Introduction

Research over the past decade has begun to explore the role that colours play in our affect, cognition, and behaviour. To provide a framework for this field, Elliot and colleagues proposed colour-in-context theory (Elliot & Maier, 2012; for a review, see Elliot & Maier, 2014), which suggests that colour–behaviour associations are context-dependent. For instance, red may be associated with both approach (Valentine's Day lingerie) and avoidance (traffic light signals) motivations, depending upon the context in which it is encountered. Although significant attention has been given to explaining the origins of these associations (e.g., red’s relationship with attractiveness due to its link with sexual fertility in nonhuman primates—Caro, 2005; Nunn, 1999), few studies have considered whether colour associations are already present in children and whether these mirror the associations displayed in adulthood.

If we first consider research with adults, as mentioned above, numerous studies have demonstrated an association between the colour red and attractiveness (e.g., Elliot & Niesta, 2008; Elliot et al., 2010). However, red may also increase perceptions of high status (Elliot et al., 2010), as well as dominance, threat, aggression, and anger (Feltman & Elliot, 2011; Little & Hill, 2007; Wiedemann, Burt, Hill, & Barton, 2015). In addition, red may be associated with lower leadership potential and ability (Maier et al., 2013), but also increased believability (Bashir & Rule, 2014). Interestingly, these associations are not always apparent (e.g., Kramer, 2016).

Although red has been investigated extensively, less is known about other colours and their associations within various social contexts. Research suggests that black is also seen as attractive, showing levels comparable with red, whereas white and yellow may be considered unattractive (Roberts, Owen, & Havlicek, 2010). Black is
also associated with aggression (Frank & Gilovich, 1988; Vrij, 1997), with evidence suggesting that both black and red may dominate blue and green in various competitive contexts (Greenlees, Eynon, & Thelwell, 2013; Hagemann, Strauss, & Leibling, 2008; Hill & Barton, 2005; Ilie, Ioan, Zagrean, & Moldovan, 2008; Krenn, 2015; Sorokowski, Szmajke, Hamamura, Jiang, & Sorokowska, 2014).

Numerous studies have also explored associations between colours and a wide range of descriptors, for example, linking blue and green with low-arousal, calming emotions (Clarke & Costall, 2008) and black with immorality (Sherman & Clore, 2009), power, and strength (Wexner, 1954). However, such relationships may not necessarily apply to social contexts (i.e., clothing colours), simply reflecting more abstract links, and to our knowledge, few studies have explored this topic.

Limited research has also investigated colour associations in children. Typically, these studies involve associating colours in the abstract sense (e.g., asking children to name the colour they think of or choose a coloured square), rather than as applied to a specific item or context. Findings suggest that bright (dark) colours are associated with positive (negative) emotions, for example, yellow and happiness in 5- to 6-year olds (Boyatzis & Varghese, 1994). In addition, children aged 9 to 11 also consistently associate concepts like love and death with certain colours (red and black, respectively; Byrnes, 1983; Karp & Karp, 1988). However, associations with characteristics that go beyond emotion terms are rarely considered, and the colour-in-context specificity of these associations is ignored. Finally, studies have not directly compared children’s and adults’ colour associations to see whether these are shared or emerge over time.

Here, we address these omissions in the literature by investigating associations for six colours in 10 different contexts, extending beyond emotion-related characteristics and asking children and adults to complete the same task. Given the extensive literature focussing on red associations in adults, we selected contexts/trait in which previous evidence suggested that this colour may show a consistent association (either positive or negative): aggression, anger, and dominance (Fetterman, Robinson, & Meier, 2012; Little & Hill, 2007; Wiedemann et al., 2015; Young, Elliot, Feltman, & Ambady, 2013), attractiveness (Elliot & Niesta, 2008; Elliot, Tracy, Pazda, & Beall, 2013), cheating and honesty (Bashir & Rule, 2014; Krenn, 2015), danger (Pravossoudovitch, Cury, Young, & Elliot, 2014), intelligence (Maier et al., 2013), and strength (Dreiskaemper, Strauss, Hagemann, & Büsch, 2013; Elliot & Aarts, 2011; Payen et al., 2011). Finally, we included “speed” because evidence suggests that people respond faster to the colour red (Shibasaki & Masatake, 2014), which is commonly associated with sports cars (e.g., the Ferrari) in popular culture.

**Method**

**Participants**

We collected data from 120 children (age range: 3-10 years old), who participated during a “Summer Scientist” event run by the University of Lincoln. This sample size was simply determined by the number of children who were able to participate, given the limited duration of the 5-day event. We excluded data from two participants—one reported being colour-blind and the other showed severe physical disabilities that meant the task was not completed. In addition, we chose to exclude children younger than 5 years old because it became apparent during testing that these participants typically responded based on irrelevant influences (e.g., a side preference that resulted in always choosing items presented in a particular location). These exclusions took place before any analyses were undertaken. Our final sample comprised 104 children (57 female; age \(M = 7.47\) years, \(SD = 1.59\) years). In all cases, parents provided written informed consent.

We also collected data from 100 university students (67 female; age \(M = 19.88\) years, \(SD = 2.25\) years), who received chocolate biscuits as compensation. We chose this sample size to be comparable with the number of children who had already participated. None of these participants reported being colour-blind. For this adult sample, the participants themselves provided written informed consent.

The University of Lincoln’s School of Psychology ethics committee approved the experiment presented here, which was carried out in accordance with the provisions of the World Medical Association Declaration of Helsinki.

**Stimuli**

We collected 10 cartoon images from the Internet to represent the traits under investigation. These traits (images) were as follows: aggression (a boxer), anger (an angry girl), attractiveness (a woman in a dress), cheating (a boy writing on paper), danger (an angry dog), dominance (a man in a suit and tie), honesty (a man speaking at a podium), intelligence (a woman holding a notebook), speed (a racing car with driver), and strength (a weightlifter holding weights above his head). Each of these images was then altered using the “replace colour” tool in Adobe Photoshop CC 2018 to produce six different versions: black, blue, green, red, white, and yellow (see Figure 1; all stimuli are available in the Supplementary Material). In all cases, the colour of a specific item of clothing (or car) varied across images, whereas the remainder of the image was unaltered. Care was taken to match the six colours in terms of lightness where possible and to utilise the same six shades of colour across the 10 sets of images.

The questions that accompanied the 10 sets of images were initially constructed to address the traits of interest.
listed above. However, we chose to adapt these where necessary to ensure our child sample would be able to understand them. As such, several of the revisions resulted in small ("pretty" instead of "attractive") or more substantial ("scary" instead of "dangerous") alterations to their meanings. The final list of questions can be found in the online Supplementary Material.

Procedure

Participants were tested individually. For each of the 10 questions, the six colour images (individually printed and laminated) were placed on a desk in a random order and position. Participants were read the corresponding question and asked to select one of the images. The chosen image was then removed from the set and participants were asked to make their choice from the remaining five images, and so on, until only one image remained. In this way, we collected rankings for all six images. During this process, the question was repeated by the experimenter as often as was needed to encourage responses, although no time limit was imposed. Choices were written down by the experimenter, making sure that these records were not visible to participants to avoid current decisions being influenced by previous ones. The order of the 10 questions was randomised for each participant.

We used the same procedure for collecting responses from our child and adult samples, and this included asking the same child-friendly questions (see the online Supplementary Material).

Results

Rankings were assigned based on participants’ responses, with first choices being given a rank of 6 and last choices receiving a rank of 1. These data are summarised in Figure 2 (with measures of spread presented in the Supplementary Material). For each sample and question, we then calculated Friedman’s test (the non-parametric equivalent of a one-way, repeated measures analysis of variance), which evaluated the differences in the medians among the six colours' rankings. In addition, for each of these χ² values, we calculated Kendall’s W, which provided a measure of effect size (ranging from 0 to 1). Table 1 provides a summary of these analyses.

For each sample and question, we also calculated preference proportions (Taplin, 1997), which quantify the proportion of responses where one colour was chosen over (before) another. For example, a value of 0.65 for “black over blue” would mean that 65% of responses featured a higher ranking for black than blue (with 50% representing no overall difference). Using these preference proportions, we calculated Taplin’s (1997) T statistic as this measure is demonstrably more robust to a variety of situations than Friedman’s test. These analyses confirmed the pattern of results produced by Friedman’s test and so we report these values in the Supplementary Material as an opportunity for comparison.

As Table 1 illustrates, we found statistically significant differences in the colour rankings for both samples and all questions other than adult responses for honesty. However, these results do not inform regarding which colours’ rankings differed from each other. Wilcoxon signed rank tests were therefore performed to make pairwise comparisons between the six colours. However, as 15 comparisons were required for each set of rankings, we implemented the conservative Bonferroni method to adjust the alpha level to .003 (given by .05/15). Table 1 provides a summary of these comparisons, and all p values and effect sizes for these tests can be found in the Supplementary Material.

In addition, we also carried out sign tests (e.g., Hollander & Wolfe, 1973) to make pairwise comparisons between the six colours by comparing the preference proportions to a value of 0.5 (see above). This test is often considered to have less power to detect differences than the signed rank test (Usman, 2015), and indeed, we found that a few instances of previously significant comparisons failed to reach significance using this method. However, in almost all cases, both tests produced identical results. We report the outcome of these tests in the Supplementary Material for comparison.

Table 1 highlights a number of patterns that were found. First, boxers with red gloves were perceived as more likely to win fights than most other colours, although black was also given a high ranking by both children and adults. This same pattern was found for the colour of dress worn in relation to how angry a girl was judged to be.
Second, children associated both white and black with which dress looked the prettiest. Anecdotally, some children mentioned associations with wedding dresses as their justification. In adults, black no longer shows such a strong association, with red also being ranked high for this question.

Third, both samples associated black with being more likely to cheat (see Figure 1), scarier when used as the colour of a dog’s collar, and more in charge when providing the colour for a man’s tie. For adults, we also found an association between red, the likelihood of cheating, and how scary the dog appeared, and a link for both red and blue with being in charge at work. Furthermore, adults believed that white was unlikely to cheat, and that yellow was perhaps the least associated with being scary or in charge (with the children also showing evidence of this latter association).

Fourth, adults associated green and yellow with being the least clever, although we found no significant colour differences in our children.

Fifth, the fastest racing cars were seen as black or red by our children. However, our adults demonstrated a strong association with red and no evidence of one with black. Adults also often considered white to be the slowest car.

Finally, our adult sample frequently ranked red as most associated with strength, whereas both samples considered yellow to be perhaps the weakest colour.

Discussion

The results of this study represent the first investigation into children’s context-specific colour associations and how these overlap with associations demonstrated by
adults. Interestingly, we find patterns showing consistent associations across both age groups for certain contexts, as well as associations which are displayed by children but not adults and vice versa.

It is clear that a number of associations are present in our sample of children. For example, red- and black-gloved boxers win more fights, wearing a black tie implies being in charge at work, and red cars are fastest. Regarding the extensive literature of red associations in adults, we found that our children’s responses also showed evidence that red dresses make girls look more angry and that red collars make dogs look more scary, but there was no evidence of a link with red for many of the contexts. Taken together, we might conclude that red is associated with aggression, anger, and speed for children. Of course, determining whether these are more biologically or culturally based is beyond the scope of the current work, although one could hypothesise that all three traits may be underpinned by arousal mechanisms, which red has been shown to affect (Dreiskaemper et al., 2013; Gorn, Chattopadhyay, Sengupta, & Tripathi, 2004; Jacobs & Hustmyer, 1974; cf. Caldwell & Jones, 1985).

In our adult sample, we found many associations across our contexts, suggesting a large influence of shared biology and/or culture. Like the children, this sample also associated black and red with winning fights and looking angry (Wiedemann et al., 2015). Interestingly, adults also showed evidence that red (as well as white) looked attractive, as predicted based upon much previous work (Elliot & Niesta, 2008; cf. Peperkoorn, Roberts, & Pollet, 2016). To some extent, both adults and children associated black with being likely to cheat, whereas adults also considered white as the opposite end of the continuum (Sherman & Clore, 2009). Black and red collars were associated with scarier dogs, with children showing similar relationships. Although black, blue, and red were all seen as tie colours worn by those in charge, no single colour dominated (for evidence against the popular “red power tie,” see Kramer, 2016). In adults, perhaps this may be related to signifiers of specific political parties, although further work is needed to address this idea. Red was also seen to depict the fastest car, in agreement with the children, whereas adults also considered white to be the slowest. Finally, there is some evidence that red is associated with strength (Elliot & Aarts, 2011). Taken together, in line with previous work, adults associate red with winning fights, anger, prettiness, scariness, being in charge, speed, and strength. However, at least in some cases, red failed to show a stronger association with these traits than some of the other colours chosen, and there was no compelling relationship with the other three traits considered.

Researchers exploring the effects of colour may use spectrophotometers or other equipment to determine the colour parameters of their stimuli from spectral data. In

### Table 1. A summary of the analyses, presented separately for each question and sample.

<table>
<thead>
<tr>
<th>Question</th>
<th>Sample</th>
<th>Friedman’s test, $\chi^2$</th>
<th>Kendall’s $W$</th>
<th>Wilcoxon signed rank tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>Most angry</td>
<td>Children</td>
<td>100.18*** .19</td>
<td></td>
<td>Bl &gt; [B, G, W, Y] and R &gt; [B, G, W, Y] and B &gt; Y</td>
</tr>
<tr>
<td></td>
<td>Adults</td>
<td>229.14*** .46</td>
<td></td>
<td>Bl &gt; [B, G, W, Y] and R &gt; [B, G, W, Y] and B &gt; [W, Y] and G &gt; [W, Y] and Y &gt; W</td>
</tr>
<tr>
<td>Prettiest</td>
<td>Children</td>
<td>48.43*** .09</td>
<td></td>
<td>W &gt; [B, G, Y] and B &gt; [B, G, Y] and R &gt; G</td>
</tr>
<tr>
<td></td>
<td>Adults</td>
<td>97.31*** .19</td>
<td></td>
<td>W &gt; [B, G, Y] and B &gt; [G, Y] and R &gt; [B, G, Y] and G &gt; B</td>
</tr>
<tr>
<td>Likely to cheat</td>
<td>Children</td>
<td>65.84*** .13</td>
<td></td>
<td>Bl &gt; [B, G, R, W, Y] and R &gt; G</td>
</tr>
<tr>
<td>Most honest</td>
<td>Children</td>
<td>16.64** .03</td>
<td></td>
<td>Bl &gt; G</td>
</tr>
<tr>
<td></td>
<td>Adults</td>
<td>203.43*** .41</td>
<td></td>
<td>R &gt; [B, B, G, W, Y] and W &lt; [B, B, G, Y] and G &lt; [B, B, B]</td>
</tr>
<tr>
<td>Strongest</td>
<td>Children</td>
<td>36.96*** .07</td>
<td></td>
<td>Bl &gt; [G, Y] and Y &lt; [B, R, W]</td>
</tr>
</tbody>
</table>

Note. Bl = black; B = blue; G = green; red; W = white; Y = yellow.

"Greater than" denotes that one colour received a higher rank than the other colour(s) listed, whereas "less than" denotes the colour received a lower rank. Reported signed rank tests are statistically significant after Bonferroni correction (using $\alpha = .05/15$).

* $p < .05$; ** $p < .01$; *** $p < .001$. 

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