

# The impact of tooth colour on the perceptions of age and social judgements.

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## ABSTRACT

**Objective:** Psychological research has established that the presence of dental anomalies negatively impact social judgements. This study sought to determine the effects of tooth colour on the subjective ratings of social judgements in a group of Caucasian adults.

**Methods:** A cross sectional experimental analogue design comprised fifty Caucasian adults: 25 women and 25 men. A total of 54 digitally modified photographs of Caucasian males and females (darkened, natural, whitened teeth) were evaluated. All participants evaluated each of the images on 12 characteristics: popularity, friendliness, social life, success, graduation, happiness, intelligence, perceived age, introversion/extraversion, self-confidence, attractiveness and satisfaction with the tooth shade. Analysis of variance (ANOVA) was used to compare ratings.

**Results:** Participants associated darkened teeth with poorer subjective ratings, with the highest ratings been given to whitened teeth, and natural teeth being intermediate. These trends were similar across all participant age groups and gender. Further, the gender and age groups of the images had a significant effect on the appraisals. Faces of younger models received higher ratings than the faces of older models and female images were rated higher than the males.

**Conclusion:** In the absence of other information, tooth colour exerts an influence upon the appraisals made in social situations. It appears that whitened tooth appearance is preferred to natural tooth appearance, irrespective of age and gender of the judge. The faces with more whitened dentition are perceived to be younger across all age groups and gender of the judges. Participants dissatisfied with their own tooth shade drew out more stereotypic behaviour.

**Clinical significance statement:** This research used standardised tooth colour as a basis to investigate perceived age and social functioning. As clinicians face daily challenges to achieve patient satisfaction with respect to dental aesthetics, standardizing the colour may enhance the patients' satisfaction. Further, participants dissatisfied with their own tooth shade drew out more stereotypic behaviour. The whitened dentition may impair the psychological well-being of the individuals and is probably a reason for the increasing demand for cosmetic dental procedures. These results may be instructive for the development of a psycho-educational intervention to prevent any unrealistic expectations.

## 1. Introduction

The aesthetics of the dentition is important for many people and concerns over their appearance and colour appear to be common [1]. Indeed, studies in many different adult populations have shown 20.4% to 50% are dissatisfied with their tooth appearance [2–4] and 19.6% to 65.9% are dissatisfied with tooth colour [5–9]. In general, this

dissatisfaction with tooth appearance and colour has been shown to be associated with an increased desire for treatments that improve dental aesthetics including tooth whitening [3,7,10,11].

Previous research has demonstrated that the appearance of the dentition can affect the way that people are viewed in social interactions, in the absence of other information. Analogue studies using digitally modified photographs have demonstrated that changing the

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appearance of an individual's teeth has a wide range of impacts (see Table 1 in supplement). To date, the explored judgements have largely been related to perceptions of social wellbeing, psychological adjustment and intellectual ability; though there has been some work exploring the effect of appearance on likelihood of employment [12].

A previous study explored the impact of tooth colour on social perceptions [13] and showed that whitened teeth led to more positive judgements. However, this study had several limitations. Firstly, only two images were used in the study: a greater range of images would allow greater variation in the impact of the independent variable. Secondly, no attempt was made to determine the degree of difference in tooth colour in the independent variable. Thirdly, given the observation that tooth colour changes naturally with age, it is possible that perceptions of age would be an important social judgement with respect to tooth colour, but these were not previously explored. A study by Montero et al. [3] showed that a perceptible change in dental lightness was the strongest factor of social appeal, particularly for the dimensions of happiness, social relations and academic performance.

The aim of the present study was to determine the effect of tooth colour on ratings of perceived age and social functioning. The null hypothesis is that tooth colour will not have an impact on perceived age or social functioning.

## 2. Methods

The study involved a cross sectional experimental analogue design. The true purpose of the study was concealed by briefing the participants that the study explored 'the way we look at each other'. Participants were shown photographs of adults. All the photographs were frontal smiling images and revealed the entire face of the models with one of three tooth colours: natural tooth colour, darkened tooth colour and whitened tooth colour. The participants were then asked to make a series of ratings concerning the age of the person in the photograph and their social functioning (as depicted in Fig. 1).

### 2.1. Stimuli

A total of 18 Caucasian models, 9 male and 9 female, equally distributed in three age ranges of 20-30, 31-40 and 41-50, were

**Table 1**  
Characteristics of the participants based on age groups.

Characteristics	20-30(N = 16)	31-40(N = 16)	41-50(N = 18)	Total (N = 50)
Gender				
Male	8	8	9	25
Female	8	8	9	25
Satisfaction with whiteness of own teeth				
<i>Dissatisfied</i>				
Male	3	4	5	12
Female	4	4	5	13
<i>Neither dissatisfied nor satisfied</i>				
Male	1	3	3	7
Female	1	1	3	5
<i>Satisfied</i>				
Male	4	1	1	6
Female	3	3	1	7
Self-oral health ratings				
<i>Unhealthy</i>				
Male	0	1	2	3
Female	0	2	0	2
<i>Neither unhealthy nor healthy</i>				
Male	0	1	1	2
Female	0	0	1	1
<i>Healthy</i>				
Male	8	6	6	20
Female	8	6	8	22

recruited for image capturing. Following informed consent, their full-face images were captured by a facial imaging system (VeriVide Ltd., UK) under a uniform D65 standard daylight illumination with a mid-grey background. Models were asked to sit in the centre of the lighting booth with a distance between their face and the camera of 57.5 cm. They were instructed to smile with exposure of as many as possible of their anterior teeth in front of the camera. All the captured images were colour-calibrated with a ColourChecker Digital SG card (VeriVide Ltd., UK). A colour characterisation model for this camera under the specific lighting that was used was built. The CIE (1976) L\*a\*b\* values and the tooth whiteness index (WIO) values [14] of each pixel of the teeth areas in the images were calculated by this model.

From a previous pilot study, colour differences of 9 L\* units and 4.5 b\* units were chosen to simulate tooth whiteness changes. A set of three images was therefore created for each model: one with the original tooth colour, one with simulated whiter teeth ( $\Delta L^*=9, \Delta b^*=-4.5, \Delta WIO=35$ ) and one with simulated less white teeth ( $\Delta L^*=-9, \Delta b^*=4.5, \Delta WIO=-35$ ). A mask technique was used to allow the colour of the teeth area to be altered while other regions of the image (gingiva, lips, skin, hair etc.) remained the same.

Presentation of the images was standardised. Ensuring that the room lighting was consistent throughout, images were presented using an Intel Pentium Quad Core J2900 2.41 GHz computer operating Windows 7 Pro 64 Bit onto a 19" Widescreen Screen – 1366 × 768 resolution. The screen was calibrated and placed at a fixed distance from the participant.

### 2.2. Procedure

There were 50 participants (25 male and 25 female), all Caucasian and screened for uncorrected visual impairments (including colour blindness). The protocol, information sheet and informed consent for this study were reviewed and approved by an independent ethics committee. All participants gave informed consent.

The total of 54 face images were shown on the display one by one in a randomised order. Thus, participants all made ratings of one image at each level of the independent variable (tooth whiteness). Between showing each image stimuli, a uniform grey was shown on the display to avoid any afterimage effect. Participants evaluated all the 54 images with 12 questions each.

### 2.3. Measures

Each respondent evaluated each of the images on 12 characteristics that were selected based on previously published research:

- Perceived Age (in years)
- Attractiveness (5 point category scale)
- Satisfaction with Shade of Teeth (*participants were asked to rate if they would be happy with the shade of teeth shown in the photograph on a 5-point category scale*)
- Social competence (3 items):
  - Popularity with Colleagues (*5-point category scale*)
  - Friendliness (*5-point category scale*)
  - Having a Good Social Life (*3-point category scale*)
- Intellectual Ability (3 items):
  - Success in School (*5-point category scale*)
  - Intelligence (*5-point category scale*)
  - Been to University (*3-point category scale*)
- Psychological Adjustment (3 items):
  - Introvert to Extrovert (*5-point category scale*)
  - Happiness (*5-point category scale*)
  - Self-Confidence (*5-point category scale*)

### 2.4. Statistical analysis

Each of the 12 dependent variables was analysed using analysis of

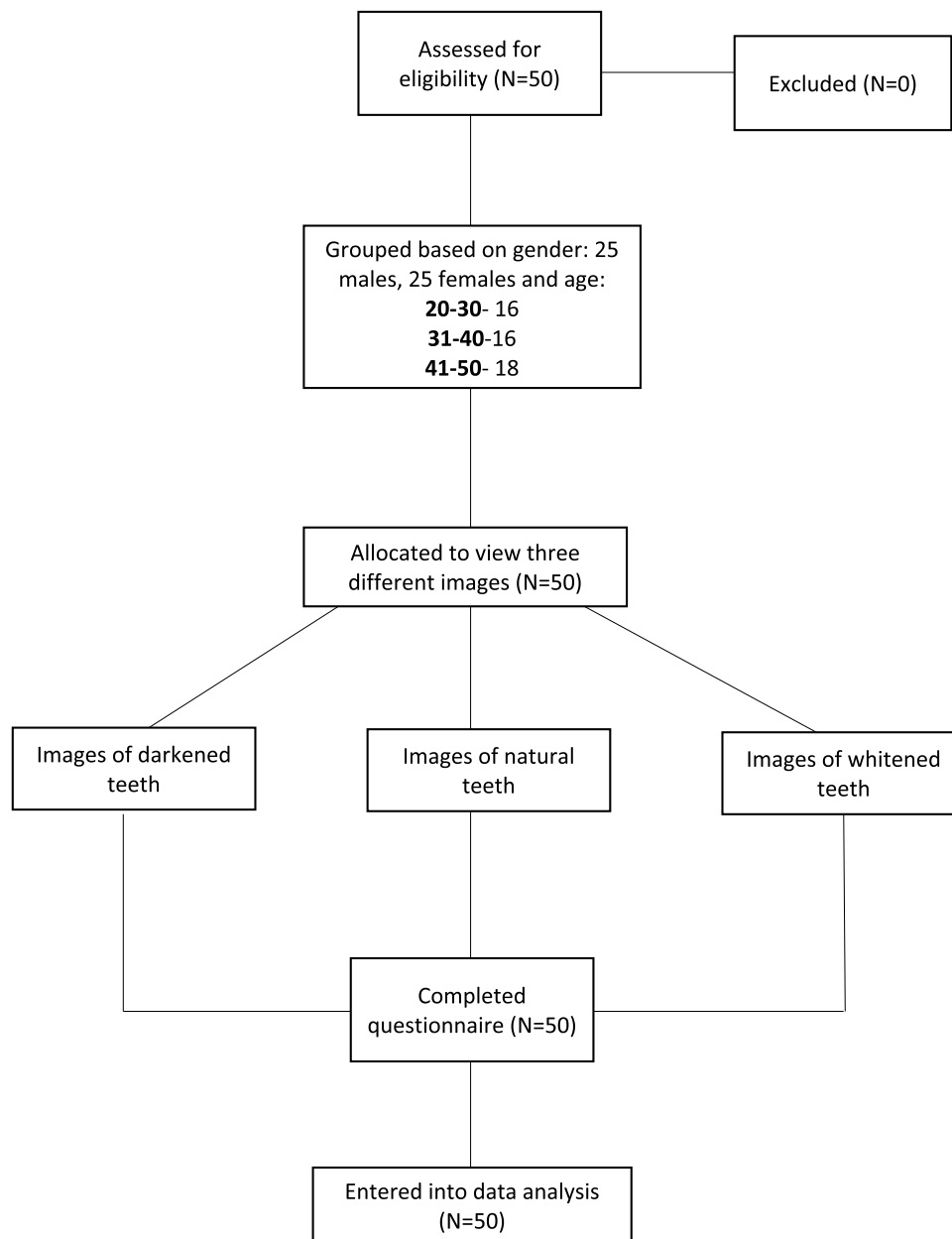


Fig. 1. Flow chart illustrating the methodology.

variance (ANOVA). In order to explore the impact of tooth colour on the dependent variables, a partially-hierarchical/split-plot ANOVA model was used. Whole-Plot/Between-Respondent Effects were:

- Main Effects of Respondent Age, Respondent Gender, and Respondent Satisfaction with the Whiteness of their Teeth.
- All Two-Way Interactions between Respondents' Age, Gender, and Satisfaction.
- "Respondent-within-Age-Gender-Satisfaction" was used as the whole-plot error term.

Sub-Plot/Between-Images Effects were:

- Main Effects of Image Age, Image Gender and Image Shade of Teeth.
- All Two-Way Interactions between Images' Age, Gender, and Shade.
- All Two-Way Interactions between respondents' Age, Gender, and Satisfaction and Images' Age, Gender, and Shade.
- Residual variability was used as the sub-plot error term.

### 3. Results

#### 3.1. Characteristics of the respondents

Fifty Caucasian adults agreed to take part in this study; 25 men and 25 women provided complete data. The age range of the entire sample was from 20 to 50. This age range was analogous with the peer group of the chosen images. Half the sample ( $N = 25$ ) was dissatisfied with the whiteness of their teeth, and 13 were satisfied, with the remaining ( $N = 12$ ) being neither satisfied nor dissatisfied. The participants predominantly rated their oral health as 'healthy' (see [Table 1](#)).

#### 3.2. The impact of tooth shade on dentally induced social judgements

Across all the dependent variables there was a trend for darkened teeth to be associated with poorer ratings on the dependent variables, with higher ratings been given to images with whitened teeth, and natural teeth being intermediate (see [Table 2](#)). These trends were similar

**Table 2**  
Mean ratings by image type (Darkened/Natural/Whitened).

Responses	Darkened	Natural	Whitened	p Value	LSD
Popularity	3.2 <sup>a</sup>	3.6 <sup>b</sup>	3.8 <sup>c</sup>	<0.001	0.1
Friendliness	3.8 <sup>a</sup>	4.0 <sup>b</sup>	4.1 <sup>c</sup>	<0.001	0.1
Good social life % yes	37 <sup>a</sup>	51 <sup>b</sup>	56 <sup>c</sup>	<0.001	5
Good social life % no	33 <sup>a</sup>	22 <sup>b</sup>	17 <sup>c</sup>	<0.001	4
Success at school	3.1 <sup>a</sup>	3.5 <sup>b</sup>	3.7 <sup>c</sup>	<0.001	0.1
Intelligence	3.3 <sup>a</sup>	3.6 <sup>b</sup>	3.8 <sup>c</sup>	<0.001	0.
Attended University % yes	36 <sup>a</sup>	49 <sup>b</sup>	57 <sup>c</sup>	<0.001	5
Attended University % no	47 <sup>a</sup>	34 <sup>b</sup>	26 <sup>c</sup>	<0.001	4
Introversion/Extroversion	3.0 <sup>a</sup>	3.2 <sup>b</sup>	3.4 <sup>c</sup>	<0.001	0.1
Happiness	3.6 <sup>a</sup>	3.8 <sup>b</sup>	4.0 <sup>c</sup>	<0.001	0.1
Self-confidence	3.1 <sup>a</sup>	3.4 <sup>b</sup>	3.7 <sup>c</sup>	<0.001	0.1
Perceived age	39 <sup>a</sup>	39 <sup>a</sup>	38 <sup>b</sup>	<0.001	1
Attractiveness	2.5 <sup>a</sup>	3.0 <sup>b</sup>	3.2 <sup>c</sup>	<0.001	0.1
Satisfaction with shade of teeth	1.6 <sup>a</sup>	2.9 <sup>b</sup>	4.2 <sup>c</sup>	<0.001	0.1

Means with different letters indicate statistically different subsets at a 95%CI. LSD-Fisher’s least significant difference (LSD) method for multiple comparisons. This is used in ANOVA to create confidence intervals for all pairwise differences.

across all participant age groups and across gender of participants.

The significance of these findings was further explored using sub-plot and whole plot ANOVA models. The following effects were explored:

- **Main effects:** respondent gender, respondent age, respondent satisfaction with the whiteness of their teeth, image gender, image age and image shade
- **All two-way interactions between:** respondents’ age, gender and satisfaction with the whiteness of their teeth; images’ age, gender shade; respondents’ age, gender and satisfaction with their whiteness of teeth and images’ age, gender and shade.

**Between-image effects:** Image shade and image age as main effects were significant across all the responses (all  $p < 0.001$ ) (Tables 2 and 3). Image gender was significant across all the responses ( $p < 0.001$ ) apart from ‘success in school’ ( $p = 0.89$ ) and ‘been to University’ ( $p = 0.09$ ) (Table 3). Images of female models received higher ratings compared to male faces and images of younger faces were consistently rated higher across most of the measures (see Table 3). Interaction of image age \* image gender was also significant across all of the responses (all  $p < 0.01$ ). This suggested that faces of 20–30-year age group were rated higher across both gender on intelligence and satisfaction measures; female faces pertaining to 41–50-year age group was rated higher in social and personality measures. Further, the interaction involving image shade and gender was significant only for the ‘satisfaction with the tooth shade’ measure ( $p = 0.043$ ) and ‘attractiveness’ ( $p = 0.036$ ). The satisfaction with the tooth shade increased from darkened to natural to whitened dental condition across all the age groups of the images and the younger age group exhibited higher ratings than the older age group

**Table 3**  
Effects of image characteristics on dentally induced social judgements.

Measures	Image age			p value	Gender		p value
	20-30	31-40	41-50		Male	Female	
Popularity	3.6a	3.3b	3.6a	<0.001	3.4b	3.6a	<0.001
Friendliness	4.0a	3.8b	4.0a	<0.001	3.9b	4.0a	<0.001
Social life % yes	54a	40b	50a	<0.001	44b	52a	<0.001
Successful at school	3.6a	3.4b	3.3c	<0.001	3.5a	3.5a	0.89
Intelligence	3.7a	3.5b	3.5b	<0.001	3.6a	3.5b	<0.001
University % yes	61a	46b	35c	<0.001	49a	46b	0.09
Introvert/extrovert	3.3a	3.0b	3.3a	<0.001	3.1b	3.3a	<0.001
Happiness	3.9a	3.6b	3.9a	<0.001	3.7b	3.9a	<0.001
Self-confidence	3.6a	3.2b	3.5c	<0.001	3.3b	3.5a	<0.001
Age	33a	38b	45c	<0.001	40a	37b	<0.001
Attractiveness	3.1a	2.8b	2.8b	<0.001	2.7b	3.1a	<0.001
Satisfaction with tooth shade	3.0a	2.9b	2.8c	<0.001	2.8b	3.0a	<0.001

Means with different letters indicate statistically different subsets at a 95%CI.

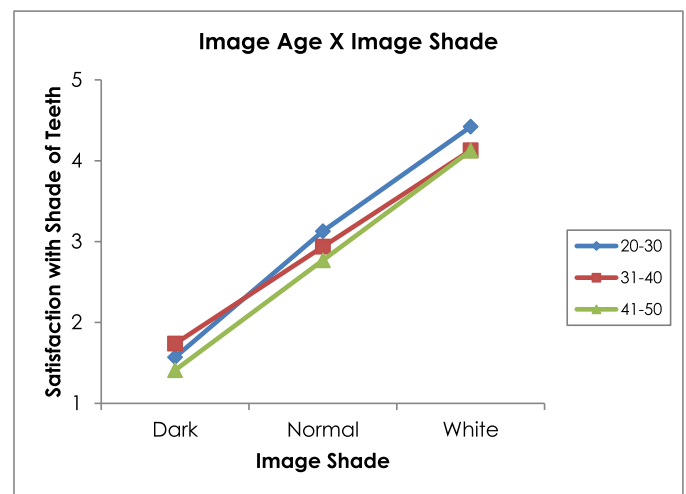
(see Fig. 2).

**Between-respondent effects:** Overall, there were relatively very few significant main and interaction effects within the respondents. In general, the participants were consistent with their responses, irrespective of age group and gender.

**Between image-respondent effects:** The majority of the significant interactions were with the respondents’ age ( $p < 0.05$ ). The younger age group gave higher and less discriminating ratings than the older age group. The significant interaction ( $p < 0.001$ ) involving respondents’ satisfaction with their whiteness of teeth\* image shade showed that participants who were dissatisfied with their whiteness of teeth tended to give lower ratings than the participants who were satisfied across all the characteristics. Whilst the participants who were dissatisfied with their whiteness of teeth gave lower or equal satisfaction scores for images with darkened and natural teeth compared to the neither dissatisfied nor satisfied and satisfied categories, the satisfaction scores were higher for images with whitened teeth in the dissatisfied category (see Fig. 3).

#### 4. Discussion

The present study sought to determine the impact of tooth colour on perceived age and social functioning. The results showed that social judgements were always the lowest in the darkened (least white) dental condition and the highest in the whitened dental condition, with the natural condition being intermediate. These trends were similar across all age groups and gender of the participants and suggest that tooth



**Fig. 2.** Interaction of image age and image shade (Darkened/ Natural/ Whitened).

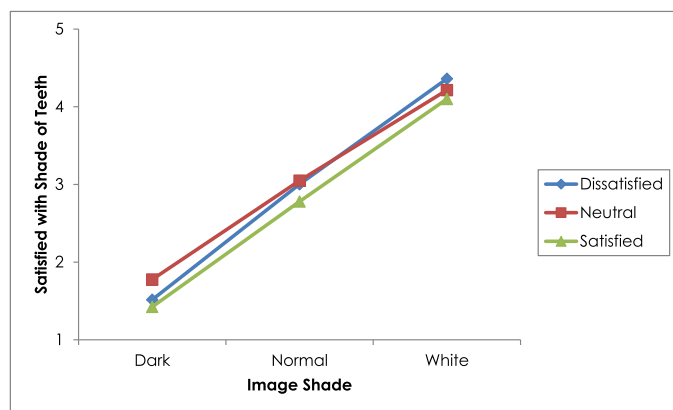


Fig. 3. Interaction of image shade (Darkened/Natural/Whitened) and respondents' satisfaction with their whiteness of teeth.

colour exerts an influence upon appraisals made in social situations. Hence, we rejected the null hypothesis. These findings are broadly compatible with previous work that explored the influence of whiteness of teeth [13], extent and location of caries [15], malocclusion [16] and orthodontic appliances [17] on dentally induced social judgements.

Based on the current and prior research, it appears that poor dental appearance may lead others to judge people negatively over a range of personality characteristics. Further, the current study reveals that the social interaction, social judgements and the social well-being of Caucasians are influenced by tooth colour. Therefore, an individual with whitened dental appearance would be regarded as the best for social acceptance. However, the extent to which this impacts an individual's psychological well-being is unknown; though there is research to suggest that such perceptions may exert a negative self-perception [18]. The present study has extended previous research by demonstrating that faces with whitened dental appearance are perceived to be younger than faces with original/darkened teeth and such effects are same across all age groups and gender of the judge.

In particular, participants who were dissatisfied with whiteness of their teeth gave greater satisfaction scores while rating faces with whitened teeth compared to the neutral and satisfied categories. These findings have a prominent dental implication. There are empirical evidences to suggest that orthodontic patients show more facial dissatisfaction after viewing idealised images than the non-patients [19–21] and media standards may negatively influence individuals' satisfaction with their own appearance thereby impacting their psychological wellbeing. This may explain why the photos of individuals with whitened teeth were ascribed greater satisfaction scores. It is likely that less satisfaction with one's own appearance is relatively a reason for the increasing demand to change the dental appearance by opting to undergo tooth-whitening and other cosmetic procedures.

Also, our research established a significant interaction effect of the gender and age groups of the images on the appraisals. Whilst the faces of 20-30 year age group were rated higher across both the gender on intelligence and satisfaction measures, the female faces pertaining to 41-50 year age group were unexpectedly rated higher in social and personality measures. However, the appraisals of the personal characteristics were not affected by the gender and age groups of the judges. There is research to suggest that gender is not consistently important in determining the impact of facial appearance on social judgements [22]. This is in contrast to a previous study that suggested an interaction effect where the impact of dental decay is greater when individuals rated faces of opposite gender [23]. Dissimilar ratings across the image age groups and gender may be explained due to differing perceptions among the participants. It is possible that individuals for whom oral health has some importance are more likely to use dental appearance as a basis for making judgements. Whereas it is also established that overall facial

appearance influences more than only the dental appearance on the social judgements [24]. Perhaps the overall attractiveness of the models pertaining to the categories was different. Future research could explore this effect by considering and comparing the baseline attractiveness and any interaction between the gender and dental status of the images.

Earlier research showed that the social judgements vary across various ethnic groups [16]. Unlike the previous work, this study involved participants not only from a similar ethnic background (Caucasians) but also from a wider age range (20-50) as that of faces in the images and both genders. This may be considered as a fair representation of the general population in the country this study was conducted. However, population demographics vary between the countries. Hence, including participants from different countries could affect the results. Whilst only two images were used in the previous studies, our results were obtained using more than two standardised photographs (54 images). It was perceived that the greater range of images would allow for greater variation in the independent variable. The higher the variance in the independent variables, the lower the variance in the parameters being estimated and vice versa. Perhaps this resulted in the significant interaction effect of image age and image gender on the appraisals.

This piece of work, however, has some limitations. Our findings ought to be interpreted within this context. Attempting to measure subjective ratings based on images is challenging. Though the confounding factors in the images were minimised by standardisation, it is unlikely that it reflected a natural setting. The order of the images displayed was randomised. However, it remained possible that photos of the same model with different tooth colours appeared successively and influenced social judgments. Further, many other factors influence the dental appearance such as amount of teeth exposure during smiling, oral hygiene rather than whiteness of teeth alone. The future studies could be recreated by comparing these aspects and overall attractiveness on social judgements. Involving a larger sample may detect any further interaction between the respondents and images.

## 5. Conclusions

In the absence of other information, tooth colour exerts an influence upon the appraisals made in social situations. It appears that whitened tooth appearance is preferred to natural tooth appearance, irrespective of age and gender of the judge. The faces with more whitened dentition are perceived to be younger across all age groups and gender of the judges. Participants dissatisfied with their own tooth colour drew out more stereotypic behaviour. This may impair the psychological well-being of the individuals and is probably a reason for the increasing demand for cosmetic dental procedures.

## Credit Author Statement

Timothy Jonathon Newton: Conceptualization; Methodology; Project administration; Supervision

Sadhvi Shankar Subramanian: Writing- original draft, Conceptualization ,

Stephan Westland: Conceptualization, Methodology; Writing-Review&Editing

Ashok Kumar Gupta: Formal Analysis, conceptualization, Data curation

Wen Luo: Writing- Review & Editing, Software; Conceptualization, Methodology

Andrew Joiner: Investigation; Writing-Review & Editing; Conceptualization, Methodology, Project administration

## Declaration of Competing Interest

Andrew Joiner, Wen Luo and Ashok Gupta are all employees of Unilever Oral Care. The Unilever Oral care funded this study.

## Supplementary materials

Supplementary material associated with this article can be found, in the online version, at [doi:10.1016/j.jdent.2021.103771](https://doi.org/10.1016/j.jdent.2021.103771).

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