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OPEN ACCESS JOURNALS

Archives of Clinical & Experimental Dermatology

**Research | Vol 2 Iss 2**

# Reliability of a Self-Assessment of Skin Color Using a Color Palette

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**Received:** July 05, 2020; **Accepted:** July 14, 2020; **Published:** July 22, 2020

## Abstract

**Purpose: The purpose of this study was to examine the reliability of a new 9-point Self-Assessment Skin Tone Palette (SASTP) for reporting skin color across different racial/ethnic groups and on sun-exposed and unexposed skin in comparison with the reliability of other sun sensitivity measures from the melanoma literature within a diverse population.**

**Methods: We examined test-retest reliability (intramethod reliability) comparing the initial survey responses to responses of the repeat survey using simple Kappas for dichotomous categories, weighted Kappas for multiple categories and interclass correlation coefficient for 7 or more ordered categories.**

**Results: The reliability of the 9-point SASTP has interclass correlation coefficients of 0.6–0.8 for categorizing skin color of the upper inner arm and the forearm on a repeat in-person survey and a repeat online survey, which was higher than reliability for tendency to sunburn, inability to tan and a subjective measure of skin color.**

**Conclusions: Our study showed substantial reliability of the SASTP for measuring skin color of the upper-inner arm and the forearm. In particular, there was high reliability between the initial in-person SASTP and the online version of the SASTP, suggesting that the SASTP can be reliably used for online surveys for measuring skin color.**

**Keyword:** ***Self-Assessment skin tone palette (SASTP); Skin color; Sun sensitivity***

## 1. Introduction

Traditional self-reported measurements of skin color in the melanoma literature were developed based on Caucasian skin colors with 3-4 response categories, as was the initial Fitzpatrick skin-type due to the much higher risk of melanoma among Caucasians [1]. Self-reported skin color questions from the melanoma literature typically ask about fair, medium and dark

skin [2], even among melanoma studies of people groups of Hispanic origin [3]. However, answering fair/light, medium or dark skin is subjective. Someone of African descent may interpret the question differently than someone of Scandinavian descent. Each may interpret the questions within people group of their perceived background, so that say medium skin color has no standard across different racial/ethnic groups.

On the other extreme of complexity, Felix Von Luschan (1854-1924) created a 36-point chromatic scale for classifying skin color [4]. Inter-observer (intramethod) differences averaged less than 1 tile when using 36 tiles to quantify skin color among 246 participants across four 4 body locations by two observers [4]. While these tiles are quantitative and potentially more accurate, characterizing skin color based on 36 tiles or colors is cumbersome to use, requiring in-person assessment so it is not very practical for many research studies. Thus, we developed a self-administered scale with 9-point color palette that could be used as part of a self-assessment questionnaire with skin color options ranging in color across different racial/ethnic groups.

The purpose of these analyses was to look at the reliability of this instrument in a racially/ethnically diverse population. Additionally, we wanted to compare such reliability to the reliability of other standard sun sensitivity measures from the melanoma literature, so also asked subjects those questions.

## 2. Methods

The Self-Assessment Skin Tone Palette (SASTP) was developed by looking at a variety of skin colors among colleagues born in the US, Mexico and Africa. The palette was designed to incorporate skin tones across various people groups while remaining compact and easy for the participant to use. Skin tones were chosen using the Red Green Blue (RGB) color codes on Adobe Photoshop and compared to the various skin tone options used for products in the make-up industry. Colleagues were asked if the shades in early drafts of the assessment tool were distinguishable enough from each other and adjustments were made by increasing or decreasing the RGB scale. A 9-point scale was determined, because the color options were discriminant while allowing for the swatches to be easily viewable on a single sheet of paper.

To assure similarity, multiple palettes were printed on the same printer (with fresh toner colors) at the same time, as toner levels could affect the printed colors. Participants had the ability to hold up the palette to compare to their forearm and inner arm during data collection. These tones can be replicated using the RGB color scale.

The upper inner arm is typically used on skin cancer research to represent the untanned skin color. We additionally looked at the forearm as a more tanned area of the body. Thus, self-assessed skin color was ascertained for these two body sites with a color palette in which participants chose from 9 skin tone choices which they believed to match their upper-inner arm and their forearm. This took about 5 min on average. Upon the participant's initial visit, a questionnaire that consisted of 15 questions about artificial tanning, sun sensitivity, self-perception on skin tone, family history of skin cancer, age, sex and race along with 4 questions to create a unique identification (ID) was completed. The survey was administered to employees and students at the University of Arizona from in fall 2016. We recruited staff, faculty and students via email and/or flyers. Additionally, we set up a data collection booth at the November Melanoma Walk on the university campus.

We consented participants and collected data from the first round of all participants and asked for information to contact them in order to complete a second survey. Participants were allowed to withdraw at any time or refuse to answer any questions. Participants' names and emails provided for recontact were not associated with their questionnaire or ID. Data were entered and stored on password-protected computers, and physical copies of the questionnaires were kept locked in an investigator's office.

## 3. Statistical Analysis

Reliability refers to the reproducibility of a measure or how consistently a measurement can be repeated on the same subjects [5]. We examined intramethod reliability, also known as test-retest reliability comparing the original survey responses to responses from a second survey with identical questions. For intramethod reliability, the interclass correlation coefficient (ICC) was estimated for continuous measures and kappa was used for categorical measures [5]. The ICCs were estimated from a one-way random effects model based on the between and within mean squares. A lower 95% confidence limit for the ICC was estimated using the F-distribution under the assumption of a normal distribution [6]. Under the parallel tests' assumption, the validity of SASTP was estimated as the square root of the reliability coefficient for each body site [5]. If the assumption of uncorrelated errors in the two measurements does not hold, the square root of reliability provides an upper limit of the validity of the measure [5]. We estimated the validity based on the ICC reliability coefficients and conservatively presented these estimates as an upper limit of validity. Kappa values were used in our assessment of the reliability of categorical measures from survey questions [5]. Weighted Cohen's kappas were used for ordered categories, and simple kappas for dichotomous categories. Kappas were calculated using SAS software with Cicchetti-Allison weights [7]. Kappas are interpreted using Cohen's suggested interpretations of $\leq 0$ as indicating no agreement and 0.01-0.20 as none to slight agreement, 0.21-0.40 as fair, 0.41-0.60 as moderate, 0.61-0.80 as substantial, and 0.81-1.00 as almost perfect agreement.

Subjects who reported use of tanning beds or sunless tanning sprays of creams in the month prior to either survey were excluded. We were concerned that these artificial tanning products could create differences in the SASTP that would reflect true changes in skin color due to the products rather than unreliable responses. Since true changes could also occur due to sun exposure, we reduced this as much as possible by conducting the initial and repeat surveys in October-December.

## 4. Results

Among non-artificial tanners (users of tanning beds or spray on tans), 181 participated in the initial survey. Three IDs from the second in-person survey and 1 ID from the online survey (repeat survey) did not match other IDs from the initial survey. This gave matches to 74 repeat surveys in-person and 72 completing a second survey online for 82.5% participation in the second survey. The majority of participants were age 18-29, female and White. However, this study did aim to include various racial/ethnic categories with only 50% self-identifying as White on the initial survey, 32% identifying as Hispanic or White-Hispanic (TABLE 1). Participants most frequently reported fair skin color but tended to tan moderately and have no sunburn on initial exposure to the sun (TABLE 1). The 9-point SASTP scale had the majority of subjects reporting 2-4 on the scale for upper-inner arm (untanned skin color) and 2-5 for skin color of the forearm (tanned skin). The majority of subjects had a difference in the sun-exposure and unexposed skin colors of 0-2 on each survey.

TABLE 1. **Distribution of Demographics and Sun Sensitivity Factors Among a Population of 181 Non-Artificial Tanning a Participants in Arizona**.

| **Host and Sun Sensitivity Factors** | **In-person Initial Survey (N=181)** | **In-person 2nd Survey (N=74)** | **Online 2nd Survey (N=72)** |
|---|---|---|---|
| **Age** | | | |
| 18-29 | 146 (81%) | 74 (96%) | 56 (78%) |
| 30-39 | 9 (5%) | 2 (3%) | 6 (8%) |
| 40-49 | 1 (1%) | 0 (0%) | 1 (1%) |
| 50-59 | 15 (8%) | 1 (1%) | 6 (8%) |
| 60+ | 10 ( 5%) | 0 ( 0%) | 3 ( 4%) |
| **Sex** | | | |
| Female | 124 (69%) | 50 (65%) | 52 (72%) |
| Male | 57 (31%) | 27 (35%) | 20 (28%) |
| **Background** | | | |
| White | 90 (50%) | 25 (32%) | 39 (54%) |
| White-Hispanic | 14 (8%) | 14 (18%) | 0 (0%) |
| Hispanic | 43 (24%) | 21 (27%) | 18 (25%) |
| Asian or Pacific Islander | 23 (13%) | 8 (10%) | 11 (15%) |
| Native American or Alaskan | 5 (3%) | 5 (6%) | 2 (3%) |
| African-American or Black | 6 ( 3%) | 4 ( 5%) | 2 ( 3%) |
| **Tendency to burn** [b] | | | |
| Severe & painful sunburn | 7 (4%) | 1 (1%) | 4 (6%) |
| Moderate sunburn | 38 (21%) | 10 (13%) | 17 (24%) |
| Mild sunburn | 63 (35%) | 26 (34%) | 24 (33%) |
| No sunburn | 73 (40%) | 40 (52%) | 27 (37%) |
| **Inability to tan** [c] | | | |
| Deeply tanned | 37 (20%) | 15 (19%) | 9 (13%) |
| Moderately tanned | 90 (50%) | 35 (45%) | 35 (49%) |
| Mildly tanned | 44 (24%) | 23 (30%) | 22 (31%) |
| Have no tan | 10 ( 6%) | 4 (5%) | 5 (7%) |
| **Skin Color of the upper inner arm (untanned)** [d] | | | |
| Fair | 105 (58%) | 41 (53%) | 49 (68%) |
| Medium | 73 (40%) | 35 (45%) | 22 (31%) |
| Dark | 3 ( 2%) | 1 ( 1%) | 1 ( 1%) |
| **Forearm compared to upper inner arm** | | | |
| About the Same | 65 (36%) | 23 (30%) | 24 (33%) |
| A little darker | 74 (41%) | 43 (57%) | 36 (50%) |
| Somewhat darker | 39 (21%) | 10 (13%) | 11 (15%) |
| A lot darker | 3 ( 2%) | 0 (0%) | 1 ( 1%) |

| | | | |
|---|---|---|---|
| **Eye Color** | | | |
| Gray | 2 (1%) | 0 (0%) | 2 (3%) |
| Blue | 30 (17%) | 6 (8%) | 16 (22%) |
| Green | 23 (13%) | 5 (7%) | 7 (10%) |
| Brown or Black | 123 (69%) | 65 (85%) | 47 (65%) |
| **Natural Hair Color** | | | |
| Red | 2 (1%) | 1 (1%) | 1 (1%) |
| Red Blond | 4 (2%) | 1 (1%) | 0 (0%) |
| Blond | 18 (10%) | 7 (9%) | 6 (8%) |
| Brown or Auburn | 113 (62%) | 47 (61%) | 52 (72%) |
| Black | 44 (24%) | 21 (27%) | 13 (18%) |
| **Color palette choice for the upper inner arm (untanned skin)** | | | |
| 1 (A1) | 19 (10%) | 6 (8%) | 17 (24%) |
| 2 (A2) | 82 (45%) | 29 (38%) | 28 (39%) |
| 3 (A3) | 33 (18%) | 20 (26%) | 14 (19%) |
| 4 (B1) | 34 (19%) | 18 (23%) | 9 (12%) |
| 5 (B2) | 7 (4%) | 2 (2%) | 2 (3%) |
| 6 (B3) | 3 (3%) | 2 (2%) | 1 (1%) |
| 7 (C1) | 1 (0.5%) | 0 (0%) | 0 (0%) |
| 8 (C2) | 1 (0.5%) | 0 (0%) | 1 (1%) |
| 9 (C3) | 1 (0.5%) | 0 (0%) | 0 ( 0%) |
| **Color palette choice for the forearm (tanned skin)** | | | |
| 1 (A1) | 1 (0.5%) | 1 (1%) | 2 (3%) |
| 2 (A2) | 32 (18%) | 15 (19%) | 23 (32%) |
| 3 (A3) | 39 (21%) | 14 (18%) | 17 (24%) |
| 4 (B1) | 44 (24%) | 20 (26%) | 16 (22%) |
| 5 (B2) | 52 (29%) | 24 (31%) | 9 (12%) |
| 6 (B3) | 8 (4%) | 2 (2%) | 3 (4%) |
| 7 (C1) | 3 (1%) | 1 (1%) | 1 (1%) |
| 8 (C2) | 1 (0.5%) | 0 (0%) | 0 (0%) |
| 9 (C3) | 1 (0.5%) | 0 ( 0%) | 1 ( 1%) |
| **Difference in the color palette choice for the forearm - the choice for the upper inner arm** | | | |
| -2 | 1 (0.5%) | 1 (1%) | 0 (0%) |
| -1 | 4 (2%) | 4 (5%) | 2 (3%) |
| 0 | 32 (18%) | 12 (16%) | 21 (29%) |
| 1 | 96 (53%) | 28 (50%) | 38 (52%) |
| 2 | 39 (22%) | 19 (25%) | 10 (14%) |
| 3 | 9 ( 5%) | 2 ( 3%) | 2 ( 3%) |

Abbreviations:
N = Sample Size
[a] People who did not report using a tanning bed or sunlamp or a spray on tan in the month prior to the survey.
[b] When your skin is first exposed to strong sunlight for an hour for the first time each spring or summer with no protection does it get...
[c] After repeated and prolonged exposure to the sun, does your skin become...
[d] How would you describe your un-tanned skin color on your upper inner arm?

The reliability of age categories, sex, family history of skin cancer, eye color and hair color were almost perfect (TABLE 2). For standard sun sensitivity measures used in studies of melanoma among Caucasians, the reliability was moderate to substantial ranging from 0.58-0.72. We had added an unpiloted new question to look at self-reported color of the forearm in comparison to the upper-inner arm (similar or darker), but it was not reliable (TABLE 2).

TABLE 2**. Test-Retest Reliability of Host and Sun Sensitivity Factors Among 146 Non-Artificial Tanninga Participants in Arizona who Completed Two Surveys.**

| Host and Sun Sensitivity Factors | In-person reliability | | Online reliability | |
|---|---|---|---|---|
| | N | Kappa[b] (95% CI) | N | Kappa[b] (95% CI) |
| Age categories (18-29, 30-39, 40-49, 50-59, 60+) | 74 | 1.00 | 71 | 0.98 (0.95-1.00) |
| Sex (female, male) | 74 | 0.94 (0.86-1.00) | 71 | 1.00 |
| Do you have a family history of skin cancer? Yes, no (Don't know excluded) | 64 | 0.96 (0.87-1.00) | 64 | 0.96 (0.89-1.00) |
| What is your eye color? (gray, blue, green, brown) | 73 | 0.97 (0.90-1.0) | 70 | 0.97 (0.92-1.0) |
| What was your natural hair color at age 20? (red, red blond, blond, brown or auburn, black) | 74 | 0.86 (0.76-0.97) | 71 | 0.85 (0.73-0.97) |
| **Sun Sensitivity:**<br><br>**Tendency to burn**: When your skin is exposed to strong sunlight for an hour for the **first time** each spring or summer with no protection, does it get… a severe and painful sunburn, moderate sunburn, mild sunburn, or no sunburn, just tans? | 74 | 0.57 (0.45, 0.71) | 71 | 0.65 (0.53, 0.78) |
| **Inability to tan**: After repeated and prolonged exposure to the sun, does your skin become… deeply tanned, moderately tanned, mildly tanned, of have no tan? | 74 | 0.72 (0.59, 0.85) | 70 | 0.65 (0.51, 0.79) |
| **Skin Color upper inner arm**: How would you describe your untanned skin color on your **upper inner arm** … fair, medium, or dark? | 74 | 0.61 (0.43, 0.79) | 71 | 0.58 (0.38, 0.77) |
| **Skin Color forearm**: How would you describe your skin color on your **forearm (about 3 inches above your wris**t) compared to the skin of your upper-inner arm ... about the same, a little darker, somewhat darker, or a lot darker? | 74 | 0.08 (0.00-0.24) | 71 | 0.36 (0.18-0.54) |

N, number of subjects
[a] People who did not report using a tanning bed or sunlamp or a spray on tan in the month prior to the survey.
[b] This is a weighted Kappa for ordered categories, simple Kappa for dichotomous factors.

The reliability of the newly developed 9-point skin color palette was substantial with ICCs of 0.59-0.83 for categorizing skin color of the upper inner arm and the forearm (TABLE 3). The upper limit of the SASTPs validity were estimated based on the reliability with a range among the upper inner arm and forearm among the repeats in-person or online ranged from 0.8-0.9 (TABLE 3).

TABLE 3. **Intraclass Correlations for Test-Retest Reliability of Self-Assessment of Skin Tone Palette (SASTP) Among 146 Non-Artificial Tanners.**

| Initial responses on the Color Palette compared to | N | ICC | Lower limit of ICC [b] | Estimate of the Upper limit of Validity [c] |
|---|---|---|---|---|
| **Second survey in-person** | | | | |
| **Upper inner arm** Instructions: Using the color palette provided what color best matches the skin color of your upper-inner arm | 73 | 0.571 | 0.426 | 0.766 |
| **Forearm** Instructions Using the color palette provided what color best matches the skin color of your forearm? | 73 | 0.724 | 0.619 | 0.872 |
| **Second survey completed online using a Qualtrics survey** | | | | |
| **Upper inner arm** Instructions: Using the color palette provided what color best matches the skin color of your upper-inner arm | 72 | 0.832 | 0.761 | 0.909 |
| **Forearm** Instructions Using the color palette provided what color best matches the skin color of your forearm? | 72 | 0.707 | 0.595 | 0.825 |

ICC, Intraclass correlation coefficient; N, number of subjects
[a] People who did not report using a tanning bed or sunlamp or a spray on tan in the month prior to either survey.
[b] Estimated based on the F distribution from the ICC.
[c] Estimated based on the parallel methods assumptions as the square root of the reliability.

## 5. Discussion

Our study showed substantial reliability of the SASTP for measuring skin color of the upper-inner arm and the forearm (ICCS of 0.6-0.8). In particular, there was high reliability between the initial in-person survey and an online version of the survey for the color palette, suggesting that the SASTP can be reliably used for online surveys. The participants completing the second survey online were those who participated in the Melanoma Walk along with some students from an undergraduate course who did not make it to a second in-person appointment. The SASTP can be considered to assess tanness, in doing so the differences of SASTP for the sun exposure location (forearm) and the non-sun-exposure location (the upper-inner arm) showed a distribution of 0-3 for differences with only 3% reporting a darker upper-inner arm.

The SASTP was similar to another survey among an ethnically diverse population that found substantial reliability of skin color by using 6 descriptive adjectives (kappa=0.7) to describe the skin color rather than just fair, medium or dark [8]. Our SASTP went a step further and provided skin color swatches developed in comparison with make-up colors so not just a general skin color can be reported, but skin color of different body sites. The reliability of the SASTP was slightly lower than the Munsell Soil Color Charts system, which had repeat reliability among two raters of 0.85 using 40 of 141 color tiles [9]. However, the Munsell Soil Color Charts or tiles system, which is based on a color atlas in which colors are represented in a

three-dimensional expression by hue, value, and chroma [10], is more complicated to use. The reliability study of the Munsell color system used 40 to 141 color tiles and required multiple study staff to assess skin color. Whereas, the SASTP can be used for self-administered surveys including online surveys.

Repeat age was almost perfect and the minimal differences seen could have been due to a few participants having a birthday between the two measurements. It is unclear if the two participants that did not report the same sex on the initial survey and follow-up in-person survey accidently checked the wrong box or if possibly they were not true matches.

The reliability for eye and hair color were higher in our population (almost perfect) than other reliability studies [8,11-13]. The reliability of the sun sensitivity measures of tendency to burn and inability to tan were similar to that seen in a melanoma case-control study among Caucasians [14] and among convenience samples [8,15], but higher than seen in a case-control study of melanoma in Connecticut [16]. Self-reported skin color of the upper inner arm (fair, medium or dark) was lower among this racially diverse population than in studies of all or mostly Caucasians [14,15], reflecting the need for a measure that incorporates multiple racial/ethnic groups.

Participants included some melanoma survivors, friends and family members of people previously diagnosed with melanoma, university faculty and staff volunteers and volunteers from an undergraduate public health course, representing diverse age and racial backgrounds. The clustering of responses to the SASTP in categories 2-5 may reflect the study subjects or may suggest a need for more variability within the lighter skin colors on the SASTP. Also due to the small number of participants self-identifying as African-American / Black and Native American, this tool needs to be further studied among these populations.

The SASTP was easy to use. However, to simplify it further, we would recommend numbering the colors 1-9 instead of A1-A3, B1-B3, and C1-C3 and placing them next to each other on an ordered grid rather than a 3 × 3 format.

To keep the surveys confidential a 5-digit ID was created from the participants reporting of their first initial, last two digits of their zip code, day of their mother's birthday and last digit of their age. After initial matches were found, additional matches were considered if they matched except for being one year older on the second survey. However, non-matches may have been due to difficulty in remembering their mother's birthday or among students consistently reporting their zip code in Tucson versus for their parents' home. Additionally, students that reported their Tucson-university zip code may have made digits 2-3 more similar for this ID. Thus, studies that may include student participants need to consider carefully use of zip code and possibly day of their mother's birthday.

Strengths of this study include a short survey, easy to use color palette (SASTP) and a diverse population included. The confidential ID helped some subjects be more comfortable participating in completing two surveys, but it lost some data by leaving several surveys unmatched. Having 50% of initial subjects self-classifying their race/ethnicity as other than White is a strength with 32% reporting to be Hispanic. A weakness in comparison to other studies was that we included Hispanic within "Which of these groups best describes your background (check all that apply)", as many Hispanics in Arizona often do not answer race as a separate question from "are you Hispanic". Since the question was worded as check all that apply, we

report multiple racial groups in the following order if more than one was chosen: Native American or Alaska Native, African American /Black, Hispanic or Asian. The participants represented more females, common in some research, but this may have created a bias.

Overall the SASTP was substantially reliable and survey items were moderate to almost perfect except for asking if your forearm was about the same, a little darker, somewhat darker, or a lot darker than your upper-inner arm which was not reliable. Furthermore, the SASTP was found to be reliable when comparing an initial in-person survey to a follow-up online survey, suggesting the SASTP can be used for online surveys in addition to other self-administered surveys.

## 6. Abbreviations

ICC: interclass correlation coefficient; N: number of subjects; SASTP: Self-Assessment Skin Tone Palette (SASTP)

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