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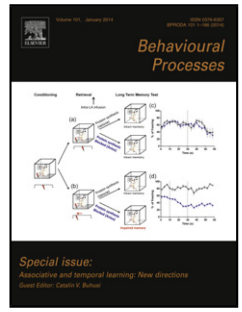

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Assessment of health in human faces is context-dependent

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Highlights

Yellow colouration influences the perception of health in faces.

The evaluation of which face looks the healthiest is influenced by the other faces present at the time of the choice.

For many traits that influence health perception there may be no optimum preferred level.

Abstract

When making decisions between options, humans are expected to choose the option that returns the highest benefit. In practice, however, adding inferior alternatives to the choice set can alter these decisions. Here we investigated whether decisions over the facial features that people find healthy looking can also be affected by the context in which they see those faces. To do this we examined the effect of choice set on the perception of health of images of faces of light-skinned Caucasian females. We manipulated apparent facial health by changing yellowness of the skin: the healthy faces were moderately yellow and the less healthy faces were either much more yellow or much less yellow. In each experiment, two healthy faces were presented along with a third, less healthy face. When the third face was much more yellow, participants chose the more yellow of the two healthy faces more often as the most healthy. However, when the third face was the least yellow, participants chose the less yellow of the two healthy faces more often. A further experiment confirmed that this result is not due to a generalised preference for an intermediate option. These results extend our understanding of context-dependent decision-making in humans, and suggest that comparative evaluation may be a common feature across many different kinds of choices that humans have to make.

Keywords: context-dependent choice; health perception; decision making.

1. Introduction

If humans make rational choices based on the absolute utility of the options available then we would predict that decision-makers should choose the option that confers the largest benefit, the 'best' option (Edwards, 1961, Rieskamp et al., 2006, Schoemaker, 1982, Simon, 1959). Humans do not, however, always choose the best option. Instead, choices can be altered by the context of the decision, either by the presence or absence of other options or by the framing of the choice. These changes in preference suggest that humans use comparative decision-making mechanisms rather than making choices based on absolute utility. Most of the evidence for comparative decision-making mechanisms comes from investigations into the effects of context on preferences for products or services (Bateman et al., 2008, Doyle, 1999, Huber et al., 1982) although there is also considerable evidence that animals also make context-dependent decisions (Bateson et al. 2003, Dougherty and Shuker 2015, Latty and Beekman, Morgan et al. 2012, Morgan et al. 2014, Scarpi 2011). The decision-making mechanisms that underlie the everyday choices that people make about products and services may, however, be different from those underpinning important social decisions, such as those used in the choice of social partners or other social groups.

There are several reasons why social group decisions might differ from less biologically pertinent decisions, such as those for products. Face perception itself is considered to be special as information about faces is processed by different parts of the brain from other visual stimuli (humans: Haxby et al., 2000, Kanwisher et al., 1997, Yovel and Kanwisher, 2004, paper wasps: Sheehan and Tibbets 2011). Facial attributes influence assessments of health and attractiveness and are probably indicators of physical and genetic health (Gangestad and Simpson, 2000). Choosing a healthy and attractive partner may have multiple benefits including superior resource acquisition, provision and defence (Andersson, 1994, Hoelzer, 1989). Healthy individuals are expected to experience better direct reproductive fitness by producing healthy offspring due to better genetics and resources, and also to attain higher indirect fitness by producing offspring who will themselves be judged attractive as potential mates (Gangestad et al., 1994, Thornhill and Gangestad, 1993). The perception and assessment of some facial attributes, especially those that indicate health and attractiveness, might therefore be sufficiently consequential so as to require choices that depend on absolute evaluations.

The alternative hypothesis is that decision-making is a process that is generalized across all types of choices. It is possible, then, that during mate choice the judgement of the attractiveness of other individuals is again context-dependent and there is at least some evidence that decisions over attractiveness or health of possible mates might be relative rather than absolute (Dougherty and Shuker 2015, Kenrick et al., 1989, Wanke et al., 2001, Wedell et al., 1987, Wedell et al., 2005). For example, males presented with images of attractive female faces rated subsequent images of average female faces as less attractive than did males presented with images of average female faces (Kenrick and Gutierres, 1980). If decisions as to which face is the most attractive or healthy depend strongly on the set of faces over which the decision is to be made, and particularly if just the presence of faces that would not be judged as attractive or healthy has a significant impact on those that are deemed attractive or healthy, then much of the work to date investigating attractiveness or health judgments might be much less robust than is currently thought.

Here we present the results of an experiment in which we attempted to determine whether the assessment of health in images of human faces is governed by an absolute or a relative decision-making mechanism. Specifically, we asked whether the assessment of two faces generally deemed healthy would be influenced by the addition of a third, unhealthy, option to the choice set.

In order to determine whether context influences the choices humans make about health, we presented participants with sets of faces that varied in a single manipulated feature, yellowness, and asked them to judge which of the faces appeared to be the healthiest. Yellowness in a human face appears to reflect both the dietary intake of anti-oxidant carotenoids and their loss via oxidative stress (Whitehead et al., 2012b). In many other vertebrate specices yellow/red pigments derived from dietary caroteniods are used as sexual selected cues to condition (Whitehead et al., 2012a). Among light-skinned people, faces with a moderate amount of yellow are considered to be healthier than either faces with very little yellow or faces with a large amount of yellow (we stress that is a repeatable finding across experiments: Stephen et al., 2009, Stephen et al., 2011, Whitehead et al., 2012a). A yellower skin tone may be preferred because it is an indicator of fitness or, alternatively, it may have culturally-derived origins. For example, as the fruit and vegetable consumption in developed countries is higher amongst people in more privileged social groups (Grimm et al., 2012, Middaugh et al., 2012), it is possible that a preference for yellower faces are at least partly due to a link between facial colour and social status. In addition to increasing the perceived health of faces, increasing the level of yellowness also increases the attractiveness of faces, across a number of cultures (Stephen et al., 2012). In both African and Caucasian faces, faces that were more yellow were considered more attractive (Stephen et al., 2012), although the yellower African faces were also lighter than were the faces that were less yellow. When participants could manipulate the lightness and colour of the skin of photographs of African faces independently, those participants increased both the lightness of the skin but also the amount of yellow (Stephen et al., 2011). As the origin of the preferences themselves should not influence decision-making mechanisms (Busemeyer et al., 2006, Luce, 1959), we did not investigate the origin of preferences for yellowness in the current study.

To determine whether assessment of health would be influenced by the decision-context we designed two experiments. In the first experiment, we presented participants with pairs or trios of light-skinned faces that varied in the degree of yellowness and asked them to choose the face that they thought looked the healthiest. We presented participants with binary choices between two moderately yellow faces and trinary choices with these faces and a face with either a much reduced or increased yellowness. In this experiment the moderate faces that were present in each choice set exhibited different levels of yellow, both of which previous studies indicated would be rated as healthy. A trio consisted of this pair plus one face with very little yellow or a great deal of yellow (Figure 1), assessed in past studies as less healthy (Stephen et al., 2009). We predicted that if the perception of the health of a face depends on the range of options within the choice set, the addition of either of the inferior options should alter the perceived health of the moderately yellow faces. Specifically we predicted that the perceived relative health of the two moderate shades would be greatest when it was the intermediate shade within the choice set.

In our second experiment we addressed whether or not there is a bias towards intermediate options regardless of the nature of those options. We hypothesized that context-dependent preferences are not a product of simply adding a third option and therefore should not be expected in all circumstances. The second experiment featured one shade that is within the range usually considered to be healthy looking as well as three shades that were less yellow than shades in this healthy range. As these shades are less yellow than those presented in Experiment 1, we predicted that upon adding either of the least yellow options to the choice that participants will not change their preference, instead choosing the yellowest option almost exclusively.

2. Methods

2.1 Ethics statement

Ethical approval was obtained from the University of St Andrews Teaching and Research Ethics Committee and prior to the experiment we obtained informed written consent from all participants.

2.2 Participants

Students at the University of St Andrews volunteered to participate in this experiment investigating of the effect of skin colour on the perception of health. They first completed a questionnaire identifying their sex, country of residence, ethnic origin (participants were given a blank box to self-identify however they wished) and sexual preference (on a 7 point Kinsey scale). In Experiment 1 was completed by thirty one undergraduate and post-graduate students from the University of St Andrews. Twenty-four of the participants identified as Caucasian and seven did not give their ethnicity. Seventeen participants identified themselves as male, twelve as female and two did not give their sex. In Experiment 2 the participants were nineteen undergraduate and post-graduate students from the University of St Andrews, none of whom had participated in Experiment 1. Eleven of the participants identified themselves as Caucasian, two as Latin American and six did not give their ethnicity. Six participants identified themselves as male, twelve as female and one participant did not give their sex. The experiment took place between 9am and 5pm and participants were alone when they completed the experiment, which took roughly an hour to complete. Participants were made aware that they could withdraw from the experiment at any time without explanation.

2.3 Image creation

The faces used in the experiment were of 30 light-skinned Caucasian females without makeup and with neutral expressions. The photographs were taken under controlled conditions and colour calibrated (for more information see (Stephen et al., 2009). Matlab was used to calculate mean colour values across skin pixels for each image thus defining the starting colour for each face. The colour of a face was then modified in Matlab to produce a colour mask that was adjusted to increase or decrease the yellowness of the faces. The mask was Gaussian blurred at the edges of the face (*SD* ± 3 pixels) to prevent obvious color borders. The mask changed the colour of the face including lips and ears but the eyes, hair and background were unchanged. In Experiment 1, four versions of each face were created which varied in the yellowness only. The least yellow shade was Yellow -1 for which the yellowness of the face was reduced by 2.666 b* units (in CIE L*a*b* space where L* is lightness (0-100 – 0 is black, 100 is white), a* is position along a green-red axis of colour (-60 to +60), b* is position along blue-yellow axis (-60 to +60)) from its original shade. The Yellow +1 shade yellowness was increased from its original shade by 2.666 units, Yellow +2 by 7.999 units and Yellow +3 by 13.333 units (Figure 1). In Experiment 2 we also used 4 versions of each face but two of the shades were different than those used in Experiment 1. The Yellow -1 and Yellow +1 shades were present in Experiment 2 but in addition to these shades that were present in Experiment 1, we also had two additional shades. We decreased the Yellow -2 option by 5.333 units and the Yellow -3 by 10.666 units (Figure 2). Shade 1+ was the only option with a value within the range of yellowness that is deemed healthy (in light-skinned Caucasian female faces).

These intervals of 5.333 units represent the lowest interval that three independent individuals could identify each of the four shades as being clearly distinct. The amount of yellow added or subtracted for each shade was determined by examining previous data on the ideal preference for yellowness and placing shades Yellow +1 and Yellow +2 either side of this ideal shade such that both are relatively healthy looking and neither would be exclusively chosen by our participants (Stephen et al. 2011). Each image was 6cm by 8cm and presented on a black background on a 19-inch Iiyama Vision Master 1451 monitor in pairs or trios. The images were numbered from left to right so that participants could identify each image and positions of the images on the screen were randomized.

2.4 Experimental Procedure

The experiments were conducted in a windowless testing room (≈ 2m x 3m) with an office desk, a chair and the computer used to run the experiment. Participants were tested singly. On arrival each participant completed a consent form and the experimental procedure was described to them. Once a participant confirmed that they understood the procedure the experimenter left the room.

2.5 Experiment 1

Once the participants had completed the on-screen questionnaire, the following screen informed them which of the two experimental conditions was about to follow: Sequential or Simultaneous (see below). The participants were presented with pairs or trios of faces. In each pair (binary set) or trio (trinary set) the images were of the same face, each differing only in the yellowness. Binary choice sets consisted of a choice between the faces that were Yellow +1 and Yellow +2, both of which are considered to be relatively healthy (Stephen et al., 2009). Trinary choice sets consisted of a Yellow +1 face, a Yellow +2 face and either a Yellow +3 face or a Yellow -1 face, which are both likely to be viewed as less healthy looking by the participants. Each face was labeled with a number (1-3) beneath the face. After each choice set participants were asked to identify the healthiest face by choosing the number of the face they considered looked the healthiest (participants could also choose not to answer if they wished), participants were also asked to rate how healthy they thought this face looked on a scale of 1-10. They then confirmed the end of the trial by clicking a centrally located button labeled "ok" and the next set of faces was presented.

As the order of presentation can influence choices (Dato-on and Dahlstrom, 2003, Geiselman et al., 1984, Jordan and Uhlarik, 1985, Wanke et al., 2001, Wedell et al., 1987), for half of the trials the faces were presented simultaneously and in half the trials the faces were presented sequentially. In the Sequential Condition the faces were presented one after another before participants were asked to choose a face, whereas in the Simultaneous Condition all of the faces were presented on the screen at the same time. For both the Simultaneous and Sequential Conditions there were three choice sets for each face (one binary and two trinary). The order of the choice sets was pseudo randomized so that choice sets using the same face did not occur adjacent to one another, and within each choice set the order of presentation of faces was randomized.

In both the Sequential and the Simultaneous Conditions the images were presented for a total of five seconds of exposure per image. This meant that in the binary choice set in the Simultaneous Condition the two images were presented simultaneously for ten seconds and in trinary choice sets the three images were presented simultaneously for fifteen seconds. In the Sequential Condition, each image was presented for five seconds, followed by blank screen for two seconds before the presentation of the next image. In the Sequential Condition the images were presented on the same position on screen in binary and trinary choices as they were in the Simultaneous Condition. The faces were numbered left to right to allow participants to identify the face that looked healthiest.

Each participant completed 90 trials (one binary and two trinary sets for each of the 30 faces) in each of the Sequential and the Simultaneous Conditions. The trials were grouped so participants completed all 90 trials of either the Sequential or the Simultaneous Condition type before starting the 90 trials of the other condition, and the order of conditions was pseudo-randomized across the participants. After 180 trials, which took 50-60 minutes, the screen instructed the participants to inform the experimenter that they had finished the experiment.

2.6 Experiment 2

Experiment 2 was almost identical in protocol to Experiment 1 except that rather than having each choice set presented either sequentially or simultaneously, the choice sets were presented simultaneously only. In Experiment 2 participants experienced a total of 90 trials in which they saw sets of two or three faces on the screen at the same time under the same experimental protocol as the Simultaneous treatment of Experiment 1. In addition to having the choice sets presented only simultaneously, Experiment 2 presented different shades of face than those presented in Experiment 1. The majority of the faces presented in Experiment 2 were less yellow than those experienced in Experiment 1. In fact the two least yellow shades from Experiment 1 were equivalent to the two yellowest faces in Experiment 2 (see Image creation for details).

2.7 Analysis

For Experiment 1 we analysed participants' decisions about which face they thought looked the healthiest by comparing the proportion of the choices made to the Yellow +2 face relative to the Yellow +1 face i.e. the number of choices of the Yellow +2 faces divided by the sum of choices of Yellow +2 and Yellow +1 faces. Assessing the proportion of choices made to the Yellow +2 face allows us to compare the choices made in binary choice sets with those made in trinary choices sets. We also directly assessed the number of choices to each option in a set because changes in proportional choices could be influenced but the number of times Yellow +1 and Yellow +2 were selected and by the number of times the third option in a trinary set was selected. In Experiment 2, we compared the proportion of choices made to the Yellow +1 face relative to the Yellow -1 face in our binary and trinary choice sets (as in Experiment 1).

In both Experiment 1 and Experiment 2 the proportional data were not normally distributed so were transformed prior to analysis using an arcsine square root transformation. In both experiments we compared choice across the conditions using 2 factor repeated-measures ANOVAs and, if the data violated the assumption of sphericity, a Greenhouse-Geisser correction was applied. Statistics were calculated in IBM SPSS Statistics 21.

3. Results

3.1 Experiment 1

Proportion of choices to the Yellow +2 shade

Choice of the healthiest option was influenced by the presence or absence of a third option within a set ($F_{1.523, 45.682} = 54.101$, $p < 0.001$, $w^2 = 0.199$; Figures 3a and b). Contrasts revealed that the proportion of choices made to the Yellow +2 option was higher in the presence of the Yellow +3 option ($F_{1,30} = 65.625$, $p < 0.001$) and lower in the presence of the Yellow -1 option ($F_{1, 30} = 18.235$, $p < 0.001$) relative to choices in the binary condition. Presentation style (simultaneous vs. sequential) did not affect choices ($F_{1,30} = 0.104$, $p = 0.749$) and there was no interaction between the choice set and presentation style ($F_{2,60} = 2.644$, $p = 0.079$).

Number of choices made to Yellow +1 and Yellow +2 shades

As the participants sometimes chose the Yellow +3 or Yellow -1 faces as the healthiest face, we examined how those choices may have influenced the proportional choices reported above. To do this we looked at whether the inclusion of these two extra faces had an impact specifically on the number of choices to one or other of the two 'healthy' faces (Yellow +1 and Yellow +2).

Choice set influenced the number of choices participants made to the Yellow +1 option ($F_{1.236, 37.082} = 59.310$, $p < 0.001$; Figure 4). The number of choices made to the Yellow +1 option was lower in the presence of the Yellow +3 option ($F_{1, 30} = 60.029$, $p < 0.001$) and higher in the presence of the Yellow -1 option ($F_{1,30} = 40.381$, $p < 0.001$). Presentation style did not affect choices to Yellow +1 ($F_{1,30} = 0.579$, $p = 0.452$), and there was no interaction between choice set and presentation style ($F_{2,60} = 2.004$, $p = 0.144$).

Examining the corresponding number of choices to the Yellow +2 option, choice set again influenced perception of the healthiest face ($F_{1.129, 33.874} = 10.903$, $p = 0.002$): the number of choices made to the Yellow +2 option was not different in the presence of the Yellow +3 option ($F_{1, 30} = 0.253$, $p = 0.618$) but was significantly lower in the presence of the Yellow -1 option ($F_{1, 30} = 57.390$, $p < 0.001$). Again, presentation style did not influence this outcome ($F_{1, 30} = 0.193$, $p = 0.664$) or its interaction with choice set ($F_{1.479,44.368} = 3.148$, $p = 0.067$) on choice of Yellow +2. Participants' rating of how healthy they though that the options looked on a scale of 1-10 also did not change across choice sets in the simultaneous ($F_{1, 30} = 2.022$, $p = 0.141$) or sequential condition ($F_{1, 30} = 1.494$, $p = 0.227$).

3.2 Experiment 2

Participants did not change how frequently they chose the Yellow +1 face as the healthiest when either the Yellow -2 or the Yellow -3 face was added to the choice between Yellow -1 and Yellow +1 (F (2,36) 3.052, p = 0.060, w^2 = 0.024; Figure 5). Participants' rating of how healthy they though that the Yellow +1 option looked on a scale of 1-10 also did not change as a result of the inclusion of the Yellow -2 option or of the Yellow -3 to the choice set ($F_{2, 36}$ = 1.616, p = 0.213).

4. Discussion

Here we found very strong context-dependent changes in preference when participants' preferences are divided between two healthy options but no context-dependent preferences when participants overwhelmingly considered only one of the options to be healthy. They then chose that face almost exclusively. In Experiment 1, the face that the participants identified as the healthiest face depended on the context, specifically, whether an extreme image was present in the choice set. Preference for either of the two moderately yellow faces in Experiment 1 was highest when it was intermediate in shade between two other options, a result consistent with context-dependent decision making. In Experiment 2, however, when all of the faces presented were much less yellow than the faces in Experiment 1, participants overwhelmingly preferred one face and their preferences were no longer context-dependent.

Here we have demonstrated that the assessment of health in human faces can be context dependent when the options vary in only a single dimension: the yellowness of the face. Typically, decision-making experiments investigating context-dependent preferences in humans or animals involve options that vary in more than one dimension and represent a trade-off between two factors. For example, in human experiments the trade-off might be between price and quality (Doyle et al. 1999) whereas in animal experiments the options might vary in both amount and quality of food (Morgan et al. 2014). However, although less frequently reported, it seems that both human and animals will also display context-dependent preferences when the options vary in only a single dimension (Morgan et al. 2012, Wedell et al. 2005).

There are a number of possible alternative explanations for the context-dependent health preferences of our participants. It could be argued that the outcome of the simultaneous condition in Experiment 1 might be due to an effect of colour constancy, whereby the colour of an object is adjusted by the retina and cortex to remain constant under different illuminating conditions. It is less clear, however, that colour constancy would explain the data from the sequential condition as each of the images was separated by a gap of two seconds. In the trinary conditions, when the decisions were made after a total of 14 seconds, the effects of colour constancy will be much reduced (Rinner and Gegenfurtner, 2000). Furthermore, context dependent decisions about faces are not confined to comparisons based on colour. When facial features such as the gap between the eyes or nose size are manipulated in a loosely similar fashion to our colour manipulation, strong context effects have also been observed (Wedell and Pettibone, 1999). As colour constancy is insufficient to explain the results of both the Sequential treatment of Experiment 1 and Experiment 2 it seems highly unlikely that colour constancy is responsible for the context-dependent health perception that we see in this experiment.

A second plausible explanation for the data is that participants simply chose the intermediate option. By doing so more frequently, it would appear as though the participants had changed their preferences and would be sufficient to explain our results from Experiment 1. If the tendency to choose the intermediate option was due to some aspect of the presentation of design the participants should have chosen this intermediate option more frequently in both experiments and the size of this context dependent effect would be similar across experiment 1 and 2. As participants changed their preferences only in Experiment 1, however, it seems more likely that the changes in preferences were the result of participants assessing health of the faces in a context-dependent manner.

Whether the options were presented simultaneously or sequentially, the participants in these experiments assessed the health of faces relative to the other images within each choice. As we saw no context effects in Experiment 2 when the shade of faces presented were outside the range of yellowness generally considered healthy, it could be that context effects in health and perhaps attractiveness judgements are limited to faces within the normal healthy range. It is possible that with a larger sample size there may be context-dependent effects even when the options are outside of the healthy range, however, it is clear that these context effects are at the very least, smaller than the context dependent preferences seen when the options are within the normal range. This is, however, a possibility that needs further testing.

The decision-making mechanism that underpins this kind of context-dependent effect is not yet clear. In rational choice theory, when the costs of choice are held constant, the value of each option should not vary with respect to the presence of poorer alternatives. However, it has been suggested that the neural response associated with a value could depend on the distribution of other values present, such that the perceived value of each option varies depending on the options present (Kable & Glimcher 2007, Louie et al. 2013). The explanation for this lies in the mechanism of normalization, which is the activity of a neuron divided by the summed activity of a larger pool of surrounding neurons (Louie et al., 2013). Normalization was originally proposed to explain activity in the primary visual cortex but normalization may also explain higher-order processes such as visual attention and decision-making (Matteo and David, 2011, Rangel and Clithero, 2012). It is not yet clear which, if any, of the currently proposed mechanisms will prove to underlie the context-dependent decisions made by humans, but the integration of ideas from neuroscience and behavioural work is leading to models that better describe the decisions people actually make.

Given that there is an increasing number of examples whereby animals make context-dependent choices in both foraging situations and in mate choice, we should not, perhaps, be surprised that humans also make context-dependent choices outside the economic domain (Trueblood et al. 2013). Our data suggest that decisions as to who is the healthiest within a particular group are highly context-dependent and rely on comparative decision-making mechanisms. As humans and animals both have highly context-dependent preferences that appear to influence choices with potentially significant fitness impacts, it seems that it would be useful to investigate further the similarities between the context-dependent decisions made by humans and animals and their outcomes.

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Figure Legends

Figure 1. An example set of faces showing each of the four shades of yellow: Yellow -1, Yellow +1, Yellow +2, Yellow +3.

Figure 2. An example set of faces showing one face in each of the four shades of yellow present in Experiment 2: Yellow -3, Yellow -2, Yellow -1, Yellow +1.

Figure 3. The proportion of trials in which participants selected the Yellow +2 option as the healthiest in the Binary and the two Trinary choice sets of (a) the Simultaneous Condition and (b) the Sequential Condition. The asterisk indicates significance at $p \leq 0.05$. The data are means ± s.e. (N = 31).

Figure 4. The number of times in (a) the Simultaneous Condition and (b) the Sequential Condition that participants selected each face shade as the healthiest in Trinary Yellow -1, Binary and Trinary Yellow +3 choices. The data are means ± s.e. (N = 31).

Figure 5. The proportion of choices participants made to the Yellow +1 shade when options were presented in binary and trinary choice sets. Binary choice sets contained Yellow +1 and Yellow -1 faces, one trinary set contained Yellow +1, Yellow -1 and Yellow -2 and the other trinary set contained Yellow +1, Yellow -1 and Yellow -3. The dotted line represents no difference in preference between Yellow +1 and Yellow -1. The data are means ± s.e. (N = 19).

Figure 1.

Yellow -1 Yellow +1 Yellow +2 Yellow +3

Figure 2.

Yellow -3 Yellow -2 Yellow -1 Yellow +1

Figure 3a.

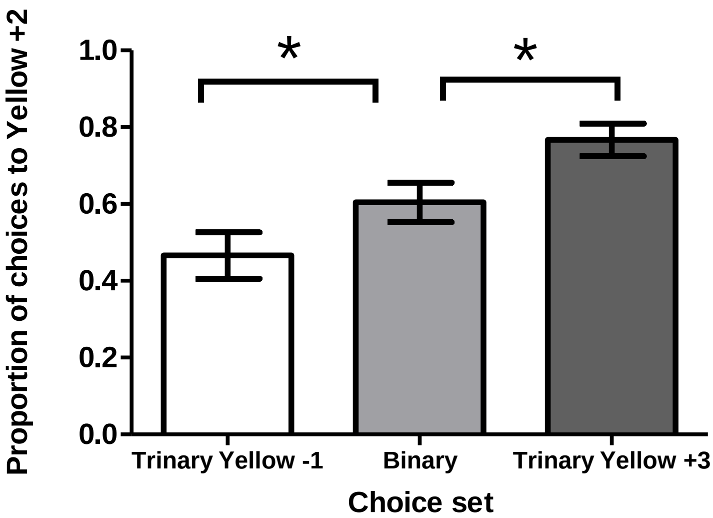

Figure 3b.

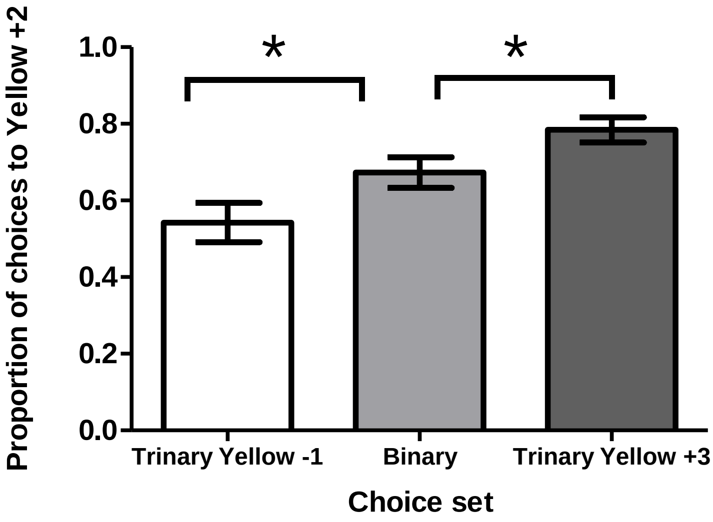

Figure 4a.

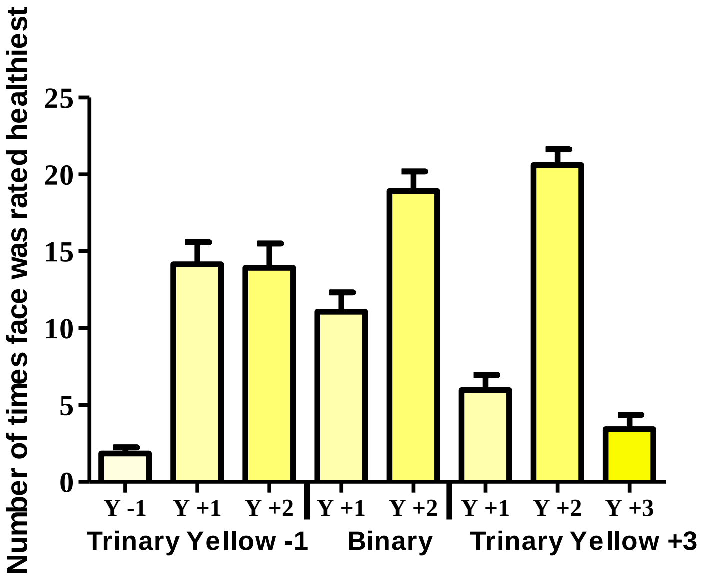

Figure 4b.

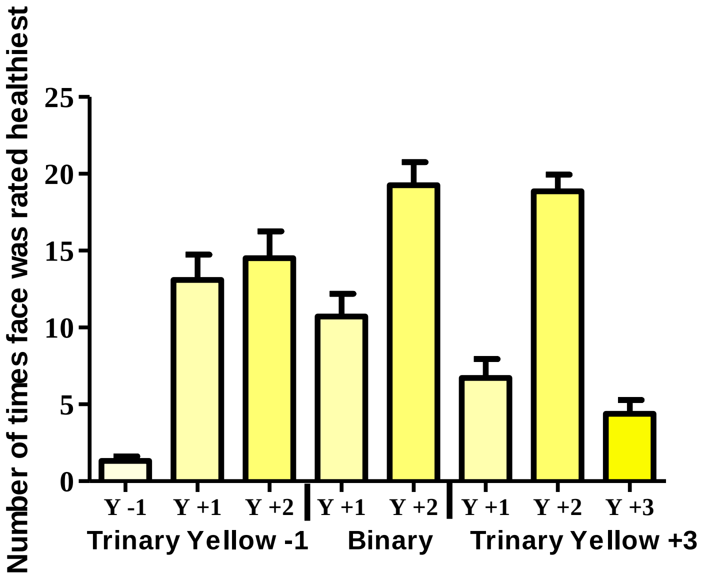

Figure 5.