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Analysis of Research Strategies to Determine Colour Preference II: AFC, Rank-Order and Rating

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Abstract

Exploring an efficient research method to understanding colour preference is important to researchers and designers. This work compares three experimental methods for individual colour preference resaerch (N-alternative-forced-choice, rank-order and rating). Three psychophysical experiments have been carried out with 338 participants. Participants were presented with six colour patches (red, orange, yellow, green, blue and purple) arranged in a random order. This work suggested orange is the strongest preferred colour and green is the weakest preferred in three individual colour preference experimental methods with six hues. The Monte Carlo Analysis method further compares the result performance for three methods, which suggests the rating and rank-order method are more stable than the AFC method when only small number participants take part in the experiment, such as for studies involving small numbers of participants, the rating and rank-order method should be preferred.

Keywords: *Colour Preferences, Experimental Method, Monte Carlo Analysis, Research Strategy.*

INTRODUCTION

Colour preference *per se* has been studied by many researchers (Camgöz et al. 2002). It is concerned with which colours individual prefer (Mikellides 2012). Finding an efficient way to understand individual colour preference is important to both researchers (Jiang et al. 2020) and designers (Lee et al. 2019; Swasty et al. 2020). The previous studies have used standardised colours, multiple research strategies, and sophisticated statistical methods (Yu et al. 2021a).

From the previous studies, a colour preference research strategy includes experimental material, experimental method and experimental environment (Yu et al. 2021a). The experimental methods could be classified as N-alternative forced-choice (N-AFC, N≥2), rank-order, subjective rating, affective judgments etc. In N-alternative forced-choice method, participants indicate which colour they 'prefer aesthetically' with all colours simultaneously presented on a visual display (Palmer et al. 2013). The 2-AFC is also called 'Paired-Comparison' (Ling et al. 2006), it is a simple response to indicate the preference from only two samples. The rank-order method requires participants to provide an order to all colours from the most to the least preferred for all colours simultaneously displayed (Holmes et al. 1985). The subjective rating (Adams, 1987) and affective judgment (Ou et al. 2004) methods are made by response scales for how much they prefer each single colour, such as N-point Likert scale or a line-mark rating. Other methods include description method, physical and behavioural measurements (Yu et al. 2021a) etc. This research concerned with finding an efficient research method to test individual colour preference. Three experimental methods have been chosen, AFC, rank-order and rating experimental methods. The research aim is: 1) to test the agreements of individual colour preference results between three methods; 2) to determine a lower limited number of participants with consistent and reliable results for three methods.

EXPERIMENTAL

For *experimental environment*, it has been suggested that there was no statistical significance between online and laboratory environments for individual colour preference test (Yu et al. 2021a). Although, the online environment is less-controlled than the laboratory environment in display technology or viewing conditions etc., the advantage is relatively easy to recruit a large number of participants, and robust estimates of individual colour preference for groups of participants (such as nationality or even socio-economic status). Thus, online questionnaire has been chosen in this research.
In this study, six colours (red, orange, yellow, green, blue and purple) were selected to determine participants' individual colour preference (Holmes et al. 1985; Yu et al. 2021b). The colours were defined by sRGB values (please see Figure 1). Three experimental methods have been used, AFC, rank-order and rating.

Participants were presented with six colour patches (red, orange, yellow, green, blue and purple) arranged in a random order on a display. In the AFC test, participants were asked to indicate which colour they prefer most; for the rank-order test, participants were asked to give the sequence of their colour preference for the six colours from the most to least; for the rating test, participants were asked to scales the colour preference for each colour by line-mark ratings. A total 338 participants were recruited to participate, comprising of 192 participants for AFC test, 85 participants for rank-order test and 41 participants for rating test.

RESULTS AND DISCUSSION

The individual colour preference percentage for each colour is the number of times that each colour has been selected as the most preferred for AFC method (Yu et al., 2018). For rating method, each colour preference percentage has been averaged by participants' rating from 0% to 100% as non-prefer to most prefer. In the rank- order method, the ordinal rank and comparative data are converted to interval-data *z* scores (Yu et al. 2021a). The rank-order data from each participant were combined to mean rank data and subsequently proportion values (between 0 and 1) (Westland *et al.*, 2014). The proportion values were converted to interval scale values *z* using the inverse of the cumulative standardized normal distribution according to case V of Thurstones Law of Comparative Judgement (Hohle 1966); additionally, the proportion of 0 and 1 are replaced with 1/999 and 999/1000 respectively when the proportions are exactly 0 or 1 (Yu et al. 2021a). In order to compare three methods, the interval scale values z have also been used on AFC and rating methods.

First, 338 responses have been collected as AFC method (the colour was placed in the first choice was considered in the rank-order method, and the colour was obtained the highest rating was counted in the rating method); 126 responses have been collected as rank-order method (the rating preference sequence was considered as a rank-order); and 41 responses have been collected in rating method.

Figure 1: The individual colour preference rank sequences from three methods.

The colour preference sequence for z scores for AFC method is blue > orange > red > yellow > purple > green; the preference sequence for rank-order method is orange > yellow > blue > red > green > purple; for rating is orange > yellow > blue > red > purple > green; which represents a similar sequence (please see Figure 2.1). However, the data were collected from different populations. In order to reduce the differentiation, the results from rating group have been re-analysed. The rank-order and rating method have a same colour preference Z scores sequence, orange > yellow > blue > red > purple > green. Also, AFC method also obtained a similar sequence, orange > blue > yellow > purple > red > green (Please dee Figure 2.2).

Moreover, this study aims to explore the efficiency way on scaling individual colour preference, between experimental methods and participant numbers. The Monte Carlo simulation analysis was used to explore the level of agreement of these three methods (Yu et al. 2021a). The data from rating were used as three methods. 41 responses were sub-sampled, and sub-sample the full population repeatedly taking a different sub-sample each time. The following four steps are: subsample n of the data from *the 41* participants randomly where *n* is [*36, 31… 6, 1*] (Step 1); calculate the individual colour preference *z* score for each *n* scale participants (n = 36, 31, 26, 21, 16, 11, 6 and 1) to obtain the three distributions of individual colour preference for each *n* scales from AFC, rank-order and rating methods (Step 2); construct the correlation coefficient (r^2) calculated between the individual colour preference from all the data (*n* = 41) and from the sub-sampled data (*n = 36, 31… 6, 1*) (Step 3, Figure 4); compare the r^2 distributions between the three methods (Step 4, Figure 3).

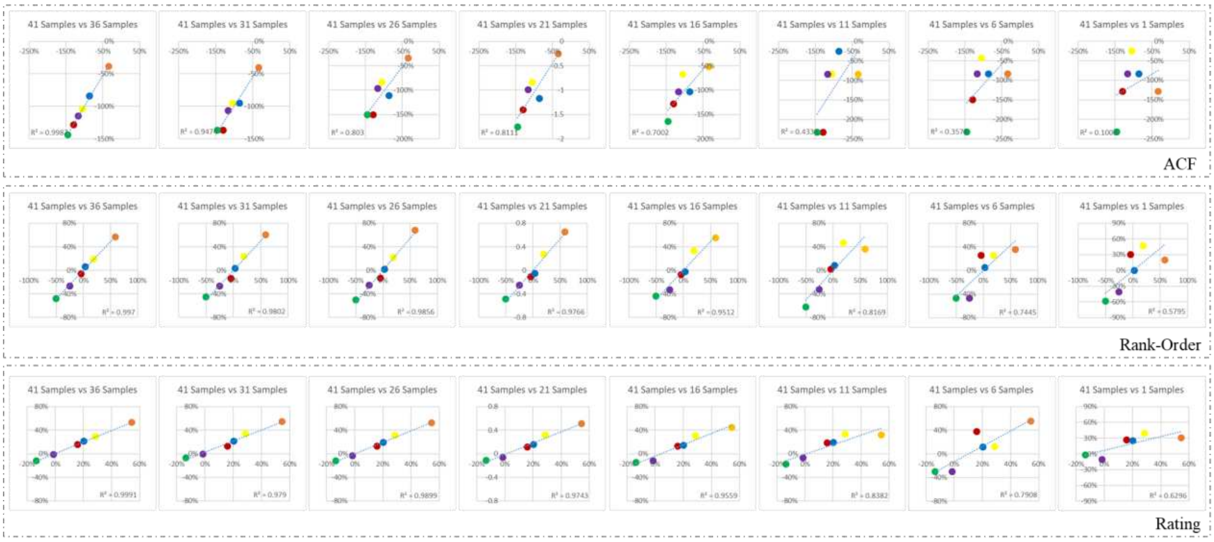

Figure 2: The correlation for the individual colour preference between full samples (n=41) and each the sub-sampled samples (n=36, 31, 26, 21, 16, 11, 6 and 1) from AFC, rank-order and rating methods (an example illustration for Step 3).

Figure 2 and Figure 3 illustrates the steps 3 and 4, presenting the correlation coefficient values with *n* scale samples (n=36, 31, 26, 21, 16, 11, 6 and 1). In Figure 3, the red, grey and blue lines show the r^2 distributions from AFC, rank-order and rating methods; each point represents the r^2 for each *n* scale samples. Comparing the small-scale samples tests (*n*=15, *n*=10 and *n*=5), the correlation coefficients hold on the high agreements) for both rating (0.84, 0.79 and 0.63) and rank-order (0.82, 0.75 and 0.60) methods. However, the correlation coefficients decrease sharply to the low agreement positions for AFC method (0.43, 0.36 and 0.1). It suggests that the rating and rank-order methods are more stable than AFC in small number of responses.

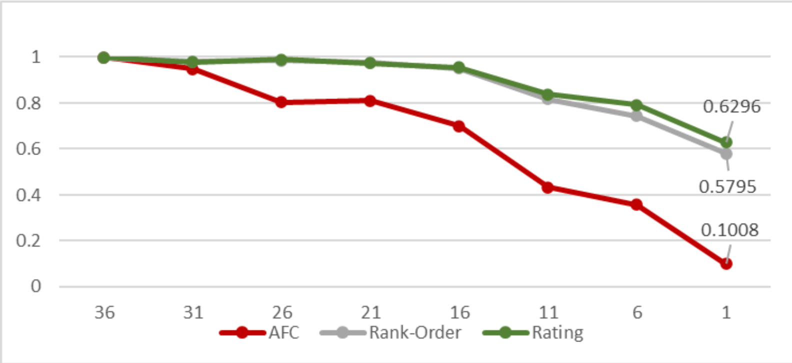

Figure 3: An example illustration for the correlation coefficient distributions from AFC, rank-order and rating methods. The vertical and horizontal axes represent r^2 values and n scale samples.

The Monte Carlo comparisons evaluate the stability of the three methods, the simulation was repeated 100 times. Each simulation starts with a different random set of scale samples, and the mean correlation coefficient was used as a measure of performance. Figure 4 displays the box plots for the r^2 distributions from 6-AFC, rank-order and rating methods, the vertical axes and horizontal axes represent the correlation coefficient values and n scale samples. Notice that the median for rating and rank-order methods are higher than AFC method when samples less than 11 for example, especially, for the sample size as 11, 6 and 1, shows by the red horizontal line (for the size 1, $r^2 \sim 0.2$ in AFC method, $r^2 \sim 0.59$ in Rank-Order method, and $r^2 \sim 0.67$ in rating method). In other words, the results from Monte Carlo simulations suggests that the rating and rank-order methods are more relay and stable than the AFC method for individual colour preference when n is small. This suggests that, for studies involving small numbers of participants, the rank-order rating and rank-order should be considered.

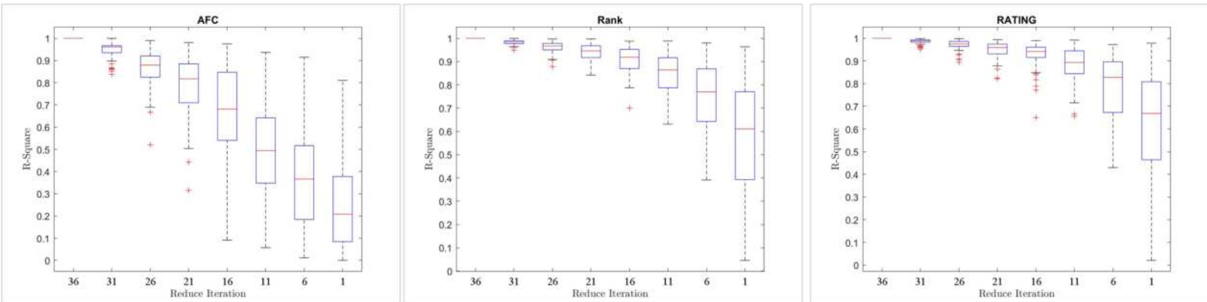

Figure 4: The box plots for the r^2 distributions from AFC, Rank-Order and Rating methods.

CONCLUSION

Colour is an important tool for products design (Gong et al. 2019), environment design (Xia et al. 2021), information design (Xia et al. 2019) etc. However, finding an efficient method to investigate individual colour preference is important for designer and researcher. The individual colour preference results from this work suggested orange is the strongest preferred colour in these six hues and green is the weakest preferred in three individual colour preference experimental methods (AFC, rank-order and rating). The Monte Carlo Analysis method also be employed to compare the result performance of the methods for individual colour preference by repeating 100 trials. The average correlation coefficients variation range for AFC method is wiled than both rating and rank-order methods in the small number of participants (less than 11 or 6). That suggests the rating and rank-order method are more stable than the AFC method when only small number participants take part in the experiment, such as for studies involving small numbers of participants (less than 11 participants), the rating and rank-order method should be preferred.

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