Impact of fresh fruit smoothie consumption on apparent health of Asian faces

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A R T I C L E  I N F O

Article history:
Initial receipt 28 September 2016
Received in revised form 3 February 2017
Final revision received 21 February 2017
Available online xxxx

A B S T R A C T

Skin carotenoid coloration has been proposed as a valid cue to health in humans, reflecting fruit and vegetable intake, and enhancing apparent health. Supplementation with a carotenoid-rich fruit and vegetable smoothie affects skin color, but it is not known if this skin color change enhances healthy appearance. In three experiments, we examine the effects of skin color change induced by supplementation with a carotenoid-rich fruit smoothie (25 mg carotenoids/d) on the apparent health of Malaysian Chinese faces. In experiment 1, observers were asked to identify the healthier looking of pairs of photographs of the same subject taken pre- and post-supplementation (or pre- and post-placebo), choosing the pre-supplementation (or pre-placebo) images. When confounding due to facial expression was eliminated in experiment 2, observers showed no preference for unmodified pre-supplementation photograph or the same image with skin color manipulated to simulate a level of smoothie-induced color change associated with 4 weeks of supplementation. In experiment 3, observers manipulated the skin color of face photographs along the smoothie-induced color change axis to optimize healthy appearance. Observers chose to induce a color change approximately equivalent to one third of the change induced by daily consumption of our carotenoid rich smoothie. This suggests that the skin color change induced by the supplementation enhanced apparent facial health, however the dose and duration of the supplementation overshot the optimal healthy-looking color of Malaysian Chinese skin. This suggests that there is an optimal carotenoid color for healthy appearance, and that this optimal level may be constrained by preferences for averageness, by the association between very yellow skin and ill health, or by negative health impacts of very high doses of carotenoids.

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1. Introduction

The human face conveys a range of important social and biological information about the bearer, and other humans detect and interpret such information. For example, observers make rapid, accurate judgments about age (Mouchetant-Rostaing & Giard, 2003), sex (Mouchetant-Rostaing & Giard, 2003), emotional state (De Sonneville et al., 2002), and even personality (Petrican, Todorov, & Grady, 2014) from brief exposures to faces. More recently, attention has turned to identifying cues to health in human faces, and facial features such as symmetry (Rhodes et al., 2001) or facial adiposity (Coetzee, Perrett, & Stephen, 2009) have been proposed to be valid cues to human health. These cues to health are theoretically important, as the leading adaptationist view of attractiveness posits a mechanism for identifying healthy and high quality mates (for a review, see Stephen & Tan, 2015). However, in order for a trait to be considered a valid cue to health, it must relate both to apparent health/attractiveness and to some aspect of physiological health (Stephen & Tan, 2015; Coetzee et al., 2009).

Several studies have now examined the role of skin color as a valid cue to health, with studies examining both the relationship between skin color and perceptions of health and attractiveness, and the relationship between skin color and underlying physiological health. Stephen, Law Smith, Stirrat, & Perrett (2009) allowed participants to manipulate skin color in color-calibrated photographs of Caucasian faces along CIELab L* (luminance), a* (red-green) and b* (yellow-blue) axes to make the faces appear as healthy as possible. Participants chose to increase facial skin luminance (L*), redness (a*), yellowness (b*) to enhance healthy appearance.

The values of these color dimensions in human skin are, of course, primarily determined by the type and density of skin pigments and...
the degree of blood oxygenation. Oxygenated haemoglobin in blood is bright red in color, whereas less oxygenated haemoglobin is a darker, blue-red color (Stephen, Coetzee, Law Smith, & Perrett, 2009). A higher level of oxygenated haemoglobin may reflect physical fitness and absence of respiratory and cardiac illnesses (Charkoudian, 2003; Johnson, 1998; Panza, Quyyumi, Brush, & Epstein, 1990), as well as levels of sex hormones (Jones et al., 2015). Participants choose to increase the apparent oxygenated blood content of facial skin to optimize healthy appearance, suggesting that observers may use this coloration as a cue to health (Stephen et al., 2009a).

The yellow component of skin color reflects the levels of melanin (which increases the b*), and reduces the L* components of skin color, giving it the characteristic brown appearance: (Stamatas, Zmudzka, Kollias, & Beer, 2004) and carotenoids (which primarily increase the b* and a* components of skin color: Alaluf, Heinrich, Stahl, Tronnier, & Wiseman, 2002; Tan, Graf, Mitra, & Stephen, 2015) in the skin. Melanin protects the skin from sunburn and skin cancer (Branda & Eaton, 1978). Small increases in melanin coloration have been shown to enhance the apparent health of facial skin (Stephen, Coetzee, & Perrett, 2011).

Carotenoids are orange, yellow or red pigments with antioxidant properties, thought to be beneficial for human immune (Alexander, Newmark, & Miller, 1988; Seifert, Ruttma, & Levenson, 1981) and reproductive (Agarwal, 2005) systems (Dowling & Simmons, 2009). It has been shown that increased skin carotenoid coloration is associated with perceived health (Stephen et al., 2011) and attractiveness (Lefevre & Perrett, 2015) in Caucasian and African (Coetzee & Perrett, 2014; Stephen et al., 2011) populations (though effects of carotenoids are more difficult to perceive in African skin Coetzee & Perrett, 2014). Most studies that examined the impact of carotenoids on the appearance of human skin have used carotenoid supplements (Alaluf et al., 2002; Heinrich et al., 2003; Stephen et al., 2011) or been correlational in nature (Stephen et al., 2011; Whitehead et al., 2012). We recently demonstrated in a placebo controlled trial that consumption of a carotenoid-rich fruit and vegetable smoothie increased the redness (a*) and yellowness (b*) components of human skin color (Tan et al., 2015), and correlational studies have shown that the yellowness (b*) of human skin is related to natural dietary intake of fruit and vegetables (Stephen et al., 2011; Whitehead et al., 2012). It is not known, however, whether experimentally-induced changes in skin color, such as those associated with supplementation with a carotenoid-rich smoothie, is perceived as healthy. Further, it is not known how quickly these effects can be seen. Here, we report the results of three studies investigating the impact of skin color changes associated with consumption of a carotenoid-rich fruit and vegetable smoothie on perceptions of health in Asian faces. We predict that increased smoothie-induced skin coloration will enhance the healthy appearance of Asian facial skin.

2. Experiment 1: Perceived health of faces before and after supplementation

This study aimed to determine whether a 4 week supplementation with a daily carotenoid rich fruit and vegetable smoothie (containing on average 25 mg total carotenoids per day) would alter the perceived healthiness of the faces of study participants. This is a within-subjects study whereby participants were asked to compare the health status of two same-subject identity images taken at different times (before and after 4 weeks of smoothie supplementation). All experiments reported here were approved by the Ethics Committee at the University of Nottingham Malaysia Campus. All participants gave both verbal and written informed prior consent. Throughout this paper, we refer to the individuals in the supplementation phase as “subjects”, and the individuals making perceptual judgements as “observers”.

2.1. Methods

2.1.1. Stimuli

Subjects in the supplementation group (n = 34, 17 male, 17 female; mean age = 20.47, SD = 1.13) consumed 500 mL freshly prepared fruit and vegetable smoothie (containing on average 25 mg total carotenoids, for further details see Tan et al., 2015) each weekday, while subjects in the control group (n = 34, 11 male, 23 female; mean age = 20.59, SD = 1.40) consumed a bottle of filtered water (500 mL; described as “purified, deoxygenated water”) each weekday (Tan et al., 2015).

For each subject, one photograph was taken before the supplementation began and another one after four weeks of supplementation (Fig. 1). Photographs were taken in a photo booth painted Munsell N5 grey and illuminated with nine T12/D65 fluorescent tubes (Verivide, UK) mounted in high frequency fixtures to reduce the effects of flicker. The camera was a Nikon D3100 with settings held constant at aperture f5.0, shutter speed 1/100 s, ISO 400. A GretagMacbeth mini ColorChecker was included in the frame, and images were color corrected following Stephen et al. (2009). Images were resized to 337 x 449 pixels, and all participants tied long hair back and wore a black hairband to remove possible confounding effects of hairstyle.

2.1.2. Judgements of perceived health

Fifty seven Malaysian Chinese (24 males, 33 females; average age = 22.35, SD = 3.17) were recruited as “observers”. All observers self-reported normal color vision and pursued undergraduate or postgraduate degrees at University Putra Malaysia (UPM) or Universiti College Sedaya International (UCSI), to reduce the likelihood of observers knowing subjects in real life.

Using the software PsychoPy (Peirce, 2009) and a 15" computer screen color-calibrated with a DataColor Spyder 4 Pro, the observers were presented with 68 pairs of same-subject-identity facial photographs taken before and after smoothie supplementation. The first facial image was presented for 750 ms, followed by a visual mask of black dots on a white background for 100 ms, and then the second image of the same subject was shown for 750 ms. Photographs taken at the beginning and at the end were presented in randomized order (i.e. sometimes the photograph taken before supplementation was shown as the first image and sometimes as the second image) and the order of identities was randomized. Observers were asked to decide which of the paired faces shown looked healthier, and indicate their choice using the keyboard. There was no explicit indication which of the paired photos was taken before supplementation, and which was taken after the supplementation.

2.2. Results

The mean number of pre-supplementation and after-supplementation images chosen as appearing healthier was calculated across participants and is presented in Table 1. Paired samples t-tests compared the frequencies of the pre-supplementation and after-supplementation images that were selected as healthier-looking, in each group. Observers deemed pre-supplementation images as healthier. However, this was observed in both the supplementation subject group, t(56) = 2.941, p = .005, (who had consumed smoothies) and the control group t(56) = 5.121, p < .001 (who had consumed water). Pearson’s chi-square found no difference in the strength of this effect between the supplementation and control groups of subjects x² (1) = .001, p = .97.

2.3. Discussion

Contrary to our hypothesis, the pre-supplementation face images were perceived as healthier than the after-supplementation images. However, the fact that this pattern was seen in the control group as well as in the smoothie group, suggests that our finding is attributable
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