denture adhesive and removed after filming because there was no permanent adhesive system existed at that time (23). In 1983, Simonsen and Calamia reactivated the interest in porcelain laminate veneers by introducing special acid-etching procedures with hydrofluoric acid that substantially improved the long term porcelain laminate veneer retention (24). From the moment, porcelain laminate veneers could be adhesively luted. With the improvement of resin cement, porcelain laminate veneers are now more predictable and harmonious as a part of the natural teeth. Many clinical studies have shown very good long-term results following the placement of anterior porcelain laminate veneers (4, 5, 25, 26).

Porcelain laminate veneers can be used for patients who wish to have anterior dental esthetic problems corrected in terms of tooth shade, morphology and alignment. Furthermore, these can also be used for repairing of fractured porcelain facings on fix prostheses (27).

Advantages of porcelain laminate veneers are conservative procedure compared to full crown preparation, high bond strength to the enamel surface, resistance to abrasion and low fluid absorption compared to composite resin (27-29).

Disadvantages of porcelain laminate veneers are high laboratory cost, monochromatic color, difficulty to replace and repair, and marginal gap (27, 29, 30). Though porcelain laminate veneers are durable and color-stable, composite luting materials gradually degrade without exception, resulting in marginal defect and discoloration in medium to long term clinical studies (4, 5, 26).

Resin Cements

Resin cements are generally used for esthetic restorations. They have become popular because of less solubility and better adhesion compared to conservative cements (31). The advent of resin cements has expanded the scope of fixed prosthodontics. Currently, no commercially available resin cement is ideal for all situations. There has been considerable discussion on the properties and performance of these cements (32).

Methyl methacrylate-based resin cement has been available since 1952 for cementation of indirect restorations. Reformulations and improvements over the last 20 years, driven by a demand for all-ceramic and bonded restorations. In 1973, Rochette (33) used resin-based luting material for the placement of the cast adhesive bridges but their longevity was limited by the hydrolytic instability and the poor resistance to wear of the cements. The introduction by Thompson et al in 1981 (34) of the Maryland bridge resulted in the development of resin cements which were claimed to have higher bond strength and lower film thickness than the macrofilled composites.

For placement of porcelain laminate veneers, light-cured resin cements were initially used. These were provided in a variety of shades, because the cement was considered to contribute the final shade of the restored unit (35). The composition of resin cements is similar to that of resin-based composite filling materials, containing four major components: organic polymer matrix, inorganic filler particles, coupling agent, and the initiator-accelerator system. The two most common oligomers which have been used in dental composites are dimethacrylates 2,2-bis[4(2-Hydroxy-3-methacryloxy-propyloxy)-phenyl] propane (Bis-GMA) and urethane dimethacrylate (UDMA). Both contain reactive carbon double bonds at each end which can undergo additional polymerization. The viscosity of the oligomers, especially Bis-GMA, is so high. Low molecular weight compounds with difunctional carbon double bonds, usually triethylene glycol dimethacrylate (TEGDMA) are added by the manufacturer to reduce and control the viscosity of the compound composite.

The purposes of filler particles are to reinforce the matrix resin and reduce polymerization shrinkage, thermal expansion, contraction, water sorption and staining

(36). Reduction of filler particle size and addition of diluents monomers have overcome initial problems with film thickness. A good bond must form between the inorganic filler and the organic oligomer by treating the surface of the filler with a coupling agent. The most common coupling agents are organic silicon compounds called silanes.

Classification of resin cements by polymerization reaction

1. Chemically activated resins

To ensure an optimal conversion in the entire cement layer, chemical luting agents have been suggested. Chemically activated products are supplied as two pastes, one which contains the benzoyl peroxide initiator and the other contains aromatic tertiary amine activator (e.g., N, N-dimethyl-*p*-toluidine). When the two pastes are mixed together, the amine reacts with the benzoyl peroxide to form free radicals, and additional polymerization is initiated. Disadvantages of these materials are relatively short working time. But a reduction of polymerization stress due to a slower hardening time can optimize the marginal adaptation and decrease risk for postoperative sensitivity.

2. Light activated resins

Light curable composite resins are supplied as a single paste in a light-proof syringe. The free radical initiating system, consisting of a photosensitizer and an amine initiator, is contained in this paste. Exposure to light in the blue region (wavelength of ~468 nm) produces an excited state of the photosensitizer, which then interacts with the amine to form free radicals and initiate the polymerization.

Camphorquinone is a commonly used photosensitizer which absorbs blue light with wavelengths between 400 and 500 nm. Only small quantities of camphorquinone are required (0.2 wt% or less in the paste). A number of amine initiators are suitable for interaction with camphorquinone, such as dimethylaminoethyl methacrylate (DMAEMA), which is also present at low levels, that is, approximately 0.15 wt%.

The advantages of using light cured products instead of chemically cured products include the following: (1) mixing is not required, which results in less porosity, less staining, and higher strength; (2) an aliphatic amine can be used instead of the aromatic amines required with chemical curing, thereby enhancing color stability; and (3) commanding polymerization on exposure to blue light provides control of working time. There are also several drawbacks to light cured materials: (1) limited curing depth; (2) relatively poor accessibility in certain posterior and interproximal locations; (3) variable exposure times because of shade differences, resulting in longer exposure times for darker shades and/ or increased opacity; and (4) sensitivity to room illumination (36).

3. Dual activated resins

In deeper parts of the cavity, light intensity is too low or absent to polymerize light cured materials. To ensure optimal conversion, a chemically activated system is combined with the visible light photo initiation system in the so-called dual cured materials consisting of two light-curable pastes, one containing benzoyl peroxide and the other containing an aromatic tertiary amine. When these two pastes are mixed and then exposed to light, light curing is promoted by the amine/ camphoquinone combination and chemical curing is promoted by the amine/ benzoyl peroxide interaction. Dual-cure materials are intended for any situation that does not allow sufficient light penetration to produce adequate monomer conversion, for example, cementation of bulky ceramic inlays. But the dual-cured resin cement which has not been light cured will show incomplete conversion and porous structure, which has a negative effect on marginal adaptation (37). This means that dual-cure cements have the same limitations as do light-activated systems, which are totally dependent on exposure time and light intensity. Ceramic and tooth substance, especially dark and opaque colors and the yellow dentin, attenuate light depending on their thickness and shade.

Color Stability of Composite Resin Materials

Clinical studies have demonstrated a discoloring potential of composite resin materials (38, 39). The discoloration may arise from a number of reasons which can be classified as extrinsic factor and intrinsic factor. Extrinsic factors are staining from foods (6-9) and external energy sources such as ambient, UV irradiation (12) and heat (40). Intrinsic factors are internal color change of the resinous material itself. Incomplete polymerization causes rough surface of composite resin materials resulting in higher water absorption which induces cracks and degradation (41). Instability of composite resin components such as amine, inhibitor, monomer content of Bis-GMA and peroxide may influence the internal discoloration.

All amines are known to form by-products during photoreaction, which tend to cause yellow to red/brown discolorations under the influence of light and/or heat. Bowen (11) and Dulik (10) found that color change of chemically cured materials is associated with the type and quantity of amine involved in the polymerization. Asmussen (13) found that light cured materials show less discoloration than chemically cured materials. Because the chemically cured materials are made to polymerize by a chromogenic compound, i.e. an aromatic, tertiary amine. On the other hand, the light cured materials are polymerized by a mechanism in which aromatic amine are not necessary. Further, the inhibitor has been found to play a role. A high concentrations of inhibitor incompletely reacted during polymerization, the remaining unreacted inhibitor may cause the color change in the polymerized resin. Besides amine and inhibitor, the monomer content of Bis-GMA and peroxide may influence the internal discoloration as well. Ruyter (42) stated that the monomer of Bis-GMA is not quite color stable, it tends to turn yellow. This tendency to yellowish may remain in the polymerized material, if all of the methacrylate groups of this monomer have not been converted. Ferracane et al (43) concluded that discoloration could be due to an oxidation of the unreacted carbon-carbon double bonds, producing yellow-colored peroxides.

Color Stability Test

There were many methods to test color stability of dental materials. They were as follows:

1. Xenon light source (according to ISO 7491, 2000): Xenon arc with ultraviolet filter of borosilicate glass, with transmittance of less than 1% below 300 nm and greater than 90% above 370 nm is used in the weathering chamber. The water shall be maintained at 37±5ºC and at a depth of 10±5 mm above the specimens.

2. Ultraviolet irradiation (according to ADA Specification Number 27, 1977): 400W ultraviolet lamp is used in weathering chamber at 60-65ºC. The specimens are sprayed with deionized water.

3. 60ºC water storage: According to a study by Asmussen (44), it was found that accelerated aging of the composite resins in 60ºC water in 1 month correlates well with the specimens stored in 37ºC water for 12 months.

4. Staining solution: Many studies used tea, coffee, juice, and red wine as staining solution (6-9).

Numerous tests have been used for artificial aging of restorative materials to investigate the color stability in vitro. The most common protocol is a combination of artificial light and storage at 100% relative humidity in water or water spray. Previous studies in color stability of resin cements by Noie (17) and Lu (18) have used the weathering machines with xenon arc filtered through borate borosilicate glass of 0.55 $W/m^2/nm$ at 340 nm which is equivalent to the UVA intensity of 60 W/m^2. Noie (17) reported that Optec and Porcelite resin cements were not perceptible color changes but most of 3M resin cements had perceptible color changes with ΔE greater than 3.3 after 179 hours of accelerated aging and the differences between light-cured and dual-cured samples were statistically significant but not perceptible. While Lu and Power (18) reported that all of the resin cements tested were perceptible color changes with ΔE greater than 3.3 after 115 hours of accelerated aging.

Color measurement

Many methods are being currently used to assess tooth color ranging from visual subjective comparisons (16) to instrumental objective measurements (17, 18). Visual color determination is a subjective process. Multiple variables such as external light conditions, the observer's experience, age, and fatigue of the eye may lead to the inconsistency and bias. Spectrophotometers generating instrumental objective measurements are designed to produce the most accurate color measurements by recording the reflectance or transmittance of an object at wavelengths in the visible range. There are two color specification systems which are widely used in dentistry; the Munsell System (19) and the CIE system (Commission Internationale de l'Eclairage or International Commission on Illumination) (20). CIELAB is the most complete color space developed by the CIE in 1976. A three dimensional representation of the CIELAB color space is shown in Fig. 1. The L* values of 0 and 100 represent a black and a reference white, respectively. The a* and b* values represent the redness-greenness, and yellowness-blueness attributes, respectively. Values from the CIE color system can be calculated to find a color difference between two colors as the following formula (20).

$$\Delta E = [(L^*_2 - L^*_1)^2 + (a^*_2 - a^*_1)^2 + (b^*_2 - b^*_1)^2]^{1/2} \text{ when}$$

L^*_2, a^*_2, b^*_2 represent L^*, a^*, b^* measured from standard sample.

L^*_1, a^*_1, b^*_1 represent L^*, a^*, b^* measured from tested sample.

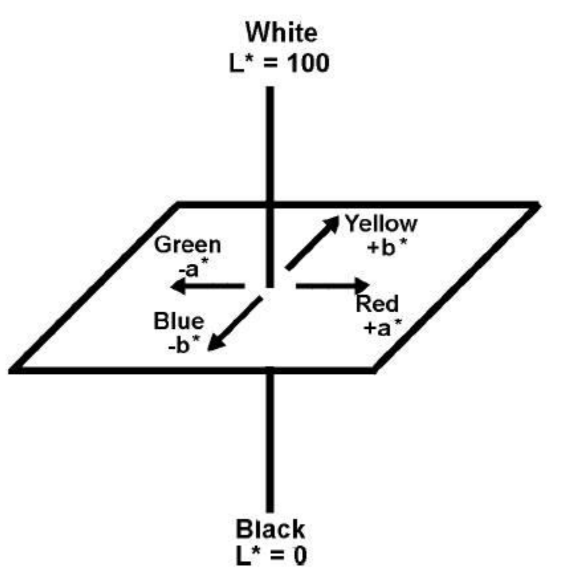

Fig. 1 CIELAB color space

Opacity (C) was represented by the contrast ratio, which is the ratio of the reflectance of a specimen disk when backed by a black standard to that when backed by a white standard as follows:

$C = y_b/y_w$ when

y_b represents the luminous reflectance with the specimen disc backed by a black standard

y_w represents the luminous reflectance with the specimen disc backed by a white standard

A review of the literature provided different values of color change which might be recognized by observers. A study by Ruyter (45) showed $\Delta E \geq 3.3$ is a clinically unacceptable color change. Kuehni and Marcus (46) found color differences of 1 ΔE unit can be visually detected by 50% of trained observers in ideal condition and $\Delta E \leq 2$ was clinically acceptable. Seghi (47) stated when $\Delta E > 2$, observers were able to always detect the difference in color (47). Since anterior teeth restorations have high esthetic requirements, $\Delta E \geq 1$ was considered as a perceptible color change in this study.

CHAPTER III

MATERIAL AND METHODS

Specimens

Three shades of four commercial resin cements were tested in this study. The shades included in the study were highly translucent shade, medium shade and opaque shade presented in Table 1.

Table 1 Materials used in this study

Brand/Shade	Batch no.	Manufacturer	Composition	
			Monomer matrix	**Filler**
NX3 (NX) Clear (C) Yellow (Y) White Opaque (WO)	 3321561 3304432 3198718	Kerr, Orange, CA, USA	BisGMA UDMA EBPADMA TEGDMA	Bariumaluminosilicate glass, Nano-sized ytterbium fluride, Colloidal silica 71.1 wt%
Variolink Veneer (VV) Medium Value 0 (M) Low Value -2 (L) High Value +3 (H)	 M33869 K12034 M25271	Ivoclar Vivadent, Schaan, Leichtenstein	Bis-GMA UDMA TEGDMA	Silicon dioxide, Ytterbium trifluoride 65.9 wt%
Variolink II (V2) Transparent (T) Yellow (Y) White Opaque (WO)	 M61732 M44875 M23971	Ivoclar Vivadent, Schaan, Leichtenstein	Bis-GMA UDMA TEGDMA	Silica, Barium glass, Ytterbium trifluoride, Ba-Al-fluorosilicant glass 73.4 wt%
RelyX Veneer (RV) Translucent (T) A3 (A3) White Opaque (WO)	 7614TR 7614A3 7614WO	3M ESPE, St. Paul, MN, USA	Bis-GMA TEGDMA	Zirconia/silica and fumed silica filler 66 wt%

Preparation of the specimens

Sixteen disk specimens, 15 mm in diameter and 1 mm in thickness (Fig. 2), were prepared for each shade using acrylic split molds. The resin cement was injected into the mold. The mold was then pressed between glass slides and the excess was removed. The top surface of each sample was irradiated in 5 overlapping areas for 40 seconds each using a light curing unit (Elipar Trilight, 3M ESPE, Seefeld, Germany) with a light intensity of 750 mW/cm2 operating on the standard mode (Fig. 3). For each shade, the 16 disk specimens were divided in 2 subgroups, subgroup 1 was stored in dry and dark condition at room temperature; subgroup 2 was stored in deionized water at room temperature. Both groups were stored for 24 hours after which initial color values were measured.

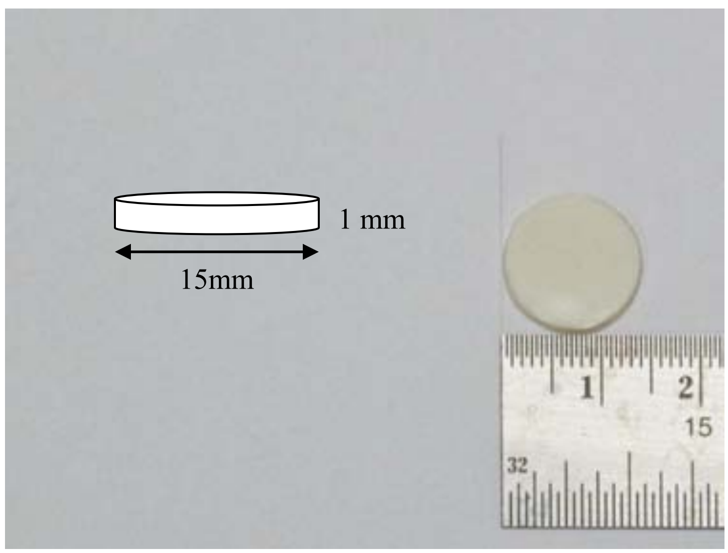

Fig. 2 Prepared specimen

Fig. 3 Light curing unit (Elipar Trilight, 3M ESPE, Seefeld, Germany)

Color Measurement

Color measurement was made before (as a baseline after 24 hours of storage) and after artificial aging. The CIE L*a*b* color system was used to measure the color of the samples in reflected light on white and black background using a spectrophotometer (Ultrascan XE, Hunter Lab, Reston, VA, USA) (Fig. 4). The spectrophotometer, using standard illuminant D65 with 10º viewing angle, was calibrated using black and white standards. The specimens were positioned with a custom-made jig. The spectrophotometer software automatically measured each sample five times and reported an average value. The CIE L*a*b* color difference (ΔE) was calculated using the following equation:

$$\Delta E = [(L^*_2 - L^*_1)^2 + (a^*_2 - a^*_1)^2 + (b^*_2 - b^*_1)^2]^{1/2} \text{ when}$$

L^*_1, a^*_1, b^*_1 represent L^*, a^*, b^* measured from sample before aging

L^*_2, a^*_2, b^*_2 represent L^*, a^*, b^* measured from sample after aging

Fig. 4 Spectrophotometer (Ultrascan XE, Hunter Lab, Reston, VA, USA)

Artificial Aging Procedure

After initial color measurement, subgroup 1 was stored in an incubator (Fig. 5) at 37ºC in dark and dry condition as a control group, subgroup 2 was artificially aged in the custom-made UV chamber (Fig. 6, 7) in deionized water 10±3 mm above the specimens at 31±2ºC. The chamber consisted of UV light source (TL 20W/10, Philips, Pila, Poland) placed on the top of the chamber 70 mm away from the top surface of the specimens to obtain a UVA intensity of 62 W/m^2. The UV light source was monitored using a UVA meter (UVA-400-C, National Biological Corporation, Twinsberg, OH, USA) to ensure consistent output. Samples were evaluated for color changes after aging at day 1, 3, 5, and 7 and also at the end of weeks 2, 3, 4, 8, and 12 of aging.

Fig. 5 Incubator

Fig. 6 UV Chamber

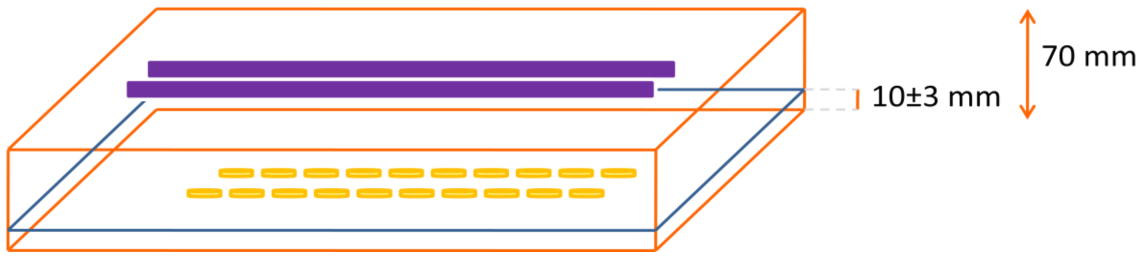

Fig. 7 Model of UV Chamber

Statistical analysis

Statistical analysis was conducted by using SigmaStat software (Systat Software Inc, Chicago, IL, USA). Two Way Repeated Measures Analysis of Variance was used followed by Tukey post hoc test. Statistical significance was considered at $P < 0.05$ for all tests.

CHAPTER IV

RESULTS

The results for ΔE over the course of the entire study are seen in Figure 8. After 12 weeks, the ΔE values ranged from 1.07 to 5.30 for the control groups and from 1.66 to 6.31 for the artificial aging groups. All artificial aging samples showed a greater color change compared to the samples kept in the dark except for NXC. For the UVA exposed samples, VVH showed the greatest color change (ΔE = 6.31) while RVA3 showed the smallest (ΔE = 1.66). Statistical analysis showed that the aging conditions and times significantly influenced the color change of each material except for RVA3 which there was no significant difference between the aging conditions. All interactions were significant.

The changes in the mean lightness, chromaticity, opacity, and total color change (ΔL*, Δa*, Δb*, ΔC, ΔE) measured in all groups after 12 weeks, are presented in Table 2. The main component of discoloration in both exposed and control groups was a decrease in L*. All mean ΔL* values were negative, indicating a darker appearance, except for RVA3 and RVT. The exposed groups had a greater change in L* value than the control groups. Mean Δa* values for the exposed groups were positive, indicating a less green and more red appearance of materials after artificial aging, except for NXY. However, the changes in b* values varied among brands and shades. All of the samples showed an increase in opacity after 12 weeks except for V2T and V2Y.

In general, for each brand, the lighter shades (translucent and white opaque shades) had a greater degree of color change than the darker shade (yellow). All specimens underwent their largest change during the first week. The least color change after accelerated aging was shown by RelyX Veneer, with a ΔE value ranging from 1.66 to 2.44. The highest color change after accelerated aging was shown by Variolink Veneer, with the ΔE value ranging from 6.15 to 6.31.

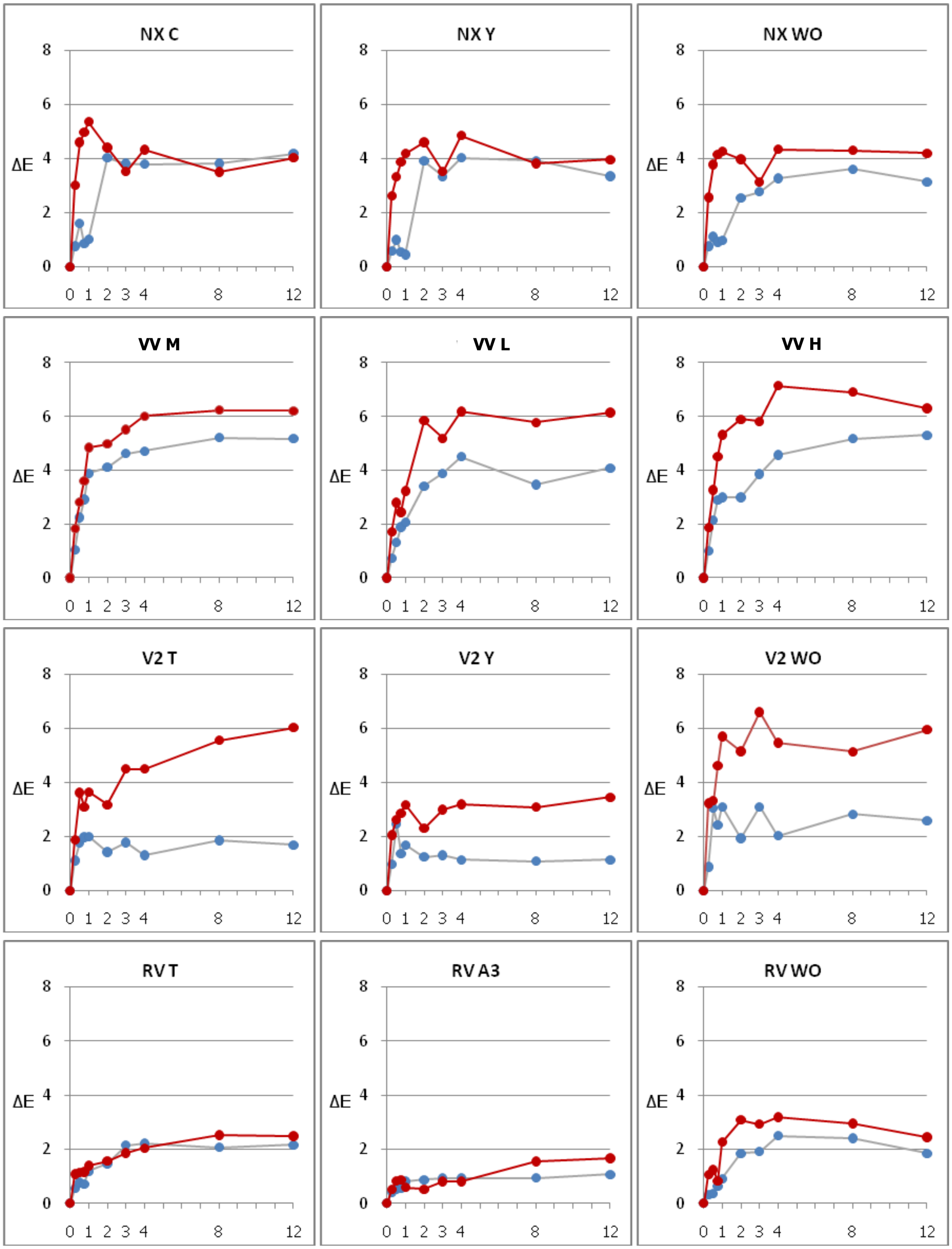

Figure. 8 Color difference values (ΔE) of control (—●—) and accelerated aging (—●—) resin cements over 12 weeks.

Table II The changes of the mean lightness (ΔL*), chromaticity (Δa*, Δb*), opacity (ΔC), and total color (ΔE) after 12 weeks

		Control					UV				
		ΔL*	Δa*	Δb*	ΔC	ΔE	ΔL*	Δa*	Δb*	ΔC	ΔE
NX	C	-2.80	-0.20	+3.10	+4.44	4.18 (±1.63)	-3.84	+1.01	-0.67	+3.81	4.03 (±0.15)
	Y	-3.23	-0.08	-0.88	+4.65	3.34 (±0.57)	-3.41	-0.49	-1.94	+3.11	3.96 (±0.43)
	WO	-2.82	-0.23	+1.34	+2.97	3.14 (±0.67)	-3.72	+1.73	-0.86	+2.68	4.19 (±0.23)
VV	M	-4.56	+1.82	+1.66	+4.26	5.18 (±0.18)	-5.08	+2.91	+2.04	+3.74	6.21 (±0.25)
	L	-3.67	-0.50	+1.71	+5.23	4.08 (±0.46)	-3.22	+1.39	-5.06	+2.85	6.15 (±0.56)
	H	-3.32	-0.40	+4.11	+3.78	5.30 (±0.35)	-4.52	+4.40	+0.11	+8.60	6.31 (±0.52)
V2	T	-0.84	-0.09	+1.41	+1.48	1.68 (±0.32)	-3.61	+2.99	+3.73	-1.24	6.02 (±0.26)
	Y	-0.58	+0.17	+0.93	+0.30	1.13 (±0.21)	-2.46	+2.10	+1.10	-1.82	3.45 (±0.34)
	WO	-2.12	+0.57	+1.36	+2.72	2.59 (±0.38)	-5.04	+0.78	+3.07	+2.14	5.95 (±0.45)
RV	T	+1.37	+0.69	-1.46	-2.10	2.16 (±0.39)	+0.83	+2.12	-0.32	-1.78	2.29 (±0.19)
	A3	+0.92	+0.21	+0.42	-2.66	1.07 (±0.31)	+0.70	+0.27	+1.28	-3.46	1.66 (±0.17)
	WO	-1.50	-0.03	-1.06	+2.90	1.84 (±0.28)	-2.36	+0.01	+0.62	+2.28	2.44 (±0.38)

CHAPTER V

DISCUSSION

The present study examined the color change of various shades of resin cements from multiple manufacturers following up to 12 weeks of accelerated aging by ultraviolet light. Color stability is an important factor in the long term success of esthetic restorations. Clinical studies of porcelain laminate veneers demonstrated marginal discoloration increases over time (4, 5). However, this present study focused on internal discoloration only. Since color instability resulting from internal color changes are due to chemical changes in the material's composition itself, this cannot be eliminated by polishing, as can be done for external discoloration.

Numerous in vitro assays have been used for the artificial aging of restorative materials to investigate color stability. The most common protocol is a combination of artificial light and storage at 100% relative humidity in water or water spray. This protocol is intended to reproduce the weathering effects which occur when materials are exposed to sunlight and moisture. While this procedure differs from the oral environment, it was chosen because the intention was to induce property changes associated with moisture, heat, and oxidation. From a pilot study, we found there was no further drastic color change between weeks 8 to 12. Therefore, in the present study, 12 weeks of exposure to ultraviolet light through water were used.

A review of the literature provided different values for color change which could be differentiated by observers. A study by Ruyter (45) showed $\Delta E \geq 3.3$ is a clinically unacceptable color change. Kuehni and Marcus (46) found color differences of 1 ΔE unit could be visually detected by 50% of trained observers under ideal conditions and $\Delta E \leq 2$ was clinically acceptable. Seghi (47) stated when $\Delta E > 2$, observers were always able to detect a difference in color (47). Since anterior teeth restorations have high esthetic requirements, $\Delta E \geq 1$ was considered as a perceptible color change in this study.

After the first week of aging, NX3 had the greatest color change among the exposed groups and there was no further significant color change between day 7 and week 12 in this brand. From week 2 to 12, Variolink Veneer had the greatest color change among the exposed groups. In contrast, RelyX Veneer had the least color change throughout the duration of this study. However, all of the resin cements tested had a ΔE greater than 1 after 12 weeks of artificial aging. This indicates all of the resin cements tested had perceptible color changes. The ΔE values of the control groups ranged from 1.07 to 5.18 and those of the exposed groups ranged from 1.66 to 6.31. It seems that the color change of the exposed groups was not obviously different from the change observed in the control groups. Asmussen (13) found that the use of UV absorbers in commercial resins can partly diminish the UV degradation process of the materials.

Ultraviolet light degrades the polymer matrix by photolysis and photo-oxidation resulting in bond breaking and subsequent chemical alteration. These alterations can cause changes in the physical, mechanical, and optical properties of the materials. The degree of change depends on the amount of ultraviolet light exposure, material composition, the number of C=C double bonds, and the presence of an ultraviolet stabilizer (48). The result of our study was in accordance with a previous study (18) which also found resin cements underwent discoloration after artificial aging. However, all of the resin cements tested in our study had ΔE values greater than 1, including the control groups. This indicates the materials still change color even in dark and dry conditions. This suggests the materials' compositions have a degree of inherent color instability. In the present study, the resin cements tested showed a color shift from green to red (positive Δa^*) and became darker (negative ΔL^*) after 12 weeks. The control groups had less negative ΔL^* than the exposed groups, and only a slight change of Δa^* values. From these results, it can be concluded that ultraviolet light can induce resin cements to become darker and more reddish in color. This confirms a previous study (17) which also found that the resin cements tested generally decreased in value. Our findings demonstrating the color shift patterns of resin cements varied among brands and shades is also supported by the results of previous studies (17, 18).

Most of the samples showed an increase in opacity after 12 weeks for both control and artificial aged groups except Variolink II and RelyX Veneer in translucent and yellow shades. This agrees with a prior study (49) which also found an increase in opacity of the composite resins. The increased opacity might be attributed to surface deterioration and surface roughening during storage in the weather chamber (21). However, the UV exposed groups had less increase in opacity than observed in the control groups which can be explained that the water absorbed in resin matrix alters the scattering pattern and lead to mutation in composite opacity (50). At this time, there is no study available for the level of clinical acceptance of opacity changes.

Our study demonstrated the resin cements tested became more reddish in color. This color change may be attributed to the formation of amine by-products during photoreaction. These by-products tend to cause yellow to red/brown discolorations under the influence of light and/or heat (14). Variolink II is a dual-cured resin cement which contains both aromatic and aliphatic amines in the base paste. RelyX Veneer is a light-cured resin cement containing only aliphatic amine which is more color stable than aromatic amines. This is likely why RelyX Veneer had the least color change observed among the test samples in our study. NX3 uses a novel initiator instead of amine, the nature of which is proprietary. The manufacturer of Variolink Veneer claims a reduction of the amine content, but color changes were still observed in our study. The color changes in all the samples may be also due to the degradation of the resin components. Furthermore, the color shifts observed in this study may be related to the nature of the resin matrix in each individual brand. The different levels of water sorption in the individual resin matrices and the use of different monomers in individual formulations might also cause the materials to vary in color (51). Thus, in spite of a decrease in amine content, Variolink Veneer may undergo a color change based on these effects. It was also found that different Bis-GMA/TEGDMA ratios affect the color stability of resin materials (52). Notably, RelyX Veneer is the only resin cement tested in our study without UDMA and RelyX Veneer underwent the least color change. This agrees with a study (53) which also found a higher degree of color change in a composite resin with UDMA. However, there is no study on the color stability of UDMA available in the literature. The effects of monomer content and ratio on color stability should be further studied.

Other factors can influence the color changes observed over time. A high volume fraction of resin also has an effect on the level of discoloration. It is believed that a higher resin content is less resistant to photolysis, photo-oxidation, and water sorption (54). The proportion of filler-matrix interface was also found to play a role in water uptake, with a decrease in the interface allowing for greater water uptake. This could be due to the breakdown of the siloxane bond between the resin and filler particles (55). The inhibitor present in the resin can also influence the discoloration of the materials (11). This might result in the darkening (negative ΔL^*) observed in the tested specimens in our study.

It is clear that the composition of the resin matrix in combination with the quality of the polymerization reaction is responsible for the color stability of the studied materials. These factors may also affect the color shift patterns of these materials. The color instability of the resin cements tested in the present study was confirmed. This instability can be a cause of esthetic failure in long-term clinical use.

CHAPTER VI

CONCLUSIONS

Within the limitations of this in vitro study, the following can be concluded:

1. All of the resin cements tested in this study exhibited perceptible color changes after artificial aging by ultraviolet irradiation.
2. Variolink Veneer exhibited the greatest ΔE values and RelyX Veneer exhibited the lowest ΔE values after artificial aging.
3. After artificial aging, most of the resin cements tested became darker and more reddish in color.

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APPENDIX

APPENDIX

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STATISTIC ANALYSIS

Tests of Normality

brand	shade	condition		day 1	day 3	day 5	day 7	wk 2	wk 3	wk 4	wk 8	wk 12
NX3	Y	control	N	8	8	8	8	8	8	8	8	8
			Kolmogorov-Smirnov Z	.428	.495	.622	.617	.632	.382	.465	.626	.538
			Asymp. Sig. (2-tailed)	.993	.967	.834	.841	.820	.999	.982	.829	.934
		UV	N	8	8	8	8	8	8	8	8	8
			Kolmogorov-Smirnov Z	.659	.351	.553	.577	.398	.416	.478	.615	.613
			Asymp. Sig. (2-tailed)	.778	1.000	.920	.894	.997	.995	.976	.845	.847
	WO	control	N	8	8	8	8	8	8	8	8	8
			Kolmogorov-Smirnov Z	.345	.621	.419	.699	.562	.770	.776	.575	.513
			Asymp. Sig. (2-tailed)	1.000	.835	.995	.712	.910	.594	.583	.895	.955
		UV	N	8	8	8	8	8	8	8	8	8
			Kolmogorov-Smirnov Z	.618	.626	.666	.665	.417	.433	.635	.532	.500
			Asymp. Sig. (2-tailed)	.840	.829	.766	.768	.995	.992	.815	.939	.964
	C	control	N	8	8	8	8	8	8	8	8	8
			Kolmogorov-Smirnov Z	.623	.678	.532	.402	.439	.508	.586	.530	.755
			Asymp. Sig. (2-tailed)	.833	.747	.940	.997	.990	.959	.882	.942	.619
		UV	N	8	8	8	8	8	8	8	8	8
			Kolmogorov-Smirnov Z	.608	.515	.784	.774	.541	.415	.607	.573	.363
			Asymp. Sig. (2-tailed)	.853	.954	.570	.586	.931	.995	.854	.898	.999
VV	L	control	N	8	8	8	8	8	8	8	8	8
			Kolmogorov-Smirnov Z	.651	.629	.573	.588	.381	.647	.420	.622	.505
			Asymp. Sig. (2-tailed)	.790	.824	.898	.879	.999	.796	.995	.834	.960
		UV	N	8	8	8	8	8	8	8	8	8
			Kolmogorov-Smirnov Z	.520	.567	.560	.525	.339	.497	.591	.719	.499
			Asymp. Sig. (2-tailed)	.949	.905	.912	.945	1.000	.966	.876	.679	.965
	H	control	N	8	8	8	8	8	8	8	8	8
			Kolmogorov-Smirnov Z	.525	.924	.493	.409	.571	.674	.749	.363	.757
			Asymp. Sig. (2-tailed)	.945	.361	.968	.996	.901	.755	.628	.999	.616
		UV	N	8	8	8	8	8	8	8	8	8
			Kolmogorov-Smirnov Z	.673	.554	.357	.460	.545	.606	.611	.413	.536
			Asymp. Sig. (2-tailed)	.756	.919	1.000	.984	.928	.856	.849	.996	.936
	M	control	N	8	8	8	8	8	8	8	8	8
			Kolmogorov-Smirnov Z	.657	.617	.643	.577	.690	.521	.496	.503	.652

			Asymp. Sig. (2-tailed)	.781	.842	.803	.893	.728	.949	.967	.962	.789
		UV	N	8	8	8	8	8	8	8	8	8
			Kolmogorov-Smirnov Z	.363	.568	.524	.792	.538	.430	.669	.439	.376
			Asymp. Sig. (2-tailed)	.999	.904	.947	.558	.935	.993	.762	.990	.999
RV	A3	control	N	8	8	8	8	8	8	8	8	8
			Kolmogorov-Smirnov Z	.479	.579	.431	.730	.657	.700	.572	.494	.537
			Asymp. Sig. (2-tailed)	.976	.891	.992	.661	.780	.711	.899	.967	.936
		UV	N	8	8	8	8	8	8	8	8	8
			Kolmogorov-Smirnov Z	.875	.685	.619	.693	.471	.441	.382	.525	.624
			Asymp. Sig. (2-tailed)	.428	.736	.838	.723	.979	.990	.999	.946	.832
	WO	control	N	8	8	8	8	8	8	8	8	8
			Kolmogorov-Smirnov Z	.520	.714	.645	.652	1.005	.406	.360	.774	.569
			Asymp. Sig. (2-tailed)	.950	.688	.800	.789	.265	.997	.999	.587	.902
		UV	N	8	8	8	8	8	8	8	8	8
			Kolmogorov-Smirnov Z	.563	.457	.485	.469	.552	.474	.498	.773	.973
			Asymp. Sig. (2-tailed)	.910	.985	.973	.981	.921	.978	.965	.588	.300
	T	control	N	8	8	8	8	8	8	8	8	8
			Kolmogorov-Smirnov Z	.449	.393	.557	.926	.693	.476	.870	.665	.547
			Asymp. Sig. (2-tailed)	.988	.998	.915	.358	.724	.977	.435	.769	.926
		UV	N	8	8	8	8	8	8	8	8	8
			Kolmogorov-Smirnov Z	.719	.667	.566	.610	.707	.685	.443	.473	.361
			Asymp. Sig. (2-tailed)	.680	.766	.906	.851	.699	.737	.989	.979	.999
V2	Y	control	N	8	8	8	8	8	8	8	8	8
			Kolmogorov-Smirnov Z	.556	.584	.996	.605	.364	.609	.492	.646	.445
			Asymp. Sig. (2-tailed)	.916	.885	.274	.857	.999	.852	.969	.798	.989
		UV	N	8	8	8	8	8	8	8	8	8
			Kolmogorov-Smirnov Z	.646	.622	.413	.497	.680	.554	.578	.509	.451
			Asymp. Sig. (2-tailed)	.799	.834	.996	.966	.744	.919	.891	.958	.987
	WO	control	N	8	8	8	8	8	8	8	8	8
			Kolmogorov-Smirnov Z	.548	.555	.592	.629	.672	.614	.557	.595	.532
			Asymp. Sig. (2-tailed)	.925	.918	.875	.824	.757	.846	.916	.871	.939
		UV	N	8	8	8	8	8	8	8	8	8
			Kolmogorov-Smirnov Z	.804	.440	.707	.681	.513	.689	.567	.408	.454
			Asymp. Sig. (2-tailed)	.538	.990	.699	.743	.955	.730	.905	.996	.986
	T	control	N	8	8	8	8	8	8	8	8	8
			Kolmogorov-Smirnov Z	.520	.403	.428	.607	.814	.544	.397	.621	.732
			Asymp. Sig. (2-tailed)	.949	.997	.993	.855	.522	.928	.997	.835	.658
		UV	N	8	8	8	8	8	8	8	8	8

	Kolmogorov-Smirnov Z	.900	.584	.775	.667	.461	.409	.826	.651	.474
	Asymp. Sig. (2-tailed)	.393	.885	.584	.766	.984	.996	.502	.791	.978

a Test distribution is Normal.
b Calculated from data.

Descriptive Statistics

brand	shade	condition		N	Mean	Std. Deviation	Minimum	Maximum
NX3	Y	control	day1	8	.6375	.13499	.42	.83
			day3	8	1.0863	.32846	.66	1.48
			day5	8	1.0875	.54502	.62	2.22
			day7	8	.7713	.27513	.42	1.11
			wk2	8	3.9363	.22557	3.47	4.13
			wk3	8	3.3775	.57268	2.32	4.15
			wk4	8	4.0963	.55706	3.33	4.88
			wk8	8	4.0600	.83409	3.26	5.85
			wk12	8	3.6238	.57066	2.88	4.63
		UV	day1	8	2.7013	.62529	2.06	3.65
			day3	8	3.3788	.49392	2.75	4.20
			day5	8	3.9338	.62919	3.27	5.04
			day7	8	4.1850	.46269	3.26	4.72
			wk2	8	4.6000	.49521	4.01	5.47
			wk3	8	3.5175	.31527	3.15	3.99
			wk4	8	4.8688	.36884	4.23	5.38
			wk8	8	3.8438	.41082	3.08	4.47
			wk12	8	4.0075	.43206	3.46	4.56
	WO	control	day1	8	.8088	.16864	.59	1.07
			day3	8	1.1413	.24527	.79	1.56
			day5	8	.9550	.25917	.65	1.36
			day7	8	1.0188	.25295	.69	1.38
			wk2	8	2.5688	.33069	2.14	3.17
			wk3	8	2.7938	.67498	2.04	3.62
			wk4	8	3.3038	.49529	2.83	4.40
			wk8	8	3.6600	.60119	2.90	4.56
			wk12	8	3.1925	.66701	2.38	4.47
		UV	day1	8	2.6938	.33110	2.29	3.38
			day3	8	3.8950	.36641	3.21	4.53
			day5	8	4.2700	.27646	3.80	4.80
			day7	8	4.3800	.26875	3.97	4.85
			wk2	8	4.1000	.32338	3.69	4.59
			wk3	8	3.2725	.29286	2.78	3.70
			wk4	8	4.4163	.37512	3.91	4.84
			wk8	8	4.3600	.26484	4.03	4.87
			wk12	8	4.2338	.23145	3.81	4.47
	C	control	day1	8	.8463	.13071	.72	1.10

			day3	8	1.6788	.57856	1.10	2.58
			day5	8	1.4013	.65503	.73	2.56
			day7	8	1.1113	.63474	.27	2.07
			wk2	8	4.0938	.59493	3.16	5.08
			wk3	8	3.9325	.75596	3.03	5.22
			wk4	8	3.9463	.80036	3.00	5.42
			wk8	8	4.0213	1.37568	2.80	6.90
			wk12	8	4.3713	1.62743	2.96	7.62
		UV	day1	8	3.0375	.38466	2.38	3.47
			day3	8	4.6238	.43045	4.01	5.24
			day5	8	4.9713	.42147	4.11	5.61
			day7	8	5.3713	.46774	4.39	5.83
			wk2	8	4.4513	.54530	3.67	5.47
			wk3	8	3.5550	.49115	2.82	4.35
			wk4	8	4.3538	.29199	3.85	4.64
			wk8	8	3.5263	.47135	2.71	4.16
			wk12	8	4.0588	.14565	3.80	4.25
VV	L	control	day1	8	.7500	.14976	.54	.97
			day3	8	1.3325	.18038	1.02	1.51
			day5	8	1.9325	.34508	1.28	2.41
			day7	8	2.1175	.51274	1.51	3.08
			wk2	8	3.4500	.26371	3.03	3.90
			wk3	8	3.9063	.39373	3.26	4.38
			wk4	8	4.5275	.38444	4.03	5.11
			wk8	8	4.7950	.38638	4.11	5.23
			wk12	8	4.1238	.46595	3.32	4.63
		UV	day1	8	1.7763	.46473	1.14	2.34
			day3	8	2.8313	.49212	1.90	3.48
			day5	8	2.4750	.51511	1.82	3.15
			day7	8	3.2513	.70247	2.12	4.03
			wk2	8	5.8588	.67240	4.77	6.98
			wk3	8	5.2050	.55962	4.14	5.86
			wk4	8	6.2000	.58260	5.04	7.08
			wk8	8	5.7863	.54055	4.64	6.36
			wk12	8	6.1588	.55681	5.25	6.81
	H	control	day1	8	1.0113	.13131	.81	1.20
			day3	8	2.1650	.18111	1.96	2.52
			day5	8	2.9150	.13115	2.70	3.15
			day7	8	3.0013	.17675	2.77	3.27
			wk2	8	3.0200	.11686	2.86	3.18
			wk3	8	3.8775	.26429	3.63	4.45
			wk4	8	4.5813	.32011	4.24	4.98
			wk8	8	5.1750	.35071	4.60	5.66
			wk12	8	5.3163	.34731	4.80	5.66
		UV	day1	8	1.8763	.08280	1.74	1.99
			day3	8	3.2988	.37616	2.91	4.10
			day5	8	4.5488	.47532	3.79	5.37

			day7	8	5.3350	.27646	4.93	5.82
			wk2	8	5.9163	.25094	5.38	6.21
			wk3	8	5.8388	.45930	5.34	6.79
			wk4	8	7.1575	.44203	6.40	7.96
			wk8	8	6.9163	.25707	6.54	7.27
			wk12	8	6.3288	.52401	5.83	7.28
	M	control	day1	8	1.0363	.09650	.90	1.18
			day3	8	2.2338	.27103	1.97	2.70
			day5	8	2.9100	.28112	2.59	3.36
			day7	8	3.8888	.25125	3.61	4.28
			wk2	8	4.1138	.25746	3.80	4.63
			wk3	8	4.6238	.22148	4.34	4.98
			wk4	8	4.7100	.24923	4.37	5.07
			wk8	8	5.2175	.24464	4.87	5.60
			wk12	8	5.1788	.17900	4.85	5.38
		UV	day1	8	1.8250	.15811	1.53	2.03
			day3	8	2.8263	.17647	2.55	3.00
			day5	8	3.6088	.14653	3.41	3.77
			day7	8	4.8375	.15682	4.59	5.01
			wk2	8	4.9788	.19060	4.68	5.18
			wk3	8	5.5238	.23952	5.11	5.86
			wk4	8	6.0163	.29554	5.44	6.43
			wk8	8	6.2413	.24695	5.78	6.57
			wk12	8	6.2150	.24991	5.75	6.52
RV	A3	control	day1	8	.4100	.14736	.17	.67
			day3	8	.5250	.12456	.36	.71
			day5	8	.5538	.12906	.38	.80
			day7	8	.8050	.24940	.48	1.31
			wk2	8	.8675	.28060	.50	1.43
			wk3	8	.9213	.20890	.64	1.27
			wk4	8	.9325	.31240	.55	1.52
			wk8	8	.9438	.28324	.56	1.46
			wk12	8	1.0725	.31340	.65	1.67
		UV	day1	8	.5125	.22670	.23	1.01
			day3	8	.8238	.25179	.44	1.09
			day5	8	.8563	.43385	.30	1.58
			day7	8	.5925	.15554	.37	.78
			wk2	8	.5200	.16009	.28	.74
			wk3	8	.7963	.19456	.48	1.04
			wk4	8	.8038	.21132	.54	1.14
			wk8	8	1.2038	.15268	1.03	1.44
			wk12	8	1.6588	.17291	1.31	1.91
	WO	control	day1	8	.3675	.18522	.14	.72
			day3	8	.4763	.17303	.31	.86
			day5	8	.6500	.11539	.50	.79
			day7	8	.9263	.08749	.80	1.04
			wk2	8	1.9088	.22744	1.68	2.44

			wk3	8	1.9300	.18501	1.71	2.21
			wk4	8	2.5138	.32759	2.05	2.92
			wk8	8	2.4188	.35831	1.71	2.90
			wk12	8	1.8563	.27923	1.34	2.16
		UV	day1	8	1.0825	.21579	.81	1.41
			day3	8	1.2488	.19313	.89	1.55
			day5	8	.8938	.11963	.69	1.09
			day7	8	2.2688	.30559	1.68	2.68
			wk2	8	3.1038	.37163	2.51	3.79
			wk3	8	2.9438	.36008	2.38	3.43
			wk4	8	3.1913	.50107	2.30	3.99
			wk8	8	2.9600	.39374	2.54	3.59
			wk12	8	2.4600	.37827	2.22	3.17
	T	control	day1	8	.5388	.25159	.19	.92
			day3	8	.7650	.25818	.44	1.17
			day5	8	.7125	.12395	.58	.91
			day7	8	1.1725	.14597	1.01	1.49
			wk2	8	1.4575	.19455	1.26	1.85
			wk3	8	2.1175	.28888	1.84	2.62
			wk4	8	2.1863	.32889	1.94	2.74
			wk8	8	2.0438	.29957	1.74	2.56
			wk12	8	2.1288	.39310	1.72	2.80
		UV	day1	8	1.0763	.27197	.66	1.64
			day3	8	1.1350	.13990	.99	1.36
			day5	8	1.2225	.13936	1.05	1.48
			day7	8	1.4238	.15510	1.09	1.59
			wk2	8	1.6200	.13016	1.36	1.78
			wk3	8	1.8925	.12510	1.67	2.08
			wk4	8	2.0838	.17295	1.86	2.40
			wk8	8	2.2988	.13357	2.13	2.47
			wk12	8	2.3300	.18447	2.05	2.61
V2	Y	control	day1	8	.9700	.41050	.29	1.76
			day3	8	2.4500	.25785	1.99	2.73
			day5	8	1.3700	.23146	1.08	1.88
			day7	8	1.6850	.20473	1.34	2.07
			wk2	8	1.2350	.32781	.72	1.72
			wk3	8	1.3125	.25789	.92	1.55
			wk4	8	1.1388	.28568	.71	1.56
			wk8	8	1.0813	.34140	.63	1.48
			wk12	8	1.1338	.21267	.73	1.40
		UV	day1	8	2.0550	.35380	1.40	2.46
			day3	8	2.6275	.38220	2.16	3.22
			day5	8	2.8613	.32348	2.38	3.27
			day7	8	3.1663	.39453	2.68	3.95
			wk2	8	2.2988	.26835	2.00	2.77
			wk3	8	2.9913	.32498	2.32	3.36
			wk4	8	3.1913	.25335	2.92	3.60

		wk8	8	3.0825	.29697	2.56	3.53
		wk12	8	3.4488	.33766	3.06	4.06
WO	control	day1	8	.8838	.20473	.64	1.21
		day3	8	3.0450	.32143	2.51	3.34
		day5	8	2.4188	.37023	1.94	2.94
		day7	8	3.0913	.59465	1.95	3.64
		wk2	8	1.9313	.31041	1.42	2.40
		wk3	8	3.0875	.77121	1.92	4.00
		wk4	8	2.0175	.24353	1.74	2.40
		wk8	8	2.8213	.48792	2.14	3.70
		wk12	8	2.5938	.38273	2.05	3.29
	UV	day1	8	3.2300	.43886	2.75	3.77
		day3	8	3.3200	.29957	2.95	3.81
		day5	8	4.6100	.65402	3.13	5.13
		day7	8	5.7013	.40105	5.15	6.09
		wk2	8	5.1500	.61542	4.11	5.98
		wk3	8	6.6000	.49731	5.76	7.12
		wk4	8	5.4613	.57215	4.39	6.23
		wk8	8	5.1313	.39582	4.57	5.73
		wk12	8	5.9500	.45036	5.35	6.63
T	control	day1	8	1.1150	.28193	.67	1.43
		day3	8	1.7788	.48067	1.01	2.44
		day5	8	1.9725	.28962	1.61	2.49
		day7	8	2.0013	.19657	1.59	2.20
		wk2	8	1.4350	.15847	1.20	1.74
		wk3	8	1.7700	.25270	1.32	2.19
		wk4	8	1.3100	.28998	.86	1.71
		wk8	8	1.8525	.34383	1.22	2.45
		wk12	8	1.6763	.31690	1.24	2.30
	UV	day1	8	1.8788	.27982	1.49	2.15
		day3	8	3.6213	.35462	3.26	4.16
		day5	8	3.0975	.22840	2.84	3.53
		day7	8	3.6388	.24445	3.37	4.11
		wk2	8	3.1725	.28434	2.73	3.49
		wk3	8	4.4963	.27974	4.14	4.90
		wk4	8	4.4950	.26630	4.24	4.96
		wk8	8	5.5463	.36269	5.10	6.01
		wk12	8	6.0175	.26054	5.58	6.37

Repeated Measures ANOVA

NX Y

Equal Variance Test: Passed (P = 0.263)

Source of Variation	DF	SS	MS	F	P
subject	7	8.190	1.170		
condition	1	67.898	67.898	80.951	<0.001
condition x subject	7	5.871	0.839		
time	8	129.058	16.132	132.839	<0.001
time x subject	56	6.801	0.121		
condition x time	8	54.184	6.773	41.357	<0.001
Residual	56	9.171	0.164		
Total	143	281.172	1.966		

NX WO

Equal Variance Test: Passed (P = 0.450)

Source of Variation	DF	SS	MS	F	P
subject	7	2.835	0.405		
condition	1	116.334	116.334	186.774	<0.001
condition x subject	7	4.360	0.623		
time	8	70.109	8.764	81.848	<0.001
time x subject	56	5.996	0.107		
condition x time	8	38.903	4.863	48.678	<0.001
Residual	56	5.594	0.0999		
Total	143	244.132	1.707		

NX C

Equal Variance Test: Passed (P = 0.077)

Source of Variation	DF	SS	MS	F	P
subject	7	14.807	2.115		
condition	1	69.959	69.959	18.120	0.004
condition x subject	7	27.026	3.861		
time	8	70.019	8.752	63.061	<0.001
time x subject	56	7.772	0.139		
condition x time	8	110.625	13.828	61.420	<0.001
Residual	56	12.608	0.225		
Total	143	312.817	2.188		

VV L

Equal Variance Test: Passed (P = 0.757)

Source of Variation	DF	SS	MS	F	P
subject	7	8.316	1.188		
condition	1	70.644	70.644	39.480	<0.001

condition x subject	7	12.525	1.789		
time	8	333.517	41.690	532.689	<0.001
time x subject	56	4.383	0.0783		
condition x time	8	10.512	1.314	21.187	<0.001
Residual	56	3.473	0.0620		
Total	143	443.371	3.100		

VV H

Equal Variance Test: Passed (P = 0.682)

Source of Variation	**DF**	**SS**	**MS**	**F**	**P**
subject	7	2.795	0.399		
condition	1	115.975	115.975	523.121	<0.001
condition x subject	7	1.552	0.222		
time	8	305.661	38.208	473.182	<0.001
time x subject	56	4.522	0.0807		
condition x time	8	16.337	2.042	31.309	<0.001
Residual	56	3.653	0.0652		
Total	143	450.495	3.150		

VV M

Equal Variance Test: Failed (P < 0.050)

Source of Variation	**DF**	**SS**	**MS**	**F**	**P**
subject	7	2.685	0.384		
condition	1	29.594	29.594	86.727	<0.001
condition x subject	7	2.389	0.341		
time	8	290.903	36.363	2748.991	<0.001
time x subject	56	0.741	0.0132		
condition x time	8	1.398	0.175	19.865	<0.001
Residual	56	0.493	0.00880		
Total	143	328.201	2.295		

RV A3

Equal Variance Test: Failed (P < 0.050)

Source of Variation	**DF**	**SS**	**MS**	**F**	**P**
subject	7	2.133	0.305		
condition	1	0.241	0.241	1.898	0.211
condition x subject	7	0.888	0.127		
time	8	8.954	1.119	33.717	<0.001
time x subject	56	1.859	0.0332		
condition x time	8	2.962	0.370	9.684	<0.001
Residual	56	2.141	0.0382		
Total	143	19.178	0.134		

RV WO

Equal Variance Test: Passed (P = 0.550)

Source of Variation	DF	SS	MS	F	P
subject	7	1.479	0.211		
condition	1	22.436	22.436	74.510	<0.001
condition x subject	7	2.108	0.301		
time	8	96.739	12.092	208.583	<0.001
time x subject	56	3.247	0.0580		
condition x time	8	3.732	0.466	7.215	<0.001
Residual	56	3.620	0.0646		
Total	143	133.360	0.933		

RV T

Equal Variance Test: Passed (P = 0.498)

Source of Variation	DF	SS	MS	F	P
subject	7	1.531	0.219		
condition	1	1.707	1.707	48.188	<0.001
condition x subject	7	0.248	0.0354		
time	8	43.334	5.417	107.451	<0.001
time x subject	56	2.823	0.0504		
condition x time	8	2.061	0.258	8.795	<0.001
Residual	56	1.640	0.0293		
Total	143	53.344	0.373		

V2 Y

Equal Variance Test: Passed (P = 0.901)

Source of Variation	DF	SS	MS	F	P
subject	7	2.243	0.320		
condition	1	79.166	79.166	152.670	<0.001
condition x subject	7	3.630	0.519		
time	8	12.740	1.592	26.171	<0.001
time x subject	56	3.408	0.0608		
condition x time	8	13.448	1.681	33.822	<0.001
Residual	56	2.783	0.0497		
Total	143	117.417	0.821		

V2 WO

Equal Variance Test: Passed (P = 0.997)

Source of Variation	DF	SS	MS	F	P
subject	7	8.154	1.165		

condition	1	240.534	240.534	212.942	<0.001
condition x subject	7	7.907	1.130		
time	8	83.518	10.440	99.846	<0.001
time x subject	56	5.855	0.105		
condition x time	8	32.874	4.109	39.902	<0.001
Residual	56	5.767	0.103		
Total	143	384.610	2.690		

V2 T

Equal Variance Test: Failed (P < 0.050)

Source of Variation	**DF**	**SS**	**MS**	**F**	**P**
subject	7	1.588	0.227		
condition	1	196.981	196.981	570.286	<0.001
condition x subject	7	2.418	0.345		
time	8	64.721	8.090	138.936	<0.001
time x subject	56	3.261	0.0582		
condition x time	8	47.063	5.883	88.445	<0.001
Residual	56	3.725	0.0665		
Total	143	319.756	2.236		

Post Hoc

Multiple Comparisons

NX Y

Comparisons for factor: **time within control**

Comparison	Diff of Means	p	q	P	P<0.05
w4 vs. d1	3.459	9	25.906	<0.001	Yes
w4 vs. d7	3.325	9	24.904	<0.001	Yes
w4 vs. d3	3.010	9	22.545	<0.001	Yes
w4 vs. d5	3.009	9	22.535	<0.001	Yes
w4 vs. w3	0.719	9	5.383	0.007	Yes
w4 vs. w12	0.473	9	3.539	0.242	No
w4 vs. w2	0.160	9	1.198	0.995	Do Not Test
w4 vs. w8	0.0363	9	0.272	1.000	Do Not Test
w8 vs. d1	3.422	9	25.634	<0.001	Yes
w8 vs. d7	3.289	9	24.632	<0.001	Yes
w8 vs. d3	2.974	9	22.273	<0.001	Yes
w8 vs. d5	2.972	9	22.264	<0.001	Yes
w8 vs. w3	0.682	9	5.112	0.013	Yes
w8 vs. w12	0.436	9	3.267	0.345	Do Not Test
w8 vs. w2	0.124	9	0.927	0.999	Do Not Test
w2 vs. d1	3.299	9	24.707	<0.001	Yes
w2 vs. d7	3.165	9	23.706	<0.001	Yes
w2 vs. d3	2.850	9	21.346	<0.001	Yes
w2 vs. d5	2.849	9	21.337	<0.001	Yes
w2 vs. w3	0.559	9	4.185	0.086	No
w2 vs. w12	0.313	9	2.341	0.772	Do Not Test
w12 vs. d1	2.986	9	22.367	<0.001	Yes
w12 vs. d7	2.853	9	21.365	<0.001	Yes
w12 vs. d3	2.537	9	19.006	<0.001	Yes
w12 vs. d5	2.536	9	18.996	<0.001	Yes
w12 vs. w3	0.246	9	1.844	0.928	Do Not Test
w3 vs. d1	2.740	9	20.522	<0.001	Yes
w3 vs. d7	2.606	9	19.521	<0.001	Yes
w3 vs. d3	2.291	9	17.161	<0.001	Yes
w3 vs. d5	2.290	9	17.152	<0.001	Yes
d5 vs. d1	0.450	9	3.370	0.304	No
d5 vs. d7	0.316	9	2.369	0.760	Do Not Test
d5 vs. d3	0.00125	9	0.00936	1.000	Do Not Test
d3 vs. d1	0.449	9	3.361	0.307	Do Not Test
d3 vs. d7	0.315	9	2.359	0.764	Do Not Test
d7 vs. d1	0.134	9	1.002	0.999	Do Not Test

Comparisons for factor: **time within uv**

Comparison	Diff of Means	p	q	P	P<0.05
w4 vs. d1	2.168	9	16.234	<0.001	Yes
w4 vs. d3	1.490	9	11.160	<0.001	Yes
w4 vs. w3	1.351	9	10.121	<0.001	Yes
w4 vs. w8	1.025	9	7.677	<0.001	Yes
w4 vs. d5	0.935	9	7.003	<0.001	Yes
w4 vs. w12	0.861	9	6.451	<0.001	Yes
w4 vs. d7	0.684	9	5.121	0.013	Yes

w4 vs. w2	0.269	9	2.013	0.887	No
w2 vs. d1	1.899	9	14.221	<0.001	Yes
w2 vs. d3	1.221	9	9.147	<0.001	Yes
w2 vs. w3	1.082	9	8.108	<0.001	Yes
w2 vs. w8	0.756	9	5.664	0.004	Yes
w2 vs. d5	0.666	9	4.990	0.017	Yes
w2 vs. w12	0.592	9	4.438	0.054	No
w2 vs. d7	0.415	9	3.108	0.415	Do Not Test
d7 vs. d1	1.484	9	11.113	<0.001	Yes
d7 vs. d3	0.806	9	6.039	0.001	Yes
d7 vs. w3	0.667	9	5.000	0.017	Yes
d7 vs. w8	0.341	9	2.556	0.677	No
d7 vs. d5	0.251	9	1.882	0.920	Do Not Test
d7 vs. w12	0.177	9	1.329	0.990	Do Not Test
w12 vs. d1	1.306	9	9.784	<0.001	Yes
w12 vs. d3	0.629	9	4.709	0.031	Yes
w12 vs. w3	0.490	9	3.670	0.201	No
w12 vs. w8	0.164	9	1.226	0.994	Do Not Test
w12 vs. d5	0.0738	9	0.552	1.000	Do Not Test
d5 vs. d1	1.232	9	9.231	<0.001	Yes
d5 vs. d3	0.555	9	4.157	0.091	No
d5 vs. w3	0.416	9	3.118	0.410	Do Not Test
d5 vs. w8	0.0900	9	0.674	1.000	Do Not Test
w8 vs. d1	1.143	9	8.557	<0.001	Yes
w8 vs. d3	0.465	9	3.483	0.262	Do Not Test
w8 vs. w3	0.326	9	2.444	0.728	Do Not Test
w3 vs. d1	0.816	9	6.114	0.001	Yes
w3 vs. d3	0.139	9	1.039	0.998	Do Not Test
d3 vs. d1	0.677	9	5.074	0.014	Yes

Comparisons for factor: **condition within d1**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.05**
uv vs. control	2.064	2	11.946	<0.001	Yes

Comparisons for factor: **condition within d3**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.05**
uv vs. control	2.292	2	13.270	<0.001	Yes

Comparisons for factor: **condition within d5**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.05**
uv vs. control	2.846	2	16.475	<0.001	Yes

Comparisons for factor: **condition within d7**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.05**
uv vs. control	3.414	2	19.760	<0.001	Yes

Comparisons for factor: **condition within w2**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.05**
uv vs. control	0.664	2	3.842	0.010	Yes

Comparisons for factor: **condition within w3**

Comparison	Diff of Means	p	q	P	P<0.05
uv vs. control	0.140	2	0.810	0.570	No

Comparisons for factor: **condition within w4**

Comparison	Diff of Means	p	q	P	P<0.05
uv vs. control	0.772	2	4.472	0.003	Yes

Comparisons for factor: **condition within w8**

Comparison	Diff of Means	p	q	P	P<0.05
control vs. uv	0.216	2	1.252	0.382	No

Comparisons for factor: **condition within w12**

Comparison	Diff of Means	p	q	P	P<0.05
uv vs. control	0.384	2	2.221	0.125	No

NX WO

All Pairwise Multiple Comparison Procedures (Tukey Test):

Comparisons for factor: **time within control**

Comparison	Diff of Means	p	q	P	P<0.05
w8 vs. d1	2.851	9	25.069	<0.001	Yes
w8 vs. d5	2.705	9	23.783	<0.001	Yes
w8 vs. d7	2.641	9	23.223	<0.001	Yes
w8 vs. d3	2.519	9	22.146	<0.001	Yes
w8 vs. w2	1.091	9	9.595	<0.001	Yes
w8 vs. w3	0.866	9	7.616	<0.001	Yes
w8 vs. w12	0.467	9	4.110	0.098	No
w8 vs. w4	0.356	9	3.132	0.404	Do Not Test
w4 vs. d1	2.495	9	21.937	<0.001	Yes
w4 vs. d5	2.349	9	20.651	<0.001	Yes
w4 vs. d7	2.285	9	20.091	<0.001	Yes
w4 vs. d3	2.163	9	19.013	<0.001	Yes
w4 vs. w2	0.735	9	6.462	<0.001	Yes
w4 vs. w3	0.510	9	4.484	0.049	Yes
w4 vs. w12	0.111	9	0.978	0.999	Do Not Test
w12 vs. d1	2.384	9	20.959	<0.001	Yes
w12 vs. d5	2.238	9	19.673	<0.001	Yes
w12 vs. d7	2.174	9	19.112	<0.001	Yes
w12 vs. d3	2.051	9	18.035	<0.001	Yes
w12 vs. w2	0.624	9	5.484	0.005	Yes
w12 vs. w3	0.399	9	3.506	0.254	No
w3 vs. d1	1.985	9	17.453	<0.001	Yes
w3 vs. d5	1.839	9	16.167	<0.001	Yes
w3 vs. d7	1.775	9	15.606	<0.001	Yes
w3 vs. d3	1.653	9	14.529	<0.001	Yes
w3 vs. w2	0.225	9	1.978	0.896	No
w2 vs. d1	1.760	9	15.475	<0.001	Yes
w2 vs. d5	1.614	9	14.189	<0.001	Yes
w2 vs. d7	1.550	9	13.628	<0.001	Yes

w2 vs. d3	1.428	9	12.551	<0.001	Yes
d3 vs. d1	0.332	9	2.923	0.501	No
d3 vs. d5	0.186	9	1.638	0.963	Do Not Test
d3 vs. d7	0.122	9	1.077	0.998	Do Not Test
d7 vs. d1	0.210	9	1.846	0.928	Do Not Test
d7 vs. d5	0.0637	9	0.561	1.000	Do Not Test
d5 vs. d1	0.146	9	1.286	0.992	Do Not Test

Comparisons for factor: **time within uv**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.05**
w4 vs. d1	1.723	9	15.145	<0.001	Yes
w4 vs. w3	1.144	9	10.056	<0.001	Yes
w4 vs. d3	0.521	9	4.583	0.040	Yes
w4 vs. w2	0.316	9	2.781	0.570	No
w4 vs. w12	0.182	9	1.605	0.968	Do Not Test
w4 vs. d5	0.146	9	1.286	0.992	Do Not Test
w4 vs. w8	0.0562	9	0.495	1.000	Do Not Test
w4 vs. d7	0.0362	9	0.319	1.000	Do Not Test
d7 vs. d1	1.686	9	14.826	<0.001	Yes
d7 vs. w3	1.107	9	9.738	<0.001	Yes
d7 vs. d3	0.485	9	4.264	0.075	No
d7 vs. w2	0.280	9	2.462	0.720	Do Not Test
d7 vs. w12	0.146	9	1.286	0.992	Do Not Test
d7 vs. d5	0.110	9	0.967	0.999	Do Not Test
d7 vs. w8	0.0200	9	0.176	1.000	Do Not Test
w8 vs. d1	1.666	9	14.650	<0.001	Yes
w8 vs. w3	1.088	9	9.562	<0.001	Yes
w8 vs. d3	0.465	9	4.088	0.102	Do Not Test
w8 vs. w2	0.260	9	2.286	0.794	Do Not Test
w8 vs. w12	0.126	9	1.110	0.997	Do Not Test
w8 vs. d5	0.0900	9	0.791	1.000	Do Not Test
d5 vs. d1	1.576	9	13.859	<0.001	Yes
d5 vs. w3	0.998	9	8.770	<0.001	Yes
d5 vs. d3	0.375	9	3.297	0.333	Do Not Test
d5 vs. w2	0.170	9	1.495	0.979	Do Not Test
d5 vs. w12	0.0362	9	0.319	1.000	Do Not Test
w12 vs. d1	1.540	9	13.540	<0.001	Yes
w12 vs. w3	0.961	9	8.452	<0.001	Yes
w12 vs. d3	0.339	9	2.978	0.475	Do Not Test
w12 vs. w2	0.134	9	1.176	0.996	Do Not Test
w2 vs. d1	1.406	9	12.364	<0.001	Yes
w2 vs. w3	0.828	9	7.276	<0.001	Yes
w2 vs. d3	0.205	9	1.802	0.937	Do Not Test
d3 vs. d1	1.201	9	10.562	<0.001	Yes
d3 vs. w3	0.622	9	5.473	0.006	Yes
w3 vs. d1	0.579	9	5.089	0.014	Yes

Comparisons for factor: **condition within d1**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.05**
uv vs. control	1.885	2	13.413	<0.001	Yes

Comparisons for factor: **condition within d3**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.05**

uv vs. control	2.754	2	19.594	<0.001	Yes

Comparisons for factor: **condition within d5**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.05**
uv vs. control	3.315	2	23.588	<0.001	Yes

Comparisons for factor: **condition within d7**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.05**
uv vs. control	3.361	2	23.917	<0.001	Yes

Comparisons for factor: **condition within w2**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.05**
uv vs. control	1.531	2	10.896	<0.001	Yes

Comparisons for factor: **condition within w3**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.05**
uv vs. control	0.479	2	3.407	0.022	Yes

Comparisons for factor: **condition within w4**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.05**
uv vs. control	1.112	2	7.916	<0.001	Yes

Comparisons for factor: **condition within w8**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.05**
uv vs. control	0.700	2	4.981	0.002	Yes

Comparisons for factor: **condition within w12**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.05**
uv vs. control	1.041	2	7.409	<0.001	Yes

NX C

All Pairwise Multiple Comparison Procedures (Tukey Test):

Comparisons for factor: **time within control**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.05**
w12 vs. d1	3.525	9	23.373	<0.001	Yes
w12 vs. d7	3.260	9	21.616	<0.001	Yes
w12 vs. d5	2.970	9	19.693	<0.001	Yes
w12 vs. d3	2.692	9	17.853	<0.001	Yes
w12 vs. w3	0.439	9	2.909	0.508	No
w12 vs. w4	0.425	9	2.818	0.552	Do Not Test
w12 vs. w8	0.350	9	2.321	0.780	Do Not Test
w12 vs. w2	0.277	9	1.840	0.929	Do Not Test
w2 vs. d1	3.248	9	21.533	<0.001	Yes
w2 vs. d7	2.982	9	19.776	<0.001	Yes
w2 vs. d5	2.692	9	17.853	<0.001	Yes

w2 vs. d3	2.415	9	16.013	<0.001	Yes
w2 vs. w3	0.161	9	1.069	0.998	Do Not Test
w2 vs. w4	0.148	9	0.978	0.999	Do Not Test
w2 vs. w8	0.0725	9	0.481	1.000	Do Not Test
w8 vs. d1	3.175	9	21.052	<0.001	Yes
w8 vs. d7	2.910	9	19.295	<0.001	Yes
w8 vs. d5	2.620	9	17.372	<0.001	Yes
w8 vs. d3	2.343	9	15.532	<0.001	Yes
w8 vs. w3	0.0888	9	0.588	1.000	Do Not Test
w8 vs. w4	0.0750	9	0.497	1.000	Do Not Test
w4 vs. d1	3.100	9	20.555	<0.001	Yes
w4 vs. d7	2.835	9	18.798	<0.001	Yes
w4 vs. d5	2.545	9	16.875	<0.001	Yes
w4 vs. d3	2.268	9	15.035	<0.001	Yes
w4 vs. w3	0.0137	9	0.0912	1.000	Do Not Test
w3 vs. d1	3.086	9	20.463	<0.001	Yes
w3 vs. d7	2.821	9	18.706	<0.001	Yes
w3 vs. d5	2.531	9	16.784	<0.001	Yes
w3 vs. d3	2.254	9	14.944	<0.001	Yes
d3 vs. d1	0.832	9	5.520	0.005	Yes
d3 vs. d7	0.567	9	3.763	0.175	No
d3 vs. d5	0.277	9	1.840	0.929	Do Not Test
d5 vs. d1	0.555	9	3.680	0.198	No
d5 vs. d7	0.290	9	1.923	0.910	Do Not Test
d7 vs. d1	0.265	9	1.757	0.945	Do Not Test

Comparisons for factor: **time within uv**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.05**
d7 vs. d1	2.334	9	15.474	<0.001	Yes
d7 vs. w8	1.845	9	12.233	<0.001	Yes
d7 vs. w3	1.816	9	12.043	<0.001	Yes
d7 vs. w12	1.313	9	8.703	<0.001	Yes
d7 vs. w4	1.017	9	6.747	<0.001	Yes
d7 vs. w2	0.920	9	6.100	0.001	Yes
d7 vs. d3	0.747	9	4.956	0.019	Yes
d7 vs. d5	0.400	9	2.652	0.632	No
d5 vs. d1	1.934	9	12.822	<0.001	Yes
d5 vs. w8	1.445	9	9.581	<0.001	Yes
d5 vs. w3	1.416	9	9.390	<0.001	Yes
d5 vs. w12	0.913	9	6.050	0.001	Yes
d5 vs. w4	0.617	9	4.094	0.102	No
d5 vs. w2	0.520	9	3.448	0.275	Do Not Test
d5 vs. d3	0.347	9	2.304	0.787	Do Not Test
d3 vs. d1	1.586	9	10.518	<0.001	Yes
d3 vs. w8	1.098	9	7.277	<0.001	Yes
d3 vs. w3	1.069	9	7.086	<0.001	Yes
d3 vs. w12	0.565	9	3.746	0.179	No
d3 vs. w4	0.270	9	1.790	0.939	Do Not Test
d3 vs. w2	0.173	9	1.144	0.996	Do Not Test
w2 vs. d1	1.414	9	9.374	<0.001	Yes
w2 vs. w8	0.925	9	6.133	0.001	Yes
w2 vs. w3	0.896	9	5.943	0.002	Yes
w2 vs. w12	0.393	9	2.602	0.656	Do Not Test
w2 vs. w4	0.0975	9	0.646	1.000	Do Not Test
w4 vs. d1	1.316	9	8.727	<0.001	Yes

w4 vs. w8	0.828	9	5.487	0.006	Yes
w4 vs. w3	0.799	9	5.296	0.009	Yes
w4 vs. w12	0.295	9	1.956	0.902	Do Not Test
w12 vs. d1	1.021	9	6.771	<0.001	Yes
w12 vs. w8	0.532	9	3.531	0.246	No
w12 vs. w3	0.504	9	3.340	0.316	Do Not Test
w3 vs. d1	0.518	9	3.431	0.281	No
w3 vs. w8	0.0288	9	0.191	1.000	Do Not Test
w8 vs. d1	0.489	9	3.241	0.357	Do Not Test

Comparisons for factor: **condition within d1**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.05**
uv vs. control	2.191	2	7.814	<0.001	Yes

Comparisons for factor: **condition within d3**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.05**
uv vs. control	2.945	2	10.502	<0.001	Yes

Comparisons for factor: **condition within d5**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.05**
uv vs. control	3.570	2	12.731	<0.001	Yes

Comparisons for factor: **condition within d7**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.05**
uv vs. control	4.260	2	15.191	<0.001	Yes

Comparisons for factor: **condition within w2**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.05**
uv vs. control	0.357	2	1.275	0.382	No

Comparisons for factor: **condition within w3**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.05**
control vs. uv	0.377	2	1.346	0.357	No

Comparisons for factor: **condition within w4**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.05**
uv vs. control	0.408	2	1.453	0.321	No

Comparisons for factor: **condition within w8**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.05**
control vs. uv	0.495	2	1.765	0.232	No

Comparisons for factor: **condition within w12**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.05**
control vs. uv	0.313	2	1.114	0.443	No

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All Pairwise Multiple Comparison Procedures (Tukey Test):

Comparisons for factor: **time within control**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.05**
w8 vs. d1	4.045	9	43.199	<0.001	Yes
w8 vs. d3	3.462	9	36.979	<0.001	Yes
w8 vs. d5	2.862	9	30.571	<0.001	Yes
w8 vs. d7	2.678	9	28.595	<0.001	Yes
w8 vs. w2	1.345	9	14.364	<0.001	Yes
w8 vs. w3	0.889	9	9.492	<0.001	Yes
w8 vs. w12	0.671	9	7.169	<0.001	Yes
w8 vs. w4	0.267	9	2.857	0.533	No
w4 vs. d1	3.778	9	40.343	<0.001	Yes
w4 vs. d3	3.195	9	34.122	<0.001	Yes
w4 vs. d5	2.595	9	27.714	<0.001	Yes
w4 vs. d7	2.410	9	25.738	<0.001	Yes
w4 vs. w2	1.078	9	11.507	<0.001	Yes
w4 vs. w3	0.621	9	6.635	<0.001	Yes
w4 vs. w12	0.404	9	4.312	0.068	No
w12 vs. d1	3.374	9	36.031	<0.001	Yes
w12 vs. d3	2.791	9	29.810	<0.001	Yes
w12 vs. d5	2.191	9	23.402	<0.001	Yes
w12 vs. d7	2.006	9	21.426	<0.001	Yes
w12 vs. w2	0.674	9	7.195	<0.001	Yes
w12 vs. w3	0.217	9	2.323	0.779	No
w3 vs. d1	3.156	9	33.708	<0.001	Yes
w3 vs. d3	2.574	9	27.487	<0.001	Yes
w3 vs. d5	1.974	9	21.079	<0.001	Yes
w3 vs. d7	1.789	9	19.103	<0.001	Yes
w3 vs. w2	0.456	9	4.873	0.022	Yes
w2 vs. d1	2.700	9	28.835	<0.001	Yes
w2 vs. d3	2.118	9	22.614	<0.001	Yes
w2 vs. d5	1.518	9	16.206	<0.001	Yes
w2 vs. d7	1.333	9	14.231	<0.001	Yes
d7 vs. d1	1.367	9	14.605	<0.001	Yes
d7 vs. d3	0.785	9	8.384	<0.001	Yes
d7 vs. d5	0.185	9	1.976	0.897	No
d5 vs. d1	1.182	9	12.629	<0.001	Yes
d5 vs. d3	0.600	9	6.408	<0.001	Yes
d3 vs. d1	0.583	9	6.221	<0.001	Yes

Comparisons for factor: **time within uv**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.05**
w4 vs. d1	4.424	9	47.244	<0.001	Yes
w4 vs. d5	3.725	9	39.782	<0.001	Yes
w4 vs. d3	3.369	9	35.977	<0.001	Yes
w4 vs. d7	2.949	9	31.492	<0.001	Yes
w4 vs. w3	0.995	9	10.626	<0.001	Yes
w4 vs. w8	0.414	9	4.419	0.056	No
w4 vs. w2	0.341	9	3.644	0.208	Do Not Test
w4 vs. w12	0.0413	9	0.441	1.000	Do Not Test

w12 vs. d1	4.382	9	46.804	<0.001	Yes
w12 vs. d5	3.684	9	39.341	<0.001	Yes
w12 vs. d3	3.327	9	35.537	<0.001	Yes
w12 vs. d7	2.907	9	31.051	<0.001	Yes
w12 vs. w3	0.954	9	10.186	<0.001	Yes
w12 vs. w8	0.372	9	3.978	0.123	Do Not Test
w12 vs. w2	0.300	9	3.204	0.372	Do Not Test
w2 vs. d1	4.082	9	43.600	<0.001	Yes
w2 vs. d5	3.384	9	36.138	<0.001	Yes
w2 vs. d3	3.027	9	32.333	<0.001	Yes
w2 vs. d7	2.607	9	27.847	<0.001	Yes
w2 vs. w3	0.654	9	6.982	<0.001	Yes
w2 vs. w8	0.0725	9	0.774	1.000	Do Not Test
w8 vs. d1	4.010	9	42.826	<0.001	Yes
w8 vs. d5	3.311	9	35.363	<0.001	Yes
w8 vs. d3	2.955	9	31.559	<0.001	Yes
w8 vs. d7	2.535	9	27.073	<0.001	Yes
w8 vs. w3	0.581	9	6.208	<0.001	Yes
w3 vs. d1	3.429	9	36.618	<0.001	Yes
w3 vs. d5	2.730	9	29.156	<0.001	Yes
w3 vs. d3	2.374	9	25.351	<0.001	Yes
w3 vs. d7	1.954	9	20.866	<0.001	Yes
d7 vs. d1	1.475	9	15.753	<0.001	Yes
d7 vs. d5	0.776	9	8.290	<0.001	Yes
d7 vs. d3	0.420	9	4.485	0.049	Yes
d3 vs. d1	1.055	9	11.267	<0.001	Yes
d3 vs. d5	0.356	9	3.805	0.164	No
d5 vs. d1	0.699	9	7.462	<0.001	Yes

Comparisons for factor: **condition within d1**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.05**
uv vs. control	1.026	2	5.760	0.002	Yes

Comparisons for factor: **condition within d3**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.05**
uv vs. control	1.499	2	8.412	<0.001	Yes

Comparisons for factor: **condition within d5**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.05**
uv vs. control	0.543	2	3.045	0.054	No

Comparisons for factor: **condition within d7**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.05**
uv vs. control	1.134	2	6.363	<0.001	Yes

Comparisons for factor: **condition within w2**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.05**
uv vs. control	2.409	2	13.520	<0.001	Yes

Comparisons for factor: **condition within w3**

Comparison	Diff of Means	p	q	P	P<0.05
uv vs. control	1.299	2	7.290	<0.001	Yes

Comparisons for factor: **condition within w4**

Comparison	Diff of Means	p	q	P	P<0.05
uv vs. control	1.672	2	9.387	<0.001	Yes

Comparisons for factor: **condition within w8**

Comparison	Diff of Means	p	q	P	P<0.05
uv vs. control	0.991	2	5.564	0.002	Yes

Comparisons for factor: **condition within w12**

Comparison	Diff of Means	p	q	P	P<0.05
uv vs. control	2.035	2	11.422	<0.001	Yes

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All Pairwise Multiple Comparison Procedures (Tukey Test):

Comparisons for factor: **time within control**

Comparison	Diff of Means	p	q	P	P<0.05
w12 vs. d1	4.305	9	45.071	<0.001	Yes
w12 vs. d3	3.151	9	32.992	<0.001	Yes
w12 vs. d5	2.401	9	25.140	<0.001	Yes
w12 vs. d7	2.315	9	24.237	<0.001	Yes
w12 vs. w2	2.296	9	24.041	<0.001	Yes
w12 vs. w3	1.439	9	15.063	<0.001	Yes
w12 vs. w4	0.735	9	7.695	<0.001	Yes
w12 vs. w8	0.141	9	1.479	0.980	No
w8 vs. d1	4.164	9	43.592	<0.001	Yes
w8 vs. d3	3.010	9	31.513	<0.001	Yes
w8 vs. d5	2.260	9	23.661	<0.001	Yes
w8 vs. d7	2.174	9	22.758	<0.001	Yes
w8 vs. w2	2.155	9	22.562	<0.001	Yes
w8 vs. w3	1.297	9	13.584	<0.001	Yes
w8 vs. w4	0.594	9	6.216	<0.001	Yes
w4 vs. d1	3.570	9	37.376	<0.001	Yes
w4 vs. d3	2.416	9	25.297	<0.001	Yes
w4 vs. d5	1.666	9	17.445	<0.001	Yes
w4 vs. d7	1.580	9	16.542	<0.001	Yes
w4 vs. w2	1.561	9	16.345	<0.001	Yes
w4 vs. w3	0.704	9	7.368	<0.001	Yes
w3 vs. d1	2.866	9	30.008	<0.001	Yes
w3 vs. d3	1.713	9	17.929	<0.001	Yes
w3 vs. d5	0.963	9	10.077	<0.001	Yes
w3 vs. d7	0.876	9	9.174	<0.001	Yes
w3 vs. w2	0.858	9	8.978	<0.001	Yes
w2 vs. d1	2.009	9	21.031	<0.001	Yes
w2 vs. d3	0.855	9	8.951	<0.001	Yes
w2 vs. d5	0.105	9	1.099	0.997	No
w2 vs. d7	0.0188	9	0.196	1.000	Do Not Test

d7 vs. d1	1.990	9	20.834	<0.001	Yes
d7 vs. d3	0.836	9	8.755	<0.001	Yes
d7 vs. d5	0.0863	9	0.903	0.999	Do Not Test
d5 vs. d1	1.904	9	19.931	<0.001	Yes
d5 vs. d3	0.750	9	7.852	<0.001	Yes
d3 vs. d1	1.154	9	12.079	<0.001	Yes

Comparisons for factor: **time within uv**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.05**
w4 vs. d1	5.281	9	55.292	<0.001	Yes
w4 vs. d3	3.859	9	40.399	<0.001	Yes
w4 vs. d5	2.609	9	27.312	<0.001	Yes
w4 vs. d7	1.823	9	19.081	<0.001	Yes
w4 vs. w3	1.319	9	13.807	<0.001	Yes
w4 vs. w2	1.241	9	12.995	<0.001	Yes
w4 vs. w12	0.829	9	8.677	<0.001	Yes
w4 vs. w8	0.241	9	2.526	0.691	No
w8 vs. d1	5.040	9	52.766	<0.001	Yes
w8 vs. d3	3.617	9	37.873	<0.001	Yes
w8 vs. d5	2.367	9	24.787	<0.001	Yes
w8 vs. d7	1.581	9	16.555	<0.001	Yes
w8 vs. w3	1.077	9	11.281	<0.001	Yes
w8 vs. w2	1.000	9	10.469	<0.001	Yes
w8 vs. w12	0.587	9	6.151	0.001	Yes
w12 vs. d1	4.453	9	46.615	<0.001	Yes
w12 vs. d3	3.030	9	31.723	<0.001	Yes
w12 vs. d5	1.780	9	18.636	<0.001	Yes
w12 vs. d7	0.994	9	10.404	<0.001	Yes
w12 vs. w3	0.490	9	5.130	0.013	Yes
w12 vs. w2	0.412	9	4.319	0.067	No
w2 vs. d1	4.040	9	42.297	<0.001	Yes
w2 vs. d3	2.618	9	27.404	<0.001	Yes
w2 vs. d5	1.368	9	14.317	<0.001	Yes
w2 vs. d7	0.581	9	6.085	0.001	Yes
w2 vs. w3	0.0775	9	0.811	1.000	No
w3 vs. d1	3.963	9	41.485	<0.001	Yes
w3 vs. d3	2.540	9	26.592	<0.001	Yes
w3 vs. d5	1.290	9	13.506	<0.001	Yes
w3 vs. d7	0.504	9	5.274	0.009	Yes
d7 vs. d1	3.459	9	36.211	<0.001	Yes
d7 vs. d3	2.036	9	21.318	<0.001	Yes
d7 vs. d5	0.786	9	8.232	<0.001	Yes
d5 vs. d1	2.673	9	27.980	<0.001	Yes
d5 vs. d3	1.250	9	13.087	<0.001	Yes
d3 vs. d1	1.423	9	14.893	<0.001	Yes

Comparisons for factor: **condition within d1**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.05**
uv vs. control	0.865	2	8.512	<0.001	Yes

Comparisons for factor: **condition within d3**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.05**
uv vs. control	1.134	2	11.157	<0.001	Yes

Comparisons for factor: **condition within d5**

Comparison	Diff of Means	p	q	P	P<0.05
uv vs. control	1.634	2	16.077	<0.001	Yes

Comparisons for factor: **condition within d7**

Comparison	Diff of Means	p	q	P	P<0.05
uv vs. control	2.334	2	22.966	<0.001	Yes

Comparisons for factor: **condition within w2**

Comparison	Diff of Means	p	q	P	P<0.05
uv vs. control	2.896	2	28.501	<0.001	Yes

Comparisons for factor: **condition within w3**

Comparison	Diff of Means	p	q	P	P<0.05
uv vs. control	1.961	2	19.300	<0.001	Yes

Comparisons for factor: **condition within w4**

Comparison	Diff of Means	p	q	P	P<0.05
uv vs. control	2.576	2	25.352	<0.001	Yes

Comparisons for factor: **condition within w8**

Comparison	Diff of Means	p	q	P	P<0.05
uv vs. control	1.741	2	17.135	<0.001	Yes

Comparisons for factor: **condition within w12**

Comparison	Diff of Means	p	q	P	P<0.05
uv vs. control	1.013	2	9.964	<0.001	Yes

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All Pairwise Multiple Comparison Procedures (Tukey Test):

Comparisons for factor: **time within control**

Comparison	Diff of Means	p	q	P	P<0.05
w8 vs. d1	4.181	9	112.693	<0.001	Yes
w8 vs. d3	2.984	9	80.418	<0.001	Yes
w8 vs. d5	2.308	9	62.192	<0.001	Yes
w8 vs. d7	1.329	9	35.812	<0.001	Yes
w8 vs. w2	1.104	9	29.748	<0.001	Yes
w8 vs. w3	0.594	9	16.003	<0.001	Yes
w8 vs. w4	0.508	9	13.678	<0.001	Yes
w8 vs. w12	0.0387	9	1.044	0.998	No
w12 vs. d1	4.143	9	111.649	<0.001	Yes
w12 vs. d3	2.945	9	79.374	<0.001	Yes
w12 vs. d5	2.269	9	61.147	<0.001	Yes
w12 vs. d7	1.290	9	34.768	<0.001	Yes

w12 vs. w2	1.065	9	28.704	<0.001	Yes
w12 vs. w3	0.555	9	14.958	<0.001	Yes
w12 vs. w4	0.469	9	12.634	<0.001	Yes
w4 vs. d1	3.674	9	99.015	<0.001	Yes
w4 vs. d3	2.476	9	66.740	<0.001	Yes
w4 vs. d5	1.800	9	48.514	<0.001	Yes
w4 vs. d7	0.821	9	22.134	<0.001	Yes
w4 vs. w2	0.596	9	16.070	<0.001	Yes
w4 vs. w3	0.0862	9	2.325	0.778	No
w3 vs. d1	3.588	9	96.690	<0.001	Yes
w3 vs. d3	2.390	9	64.415	<0.001	Yes
w3 vs. d5	1.714	9	46.189	<0.001	Yes
w3 vs. d7	0.735	9	19.810	<0.001	Yes
w3 vs. w2	0.510	9	13.746	<0.001	Yes
w2 vs. d1	3.077	9	82.945	<0.001	Yes
w2 vs. d3	1.880	9	50.670	<0.001	Yes
w2 vs. d5	1.204	9	32.443	<0.001	Yes
w2 vs. d7	0.225	9	6.064	0.001	Yes
d7 vs. d1	2.852	9	76.881	<0.001	Yes
d7 vs. d3	1.655	9	44.606	<0.001	Yes
d7 vs. d5	0.979	9	26.379	<0.001	Yes
d5 vs. d1	1.874	9	50.501	<0.001	Yes
d5 vs. d3	0.676	9	18.226	<0.001	Yes
d3 vs. d1	1.197	9	32.275	<0.001	Yes

Comparisons for factor: **time within uv**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.05**
w8 vs. d1	4.416	9	119.027	<0.001	Yes
w8 vs. d3	3.415	9	92.041	<0.001	Yes
w8 vs. d5	2.632	9	70.951	<0.001	Yes
w8 vs. d7	1.404	9	37.834	<0.001	Yes
w8 vs. w2	1.263	9	34.027	<0.001	Yes
w8 vs. w3	0.718	9	19.338	<0.001	Yes
w8 vs. w4	0.225	9	6.064	0.001	Yes
w8 vs. w12	0.0263	9	0.707	1.000	No
w12 vs. d1	4.390	9	118.319	<0.001	Yes
w12 vs. d3	3.389	9	91.334	<0.001	Yes
w12 vs. d5	2.606	9	70.244	<0.001	Yes
w12 vs. d7	1.378	9	37.126	<0.001	Yes
w12 vs. w2	1.236	9	33.319	<0.001	Yes
w12 vs. w3	0.691	9	18.631	<0.001	Yes
w12 vs. w4	0.199	9	5.357	0.008	Yes
w4 vs. d1	4.191	9	112.963	<0.001	Yes
w4 vs. d3	3.190	9	85.977	<0.001	Yes
w4 vs. d5	2.408	9	64.887	<0.001	Yes
w4 vs. d7	1.179	9	31.770	<0.001	Yes
w4 vs. w2	1.038	9	27.963	<0.001	Yes
w4 vs. w3	0.493	9	13.274	<0.001	Yes
w3 vs. d1	3.699	9	99.689	<0.001	Yes
w3 vs. d3	2.697	9	72.703	<0.001	Yes
w3 vs. d5	1.915	9	51.613	<0.001	Yes
w3 vs. d7	0.686	9	18.496	<0.001	Yes
w3 vs. w2	0.545	9	14.689	<0.001	Yes
w2 vs. d1	3.154	9	85.000	<0.001	Yes
w2 vs. d3	2.152	9	58.014	<0.001	Yes

w2 vs. d5	1.370	9	36.924	<0.001	Yes
w2 vs. d7	0.141	9	3.807	0.163	No
d7 vs. d1	3.012	9	81.193	<0.001	Yes
d7 vs. d3	2.011	9	54.207	<0.001	Yes
d7 vs. d5	1.229	9	33.117	<0.001	Yes
d5 vs. d1	1.784	9	48.076	<0.001	Yes
d5 vs. d3	0.783	9	21.090	<0.001	Yes
d3 vs. d1	1.001	9	26.986	<0.001	Yes

Comparisons for factor: **condition within d1**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.05**
uv vs. control	0.789	2	10.432	<0.001	Yes

Comparisons for factor: **condition within d3**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.05**
uv vs. control	0.593	2	7.836	<0.001	Yes

Comparisons for factor: **condition within d5**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.05**
uv vs. control	0.699	2	9.242	<0.001	Yes

Comparisons for factor: **condition within d7**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.05**
uv vs. control	0.949	2	12.548	<0.001	Yes

Comparisons for factor: **condition within w2**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.05**
uv vs. control	0.865	2	11.440	<0.001	Yes

Comparisons for factor: **condition within w3**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.05**
uv vs. control	0.900	2	11.903	<0.001	Yes

Comparisons for factor: **condition within w4**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.05**
uv vs. control	1.306	2	17.276	<0.001	Yes

Comparisons for factor: **condition within w8**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.05**
uv vs. control	1.024	2	13.540	<0.001	Yes

Comparisons for factor: **condition within w12**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.05**
uv vs. control	1.036	2	13.705	<0.001	Yes

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All Pairwise Multiple Comparison Procedures (Tukey Test):

Comparisons for factor: **time within control**

Comparison	Diff of Means	p	q	P	P<0.05
w12 vs. d1	0.662	9	9.916	<0.001	Yes
w12 vs. d3	0.547	9	8.194	<0.001	Yes
w12 vs. d5	0.519	9	7.764	<0.001	Yes
w12 vs. d7	0.267	9	4.004	0.118	No
w12 vs. w2	0.205	9	3.068	0.433	Do Not Test
w12 vs. w3	0.151	9	2.264	0.803	Do Not Test
w12 vs. w4	0.140	9	2.095	0.862	Do Not Test
w12 vs. w8	0.129	9	1.927	0.909	Do Not Test
w8 vs. d1	0.534	9	7.989	<0.001	Yes
w8 vs. d3	0.419	9	6.267	<0.001	Yes
w8 vs. d5	0.390	9	5.837	0.002	Yes
w8 vs. d7	0.139	9	2.077	0.868	Do Not Test
w8 vs. w2	0.0763	9	1.141	0.997	Do Not Test
w8 vs. w3	0.0225	9	0.337	1.000	Do Not Test
w8 vs. w4	0.0113	9	0.168	1.000	Do Not Test
w4 vs. d1	0.522	9	7.820	<0.001	Yes
w4 vs. d3	0.407	9	6.099	0.001	Yes
w4 vs. d5	0.379	9	5.669	0.004	Yes
w4 vs. d7	0.127	9	1.908	0.914	Do Not Test
w4 vs. w2	0.0650	9	0.973	0.999	Do Not Test
w4 vs. w3	0.0112	9	0.168	1.000	Do Not Test
w3 vs. d1	0.511	9	7.652	<0.001	Yes
w3 vs. d3	0.396	9	5.931	0.002	Yes
w3 vs. d5	0.367	9	5.500	0.005	Yes
w3 vs. d7	0.116	9	1.740	0.948	Do Not Test
w3 vs. w2	0.0537	9	0.804	1.000	Do Not Test
w2 vs. d1	0.457	9	6.847	<0.001	Yes
w2 vs. d3	0.342	9	5.126	0.013	Yes
w2 vs. d5	0.314	9	4.696	0.032	Yes
w2 vs. d7	0.0625	9	0.935	0.999	Do Not Test
d7 vs. d1	0.395	9	5.912	0.002	Yes
d7 vs. d3	0.280	9	4.191	0.085	No
d7 vs. d5	0.251	9	3.760	0.175	Do Not Test
d5 vs. d1	0.144	9	2.151	0.843	No
d5 vs. d3	0.0287	9	0.430	1.000	Do Not Test
d3 vs. d1	0.115	9	1.721	0.951	Do Not Test

Comparisons for factor: **time within uv**

Comparison	Diff of Means	p	q	P	P<0.05
w12 vs. d1	1.146	9	17.156	<0.001	Yes
w12 vs. w2	1.139	9	17.044	<0.001	Yes
w12 vs. d7	1.066	9	15.958	<0.001	Yes
w12 vs. w3	0.863	9	12.909	<0.001	Yes
w12 vs. w4	0.855	9	12.797	<0.001	Yes
w12 vs. d3	0.835	9	12.497	<0.001	Yes
w12 vs. d5	0.803	9	12.011	<0.001	Yes
w12 vs. w8	0.455	9	6.810	<0.001	Yes
w8 vs. d1	0.691	9	10.346	<0.001	Yes

w8 vs. w2	0.684	9	10.234	<0.001	Yes
w8 vs. d7	0.611	9	9.149	<0.001	Yes
w8 vs. w3	0.407	9	6.099	0.001	Yes
w8 vs. w4	0.400	9	5.987	0.002	Yes
w8 vs. d3	0.380	9	5.687	0.003	Yes
w8 vs. d5	0.347	9	5.201	0.011	Yes
d5 vs. d1	0.344	9	5.145	0.012	Yes
d5 vs. w2	0.336	9	5.033	0.016	Yes
d5 vs. d7	0.264	9	3.948	0.130	No
d5 vs. w3	0.0600	9	0.898	0.999	Do Not Test
d5 vs. w4	0.0525	9	0.786	1.000	Do Not Test
d5 vs. d3	0.0325	9	0.486	1.000	Do Not Test
d3 vs. d1	0.311	9	4.658	0.035	Yes
d3 vs. w2	0.304	9	4.546	0.043	Yes
d3 vs. d7	0.231	9	3.461	0.270	Do Not Test
d3 vs. w3	0.0275	9	0.412	1.000	Do Not Test
d3 vs. w4	0.0200	9	0.299	1.000	Do Not Test
w4 vs. d1	0.291	9	4.359	0.062	No
w4 vs. w2	0.284	9	4.247	0.077	Do Not Test
w4 vs. d7	0.211	9	3.162	0.390	Do Not Test
w4 vs. w3	0.00750	9	0.112	1.000	Do Not Test
w3 vs. d1	0.284	9	4.247	0.077	Do Not Test
w3 vs. w2	0.276	9	4.135	0.094	Do Not Test
w3 vs. d7	0.204	9	3.050	0.441	Do Not Test
d7 vs. d1	0.0800	9	1.197	0.995	Do Not Test
d7 vs. w2	0.0725	9	1.085	0.998	Do Not Test
w2 vs. d1	0.00750	9	0.112	1.000	Do Not Test

Comparisons for factor: **condition within d1**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.05**
uv vs. control	0.102	2	1.322	0.355	No

Comparisons for factor: **condition within d3**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.05**
uv vs. control	0.299	2	3.854	0.009	Yes

Comparisons for factor: **condition within d5**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.05**
uv vs. control	0.302	2	3.902	0.008	Yes

Comparisons for factor: **condition within d7**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.05**
control vs. uv	0.213	2	2.741	0.059	No

Comparisons for factor: **condition within w2**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.05**
control vs. uv	0.347	2	4.482	0.003	Yes

Comparisons for factor: **condition within w3**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.05**

control vs. uv	0.125	2	1.612	0.260	No

Comparisons for factor: **condition within w4**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.05**
control vs. uv	0.129	2	1.661	0.246	No

Comparisons for factor: **condition within w8**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.05**
uv vs. control	0.260	2	3.354	0.022	Yes

Comparisons for factor: **condition within w12**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.05**
uv vs. control	0.586	2	7.562	<0.001	Yes

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All Pairwise Multiple Comparison Procedures (Tukey Test):

Comparisons for factor: **time within control**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.05**
w4 vs. d1	2.146	9	24.517	<0.001	Yes
w4 vs. d3	2.037	9	23.274	<0.001	Yes
w4 vs. d5	1.864	9	21.290	<0.001	Yes
w4 vs. d7	1.587	9	18.134	<0.001	Yes
w4 vs. w12	0.657	9	7.511	<0.001	Yes
w4 vs. w2	0.605	9	6.911	<0.001	Yes
w4 vs. w3	0.584	9	6.668	<0.001	Yes
w4 vs. w8	0.0950	9	1.085	0.998	No
w8 vs. d1	2.051	9	23.431	<0.001	Yes
w8 vs. d3	1.942	9	22.189	<0.001	Yes
w8 vs. d5	1.769	9	20.204	<0.001	Yes
w8 vs. d7	1.492	9	17.049	<0.001	Yes
w8 vs. w12	0.562	9	6.425	<0.001	Yes
w8 vs. w2	0.510	9	5.826	0.002	Yes
w8 vs. w3	0.489	9	5.583	0.004	Yes
w3 vs. d1	1.563	9	17.848	<0.001	Yes
w3 vs. d3	1.454	9	16.606	<0.001	Yes
w3 vs. d5	1.280	9	14.621	<0.001	Yes
w3 vs. d7	1.004	9	11.466	<0.001	Yes
w3 vs. w12	0.0737	9	0.842	1.000	No
w3 vs. w2	0.0212	9	0.243	1.000	Do Not Test
w2 vs. d1	1.541	9	17.606	<0.001	Yes
w2 vs. d3	1.433	9	16.363	<0.001	Yes
w2 vs. d5	1.259	9	14.379	<0.001	Yes
w2 vs. d7	0.983	9	11.223	<0.001	Yes
w2 vs. w12	0.0525	9	0.600	1.000	Do Not Test
w12 vs. d1	1.489	9	17.006	<0.001	Yes
w12 vs. d3	1.380	9	15.764	<0.001	Yes
w12 vs. d5	1.206	9	13.779	<0.001	Yes
w12 vs. d7	0.930	9	10.623	<0.001	Yes
d7 vs. d1	0.559	9	6.383	<0.001	Yes

d7 vs. d3	0.450	9	5.140	0.012	Yes
d7 vs. d5	0.276	9	3.156	0.393	No
d5 vs. d1	0.283	9	3.227	0.362	No
d5 vs. d3	0.174	9	1.985	0.894	Do Not Test
d3 vs. d1	0.109	9	1.242	0.994	Do Not Test

Comparisons for factor: **time within uv**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.05**
w4 vs. d5	2.298	9	26.244	<0.001	Yes
w4 vs. d1	2.109	9	24.088	<0.001	Yes
w4 vs. d3	1.942	9	22.189	<0.001	Yes
w4 vs. d7	0.923	9	10.538	<0.001	Yes
w4 vs. w12	0.731	9	8.353	<0.001	Yes
w4 vs. w3	0.248	9	2.827	0.547	No
w4 vs. w8	0.231	9	2.642	0.637	Do Not Test
w4 vs. w2	0.0875	9	1.000	0.999	Do Not Test
w2 vs. d5	2.210	9	25.245	<0.001	Yes
w2 vs. d1	2.021	9	23.089	<0.001	Yes
w2 vs. d3	1.855	9	21.190	<0.001	Yes
w2 vs. d7	0.835	9	9.538	<0.001	Yes
w2 vs. w12	0.644	9	7.354	<0.001	Yes
w2 vs. w3	0.160	9	1.828	0.932	Do Not Test
w2 vs. w8	0.144	9	1.642	0.963	Do Not Test
w8 vs. d5	2.066	9	23.603	<0.001	Yes
w8 vs. d1	1.877	9	21.447	<0.001	Yes
w8 vs. d3	1.711	9	19.548	<0.001	Yes
w8 vs. d7	0.691	9	7.896	<0.001	Yes
w8 vs. w12	0.500	9	5.711	0.003	Yes
w8 vs. w3	0.0163	9	0.186	1.000	Do Not Test
w3 vs. d5	2.050	9	23.417	<0.001	Yes
w3 vs. d1	1.861	9	21.261	<0.001	Yes
w3 vs. d3	1.695	9	19.362	<0.001	Yes
w3 vs. d7	0.675	9	7.711	<0.001	Yes
w3 vs. w12	0.484	9	5.526	0.005	Yes
w12 vs. d5	1.566	9	17.891	<0.001	Yes
w12 vs. d1	1.377	9	15.735	<0.001	Yes
w12 vs. d3	1.211	9	13.836	<0.001	Yes
w12 vs. d7	0.191	9	2.185	0.832	No
d7 vs. d5	1.375	9	15.707	<0.001	Yes
d7 vs. d1	1.186	9	13.551	<0.001	Yes
d7 vs. d3	1.020	9	11.651	<0.001	Yes
d3 vs. d5	0.355	9	4.055	0.108	No
d3 vs. d1	0.166	9	1.899	0.916	Do Not Test
d1 vs. d5	0.189	9	2.156	0.842	Do Not Test

Comparisons for factor: **condition within d1**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.05**
uv vs. control	0.715	2	6.707	<0.001	Yes

Comparisons for factor: **condition within d3**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.05**
uv vs. control	0.773	2	7.246	<0.001	Yes

Comparisons for factor: **condition within d5**

Comparison	Diff of Means	p	q	P	P<0.05
uv vs. control	0.244	2	2.286	0.114	No

Comparisons for factor: **condition within d7**

Comparison	Diff of Means	p	q	P	P<0.05
uv vs. control	1.342	2	12.593	<0.001	Yes

Comparisons for factor: **condition within w2**

Comparison	Diff of Means	p	q	P	P<0.05
uv vs. control	1.195	2	11.209	<0.001	Yes

Comparisons for factor: **condition within w3**

Comparison	Diff of Means	p	q	P	P<0.05
uv vs. control	1.014	2	9.509	<0.001	Yes

Comparisons for factor: **condition within w4**

Comparison	Diff of Means	p	q	P	P<0.05
uv vs. control	0.678	2	6.355	<0.001	Yes

Comparisons for factor: **condition within w8**

Comparison	Diff of Means	p	q	P	P<0.05
uv vs. control	0.541	2	5.077	0.001	Yes

Comparisons for factor: **condition within w12**

Comparison	Diff of Means	p	q	P	P<0.05
uv vs. control	0.604	2	5.663	<0.001	Yes

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All Pairwise Multiple Comparison Procedures (Tukey Test):

Comparisons for factor: **time within control**

Comparison	Diff of Means	p	q	P	P<0.05
w4 vs. d1	1.648	9	23.343	<0.001	Yes
w4 vs. d5	1.474	9	20.881	<0.001	Yes
w4 vs. d3	1.421	9	20.137	<0.001	Yes
w4 vs. d7	1.014	9	14.363	<0.001	Yes
w4 vs. w2	0.729	9	10.325	<0.001	Yes
w4 vs. w8	0.142	9	2.019	0.885	No
w4 vs. w3	0.0687	9	0.974	0.999	Do Not Test
w4 vs. w12	0.0575	9	0.815	1.000	Do Not Test
w12 vs. d1	1.590	9	22.528	<0.001	Yes
w12 vs. d5	1.416	9	20.066	<0.001	Yes
w12 vs. d3	1.364	9	19.322	<0.001	Yes
w12 vs. d7	0.956	9	13.549	<0.001	Yes
w12 vs. w2	0.671	9	9.511	<0.001	Yes

w12 vs. w8	0.0850	9	1.204	0.995	Do Not Test
w12 vs. w3	0.0112	9	0.159	1.000	Do Not Test
w3 vs. d1	1.579	9	22.369	<0.001	Yes
w3 vs. d5	1.405	9	19.907	<0.001	Yes
w3 vs. d3	1.353	9	19.163	<0.001	Yes
w3 vs. d7	0.945	9	13.389	<0.001	Yes
w3 vs. w2	0.660	9	9.351	<0.001	Yes
w3 vs. w8	0.0737	9	1.045	0.998	Do Not Test
w8 vs. d1	1.505	9	21.324	<0.001	Yes
w8 vs. d5	1.331	9	18.862	<0.001	Yes
w8 vs. d3	1.279	9	18.118	<0.001	Yes
w8 vs. d7	0.871	9	12.344	<0.001	Yes
w8 vs. w2	0.586	9	8.306	<0.001	Yes
w2 vs. d1	0.919	9	13.017	<0.001	Yes
w2 vs. d5	0.745	9	10.556	<0.001	Yes
w2 vs. d3	0.692	9	9.812	<0.001	Yes
w2 vs. d7	0.285	9	4.038	0.112	No
d7 vs. d1	0.634	9	8.979	<0.001	Yes
d7 vs. d5	0.460	9	6.518	<0.001	Yes
d7 vs. d3	0.407	9	5.774	0.003	Yes
d3 vs. d1	0.226	9	3.206	0.372	No
d3 vs. d5	0.0525	9	0.744	1.000	Do Not Test
d5 vs. d1	0.174	9	2.462	0.720	Do Not Test

Comparisons for factor: **time within uv**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.05**
w12 vs. d1	1.254	9	17.764	<0.001	Yes
w12 vs. d3	1.195	9	16.931	<0.001	Yes
w12 vs. d5	1.107	9	15.692	<0.001	Yes
w12 vs. d7	0.906	9	12.840	<0.001	Yes
w12 vs. w2	0.710	9	10.060	<0.001	Yes
w12 vs. w3	0.437	9	6.199	0.001	Yes
w12 vs. w4	0.246	9	3.489	0.260	No
w12 vs. w8	0.0312	9	0.443	1.000	Do Not Test
w8 vs. d1	1.223	9	17.321	<0.001	Yes
w8 vs. d3	1.164	9	16.489	<0.001	Yes
w8 vs. d5	1.076	9	15.249	<0.001	Yes
w8 vs. d7	0.875	9	12.398	<0.001	Yes
w8 vs. w2	0.679	9	9.617	<0.001	Yes
w8 vs. w3	0.406	9	5.756	0.003	Yes
w8 vs. w4	0.215	9	3.046	0.443	Do Not Test
w4 vs. d1	1.008	9	14.275	<0.001	Yes
w4 vs. d3	0.949	9	13.442	<0.001	Yes
w4 vs. d5	0.861	9	12.203	<0.001	Yes
w4 vs. d7	0.660	9	9.351	<0.001	Yes
w4 vs. w2	0.464	9	6.571	<0.001	Yes
w4 vs. w3	0.191	9	2.710	0.604	No
w3 vs. d1	0.816	9	11.565	<0.001	Yes
w3 vs. d3	0.758	9	10.733	<0.001	Yes
w3 vs. d5	0.670	9	9.493	<0.001	Yes
w3 vs. d7	0.469	9	6.642	<0.001	Yes
w3 vs. w2	0.272	9	3.861	0.150	No
w2 vs. d1	0.544	9	7.704	<0.001	Yes
w2 vs. d3	0.485	9	6.872	<0.001	Yes
w2 vs. d5	0.398	9	5.632	0.004	Yes

w2 vs. d7	0.196	9	2.781	0.570	No
d7 vs. d1	0.347	9	4.924	0.020	Yes
d7 vs. d3	0.289	9	4.091	0.102	No
d7 vs. d5	0.201	9	2.851	0.536	Do Not Test
d5 vs. d1	0.146	9	2.072	0.869	No
d5 vs. d3	0.0875	9	1.240	0.994	Do Not Test
d3 vs. d1	0.0588	9	0.832	1.000	Do Not Test

Comparisons for factor: **condition within d1**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.05**
uv vs. control	0.537	2	8.781	<0.001	Yes

Comparisons for factor: **condition within d3**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.05**
uv vs. control	0.370	2	6.045	<0.001	Yes

Comparisons for factor: **condition within d5**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.05**
uv vs. control	0.510	2	8.332	<0.001	Yes

Comparisons for factor: **condition within d7**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.05**
uv vs. control	0.251	2	4.105	0.005	Yes

Comparisons for factor: **condition within w2**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.05**
uv vs. control	0.163	2	2.655	0.065	No

Comparisons for factor: **condition within w3**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.05**
control vs. uv	0.225	2	3.676	0.012	Yes

Comparisons for factor: **condition within w4**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.05**
control vs. uv	0.102	2	1.675	0.241	No

Comparisons for factor: **condition within w8**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.05**
uv vs. control	0.255	2	4.166	0.005	Yes

Comparisons for factor: **condition within w12**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.05**
uv vs. control	0.201	2	3.288	0.023	Yes

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All Pairwise Multiple Comparison Procedures (Tukey Test):

Comparisons for factor: **time within control**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.05**
d3 vs. d1	1.480	9	17.805	<0.001	Yes
d3 vs. w8	1.369	9	16.467	<0.001	Yes
d3 vs. w12	1.316	9	15.835	<0.001	Yes
d3 vs. w4	1.311	9	15.775	<0.001	Yes
d3 vs. w2	1.215	9	14.617	<0.001	Yes
d3 vs. w3	1.138	9	13.684	<0.001	Yes
d3 vs. d5	1.080	9	12.993	<0.001	Yes
d3 vs. d7	0.765	9	9.203	<0.001	Yes
d7 vs. d1	0.715	9	8.602	<0.001	Yes
d7 vs. w8	0.604	9	7.263	<0.001	Yes
d7 vs. w12	0.551	9	6.632	<0.001	Yes
d7 vs. w4	0.546	9	6.572	<0.001	Yes
d7 vs. w2	0.450	9	5.414	0.007	Yes
d7 vs. w3	0.373	9	4.481	0.049	Yes
d7 vs. d5	0.315	9	3.790	0.167	No
d5 vs. d1	0.400	9	4.812	0.025	Yes
d5 vs. w8	0.289	9	3.474	0.265	No
d5 vs. w12	0.236	9	2.842	0.540	Do Not Test
d5 vs. w4	0.231	9	2.782	0.569	Do Not Test
d5 vs. w2	0.135	9	1.624	0.965	Do Not Test
d5 vs. w3	0.0575	9	0.692	1.000	Do Not Test
w3 vs. d1	0.342	9	4.120	0.097	No
w3 vs. w8	0.231	9	2.782	0.569	Do Not Test
w3 vs. w12	0.179	9	2.150	0.844	Do Not Test
w3 vs. w4	0.174	9	2.090	0.863	Do Not Test
w3 vs. w2	0.0775	9	0.932	0.999	Do Not Test
w2 vs. d1	0.265	9	3.188	0.379	Do Not Test
w2 vs. w8	0.154	9	1.850	0.927	Do Not Test
w2 vs. w12	0.101	9	1.218	0.995	Do Not Test
w2 vs. w4	0.0963	9	1.158	0.996	Do Not Test
w4 vs. d1	0.169	9	2.030	0.882	Do Not Test
w4 vs. w8	0.0575	9	0.692	1.000	Do Not Test
w4 vs. w12	0.00500	9	0.0602	1.000	Do Not Test
w12 vs. d1	0.164	9	1.970	0.898	Do Not Test
w12 vs. w8	0.0525	9	0.632	1.000	Do Not Test
w8 vs. d1	0.111	9	1.338	0.990	Do Not Test

Comparisons for factor: **time within uv**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.05**
w12 vs. d1	1.394	9	16.767	<0.001	Yes
w12 vs. w2	1.150	9	13.835	<0.001	Yes
w12 vs. d3	0.821	9	9.880	<0.001	Yes
w12 vs. d5	0.587	9	7.068	<0.001	Yes
w12 vs. w3	0.458	9	5.504	0.005	Yes
w12 vs. w8	0.366	9	4.406	0.057	No
w12 vs. d7	0.283	9	3.399	0.293	Do Not Test
w12 vs. w4	0.258	9	3.098	0.419	Do Not Test

w4 vs. d1	1.136	9	13.669	<0.001	Yes
w4 vs. w2	0.892	9	10.737	<0.001	Yes
w4 vs. d3	0.564	9	6.782	<0.001	Yes
w4 vs. d5	0.330	9	3.970	0.125	No
w4 vs. w3	0.200	9	2.406	0.745	Do Not Test
w4 vs. w8	0.109	9	1.308	0.991	Do Not Test
w4 vs. d7	0.0250	9	0.301	1.000	Do Not Test
d7 vs. d1	1.111	9	13.369	<0.001	Yes
d7 vs. w2	0.867	9	10.436	<0.001	Yes
d7 vs. d3	0.539	9	6.481	<0.001	Yes
d7 vs. d5	0.305	9	3.669	0.201	Do Not Test
d7 vs. w3	0.175	9	2.105	0.859	Do Not Test
d7 vs. w8	0.0838	9	1.008	0.999	Do Not Test
w8 vs. d1	1.027	9	12.361	<0.001	Yes
w8 vs. w2	0.784	9	9.429	<0.001	Yes
w8 vs. d3	0.455	9	5.474	0.006	Yes
w8 vs. d5	0.221	9	2.662	0.627	Do Not Test
w8 vs. w3	0.0912	9	1.098	0.997	Do Not Test
w3 vs. d1	0.936	9	11.263	<0.001	Yes
w3 vs. w2	0.692	9	8.331	<0.001	Yes
w3 vs. d3	0.364	9	4.376	0.061	No
w3 vs. d5	0.130	9	1.564	0.972	Do Not Test
d5 vs. d1	0.806	9	9.699	<0.001	Yes
d5 vs. w2	0.563	9	6.767	<0.001	Yes
d5 vs. d3	0.234	9	2.812	0.555	Do Not Test
d3 vs. d1	0.573	9	6.887	<0.001	Yes
d3 vs. w2	0.329	9	3.955	0.128	No
w2 vs. d1	0.244	9	2.932	0.497	No

Comparisons for factor: **condition within d1**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.05**
uv vs. control	1.085	2	9.619	<0.001	Yes

Comparisons for factor: **condition within d3**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.05**
uv vs. control	0.178	2	1.574	0.279	No

Comparisons for factor: **condition within d5**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.05**
uv vs. control	1.491	2	13.220	<0.001	Yes

Comparisons for factor: **condition within d7**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.05**
uv vs. control	1.481	2	13.131	<0.001	Yes

Comparisons for factor: **condition within w2**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.05**
uv vs. control	1.064	2	9.430	<0.001	Yes

Comparisons for factor: **condition within w3**

Comparison	Diff of Means	p	q	P	P<0.05
uv vs. control	1.679	2	14.882	<0.001	Yes

Comparisons for factor: **condition within w4**

Comparison	Diff of Means	p	q	P	P<0.05
uv vs. control	2.053	2	18.195	<0.001	Yes

Comparisons for factor: **condition within w8**

Comparison	Diff of Means	p	q	P	P<0.05
uv vs. control	2.001	2	17.741	<0.001	Yes

Comparisons for factor: **condition within w12**

Comparison	Diff of Means	p	q	P	P<0.05
uv vs. control	2.315	2	20.523	<0.001	Yes

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All Pairwise Multiple Comparison Procedures (Tukey Test):

Comparisons for factor: **time within control**

Comparison	Diff of Means	p	q	P	P<0.05
d7 vs. d1	2.207	9	19.382	<0.001	Yes
d7 vs. w2	1.160	9	10.185	<0.001	Yes
d7 vs. w4	1.074	9	9.428	<0.001	Yes
d7 vs. d5	0.672	9	5.905	0.002	Yes
d7 vs. w12	0.497	9	4.368	0.061	No
d7 vs. w8	0.270	9	2.371	0.760	Do Not Test
d7 vs. d3	0.0462	9	0.406	1.000	Do Not Test
d7 vs. w3	0.00375	9	0.0329	1.000	Do Not Test
w3 vs. d1	2.204	9	19.349	<0.001	Yes
w3 vs. w2	1.156	9	10.152	<0.001	Yes
w3 vs. w4	1.070	9	9.395	<0.001	Yes
w3 vs. d5	0.669	9	5.872	0.002	Yes
w3 vs. w12	0.494	9	4.335	0.065	Do Not Test
w3 vs. w8	0.266	9	2.338	0.773	Do Not Test
w3 vs. d3	0.0425	9	0.373	1.000	Do Not Test
d3 vs. d1	2.161	9	18.976	<0.001	Yes
d3 vs. w2	1.114	9	9.779	<0.001	Yes
d3 vs. w4	1.028	9	9.022	<0.001	Yes
d3 vs. d5	0.626	9	5.499	0.005	Yes
d3 vs. w12	0.451	9	3.962	0.127	Do Not Test
d3 vs. w8	0.224	9	1.965	0.900	Do Not Test
w8 vs. d1	1.938	9	17.012	<0.001	Yes
w8 vs. w2	0.890	9	7.814	<0.001	Yes
w8 vs. w4	0.804	9	7.057	<0.001	Yes
w8 vs. d5	0.403	9	3.534	0.244	No
w8 vs. w12	0.228	9	1.998	0.891	Do Not Test
w12 vs. d1	1.710	9	15.014	<0.001	Yes
w12 vs. w2	0.663	9	5.817	0.002	Yes
w12 vs. w4	0.576	9	5.060	0.015	Yes
w12 vs. d5	0.175	9	1.537	0.975	Do Not Test

d5 vs. d1	1.535	9	13.478	<0.001	Yes
d5 vs. w2	0.487	9	4.280	0.072	No
d5 vs. w4	0.401	9	3.523	0.248	Do Not Test
w4 vs. d1	1.134	9	9.955	<0.001	Yes
w4 vs. w2	0.0863	9	0.757	1.000	Do Not Test
w2 vs. d1	1.047	9	9.197	<0.001	Yes

Comparisons for factor: **time within uv**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.05**
w3 vs. d1	3.370	9	29.589	<0.001	Yes
w3 vs. d3	3.280	9	28.799	<0.001	Yes
w3 vs. d5	1.990	9	17.473	<0.001	Yes
w3 vs. w8	1.469	9	12.896	<0.001	Yes
w3 vs. w2	1.450	9	12.731	<0.001	Yes
w3 vs. w4	1.139	9	9.998	<0.001	Yes
w3 vs. d7	0.899	9	7.891	<0.001	Yes
w3 vs. w12	0.650	9	5.707	0.003	Yes
w12 vs. d1	2.720	9	23.882	<0.001	Yes
w12 vs. d3	2.630	9	23.092	<0.001	Yes
w12 vs. d5	1.340	9	11.766	<0.001	Yes
w12 vs. w8	0.819	9	7.189	<0.001	Yes
w12 vs. w2	0.800	9	7.024	<0.001	Yes
w12 vs. w4	0.489	9	4.291	0.071	No
w12 vs. d7	0.249	9	2.184	0.832	Do Not Test
d7 vs. d1	2.471	9	21.698	<0.001	Yes
d7 vs. d3	2.381	9	20.908	<0.001	Yes
d7 vs. d5	1.091	9	9.581	<0.001	Yes
d7 vs. w8	0.570	9	5.005	0.017	Yes
d7 vs. w2	0.551	9	4.840	0.024	Yes
d7 vs. w4	0.240	9	2.107	0.858	Do Not Test
w4 vs. d1	2.231	9	19.591	<0.001	Yes
w4 vs. d3	2.141	9	18.801	<0.001	Yes
w4 vs. d5	0.851	9	7.474	<0.001	Yes
w4 vs. w8	0.330	9	2.897	0.513	No
w4 vs. w2	0.311	9	2.733	0.593	Do Not Test
w2 vs. d1	1.920	9	16.858	<0.001	Yes
w2 vs. d3	1.830	9	16.068	<0.001	Yes
w2 vs. d5	0.540	9	4.741	0.029	Yes
w2 vs. w8	0.0188	9	0.165	1.000	Do Not Test
w8 vs. d1	1.901	9	16.693	<0.001	Yes
w8 vs. d3	1.811	9	15.903	<0.001	Yes
w8 vs. d5	0.521	9	4.577	0.041	Yes
d5 vs. d1	1.380	9	12.117	<0.001	Yes
d5 vs. d3	1.290	9	11.327	<0.001	Yes
d3 vs. d1	0.0900	9	0.790	1.000	No

Comparisons for factor: **condition within d1**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.05**
uv vs. control	2.346	2	14.244	<0.001	Yes

Comparisons for factor: **condition within d3**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.05**
uv vs. control	0.275	2	1.670	0.252	No

Comparisons for factor: **condition within d5**

Comparison	Diff of Means	p	q	P	P<0.05
uv vs. control	2.191	2	13.303	<0.001	Yes

Comparisons for factor: **condition within d7**

Comparison	Diff of Means	p	q	P	P<0.05
uv vs. control	2.610	2	15.845	<0.001	Yes

Comparisons for factor: **condition within w2**

Comparison	Diff of Means	p	q	P	P<0.05
uv vs. control	3.219	2	19.541	<0.001	Yes

Comparisons for factor: **condition within w3**

Comparison	Diff of Means	p	q	P	P<0.05
uv vs. control	3.512	2	21.325	<0.001	Yes

Comparisons for factor: **condition within w4**

Comparison	Diff of Means	p	q	P	P<0.05
uv vs. control	3.444	2	20.907	<0.001	Yes

Comparisons for factor: **condition within w8**

Comparison	Diff of Means	p	q	P	P<0.05
uv vs. control	2.310	2	14.024	<0.001	Yes

Comparisons for factor: **condition within w12**

Comparison	Diff of Means	p	q	P	P<0.05
uv vs. control	3.356	2	20.376	<0.001	Yes

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All Pairwise Multiple Comparison Procedures (Tukey Test):

Comparisons for factor: **time within control**

Comparison	Diff of Means	p	q	P	P<0.05
d7 vs. d1	0.886	9	10.037	<0.001	Yes
d7 vs. w4	0.691	9	7.829	<0.001	Yes
d7 vs. w2	0.566	9	6.413	<0.001	Yes
d7 vs. w12	0.325	9	3.681	0.198	No
d7 vs. w3	0.231	9	2.619	0.648	Do Not Test
d7 vs. d3	0.222	9	2.520	0.694	Do Not Test
d7 vs. w8	0.149	9	1.685	0.957	Do Not Test
d7 vs. d5	0.0287	9	0.326	1.000	Do Not Test
d5 vs. d1	0.858	9	9.711	<0.001	Yes
d5 vs. w4	0.663	9	7.503	<0.001	Yes
d5 vs. w2	0.538	9	6.087	0.001	Yes
d5 vs. w12	0.296	9	3.355	0.310	Do Not Test

d5 vs. w3	0.203	9	2.293	0.791	Do Not Test
d5 vs. d3	0.194	9	2.194	0.828	Do Not Test
d5 vs. w8	0.120	9	1.359	0.989	Do Not Test
w8 vs. d1	0.738	9	8.352	<0.001	Yes
w8 vs. w4	0.543	9	6.144	0.001	Yes
w8 vs. w2	0.418	9	4.728	0.030	Yes
w8 vs. w12	0.176	9	1.996	0.891	Do Not Test
w8 vs. w3	0.0825	9	0.934	0.999	Do Not Test
w8 vs. d3	0.0738	9	0.835	1.000	Do Not Test
d3 vs. d1	0.664	9	7.517	<0.001	Yes
d3 vs. w4	0.469	9	5.309	0.008	Yes
d3 vs. w2	0.344	9	3.893	0.142	No
d3 vs. w12	0.103	9	1.161	0.996	Do Not Test
d3 vs. w3	0.00875	9	0.0991	1.000	Do Not Test
w3 vs. d1	0.655	9	7.418	<0.001	Yes
w3 vs. w4	0.460	9	5.210	0.010	Yes
w3 vs. w2	0.335	9	3.794	0.166	Do Not Test
w3 vs. w12	0.0938	9	1.062	0.998	Do Not Test
w12 vs. d1	0.561	9	6.356	<0.001	Yes
w12 vs. w4	0.366	9	4.148	0.092	No
w12 vs. w2	0.241	9	2.732	0.593	Do Not Test
w2 vs. d1	0.320	9	3.624	0.215	No
w2 vs. w4	0.125	9	1.416	0.985	Do Not Test
w4 vs. d1	0.195	9	2.208	0.823	Do Not Test

Comparisons for factor: **time within uv**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.05**
w12 vs. d1	4.139	9	46.873	<0.001	Yes
w12 vs. d5	2.920	9	33.070	<0.001	Yes
w12 vs. w2	2.845	9	32.221	<0.001	Yes
w12 vs. d3	2.396	9	27.138	<0.001	Yes
w12 vs. d7	2.379	9	26.940	<0.001	Yes
w12 vs. w4	1.522	9	17.243	<0.001	Yes
w12 vs. w3	1.521	9	17.229	<0.001	Yes
w12 vs. w8	0.471	9	5.337	0.008	Yes
w8 vs. d1	3.668	9	41.536	<0.001	Yes
w8 vs. d5	2.449	9	27.733	<0.001	Yes
w8 vs. w2	2.374	9	26.884	<0.001	Yes
w8 vs. d3	1.925	9	21.801	<0.001	Yes
w8 vs. d7	1.908	9	21.603	<0.001	Yes
w8 vs. w4	1.051	9	11.906	<0.001	Yes
w8 vs. w3	1.050	9	11.892	<0.001	Yes
w3 vs. d1	2.617	9	29.644	<0.001	Yes
w3 vs. d5	1.399	9	15.841	<0.001	Yes
w3 vs. w2	1.324	9	14.992	<0.001	Yes
w3 vs. d3	0.875	9	9.910	<0.001	Yes
w3 vs. d7	0.857	9	9.711	<0.001	Yes
w3 vs. w4	0.00125	9	0.0142	1.000	No
w4 vs. d1	2.616	9	29.630	<0.001	Yes
w4 vs. d5	1.398	9	15.827	<0.001	Yes
w4 vs. w2	1.323	9	14.978	<0.001	Yes
w4 vs. d3	0.874	9	9.896	<0.001	Yes
w4 vs. d7	0.856	9	9.697	<0.001	Yes
d7 vs. d1	1.760	9	19.933	<0.001	Yes
d7 vs. d5	0.541	9	6.130	0.001	Yes

d7 vs. w2	0.466	9	5.280	0.009	Yes
d7 vs. d3	0.0175	9	0.198	1.000	No
d3 vs. d1	1.742	9	19.734	<0.001	Yes
d3 vs. d5	0.524	9	5.932	0.002	Yes
d3 vs. w2	0.449	9	5.082	0.014	Yes
w2 vs. d1	1.294	9	14.652	<0.001	Yes
w2 vs. d5	0.0750	9	0.849	1.000	No
d5 vs. d1	1.219	9	13.803	<0.001	Yes

Comparisons for factor: **condition within d1**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.05**
uv vs. control	0.764	2	6.918	<0.001	Yes

Comparisons for factor: **condition within d3**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.05**
uv vs. control	1.842	2	16.690	<0.001	Yes

Comparisons for factor: **condition within d5**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.05**
uv vs. control	1.125	2	10.190	<0.001	Yes

Comparisons for factor: **condition within d7**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.05**
uv vs. control	1.638	2	14.833	<0.001	Yes

Comparisons for factor: **condition within w2**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.05**
uv vs. control	1.738	2	15.738	<0.001	Yes

Comparisons for factor: **condition within w3**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.05**
uv vs. control	2.726	2	24.695	<0.001	Yes

Comparisons for factor: **condition within w4**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.05**
uv vs. control	3.185	2	28.850	<0.001	Yes

Comparisons for factor: **condition within w8**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.05**
uv vs. control	3.694	2	33.458	<0.001	Yes

Comparisons for factor: **condition within w12**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.05**
uv vs. control	4.341	2	39.324	<0.001	Yes

BIOGRAPHY

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