What colour do you feel? Cross-modal interactions between colour and food texture

Gavin Northey*. University of Western Sydney. g.northey@uws.edu.au
Mathew Chylinski. University of New South Wales. m.chylinski@unsw.edu.au
Liem Ngo, University of New South Wales. liem.ngo@unsw.edu.au

Abstract
This research explores the cross-modal interaction between colour and perceived texture, and links its influence with standard marketing metrics. In line with our expectation, we find that colour interacts with actual texture to affect an individual’s overall perception of texture. Specifically, we show that changing hue from red to blue dampens the perception of particular types of texture. Further analysis of the effects of colour on marketing metrics shows that the effect on pleasure and intention to purchase is mediated by the cross-modal perceptions of texture. These results contribute to emerging marketing literature on cross-modal sensory interactions and consumer behaviour.

Keywords: colour, cross-modal, sensory perception, haptic, texture,

Track: Consumer Behaviour
Introduction
Colour affects perceived texture according to a cross-modal sensory interaction. When eating a lunch snack for example, we typically view the snack before experiencing its texture in the mouth. Interestingly, however, the oral somatosensory experience of texture is altered by the prior visual perception of its colour. While much of this perception can be attributed to learned or acquired knowledge, there is a large body of research (e.g. Spence and Gallace, 2011; Bellizzi and Hite, 1992) that indicates a range of interactions between perceptions of colour and other sensory modalities. In particular, Labrecque, Patrick, and Milne (2013) suggest that “the phenomenon of synaesthesia supports the notion that colours have strong biological links to emotions and physical reactions” [p192]. These sensory interactions, or cross-modal effects, are unique in that a stimulus in one sensory modality (such as vision) is expressed in another modality (i.e. touch). This implies effects of colour on processing of non-visual information such as texture. Our findings indicate two-way interactions between colour and actual texture on perceptions of texture.

Literature review and hypotheses
On a daily basis, consumers make a large number of decisions about food choices that have immediate, as well as long term consequences for their wellbeing. These decisions involve colour at both a sensory, perceptual level as well as cognitive levels. Yet, “despite evidence from studies and real-world examples, marketers know little about the boundary conditions of the effects of altered food colours” (Labrecque et al., 2013). In particular, we do not know if consumers obtain a sensory feel of the product through visual inspection of colour, or to what extent unexpected food colours, such as blue beans or red rice, alter that sensory feel (Labrecque et al., 2013). For the purpose of this research, we focus on hue as the main expression of colour and creaminess and crunchiness as expressions of food texture. The broad body of work on colours does incorporate many hues, but there is a general skew towards red and blue as independent variables throughout the research (Bellizzi & Hite, 1992). Similarly, literature on food texture primarily considers creamy and crunchy textures. For that reason, and due to their positions at opposite ends of the colour and texture spectrum, this study will examine the effects on perception of creamy and crunchy texture as we move along the spectrum from red to blue.

When people experience food products, flavour is a critical determinant in overall satisfaction. However, previous research has shown that flavour is a complex combination of three elements that occur in different sensory modalities – taste, smell and oral somatosensation. (Delwiche, 2004; Spence, Levitan, Shankar & Zampini, 2010). If we look at each of these modalities individually, there does appear to be a significant cross-modal influence from colour. Because of this cross-modal effect, colour has been shown to influence taste ratings and intensity levels of various foods (Shankar, Levitan, Prescott, & Spence, 2009). In a similar way, Morrot, Brochet, and Dubourdieu (2001) carried out a lexical analysis of wine tasters and showed that manipulation of wine colour (white wine to red wine) changed the tasters’ perception of odour. However, the literature is not as clear when we look at the influence of colour on the third determinant of flavour, that of oral somatosensory perception (texture). With regards to the influence of colour on oral texture, there is evidence that a change in colour saturation (as opposed to hue or brightness) influences perceived texture of foods (Tom, Barnett, Lew, & Selman, 1987). This is supported by Simner and Ludwig (2012), who demonstrated that non-synaesthetes systematically relate tactile properties, such as smoothness and softness, to luminance (brightness) and chroma (saturation). Importantly, a subsequent study of theirs provided evidence of a link between
texture and hue (e.g. Pink – softness) and suggested that hue, saturation and brightness operate independently in the cross-modal determination of texture (Ludwig & Simner, 2012).

**Haptic Sensitivity** - Based on the above literature, it is within reason to suggest that a change in hue will cause a subsequent change in perceived texture. However, research indicates that along with this sensory level cross-modal association, colour also has an affective component that may influence a person’s haptic sensitivity. For example, red has long been associated with arousal, stimulation and excitement more than blue (Clarke & Costall, 2008). Because of this increased arousal, it is possible that when we encounter an object that is coloured red, the red colour primes the general haptic sensitivity (readies the body for further sensory stimulation) and heightens our sensitivity to any changes that might occur. However, given that this research will also be manipulating actual texture of the food products, it is possible that as actual texture changes, this may also cause a change in haptic sensitivity. For example, James (1884) suggested that creaminess is one of the keys (along with sweetness) that unlock “the generating brain circuits which apply pleasure and desire” to food, and this pairing of creaminess and hedonics is consistently reported in the literature (Elmore, Heymann, Johnson, & Hewett, 1999). Thus, we suspect creaminess will be more congruent with aspects of heightened haptic sensitivity than crunchiness. Because of this, we propose (H1a) that, as we change the hue of food products from red to blue, the cross-modal effect of colour on perceived texture will be more pronounced for creamy texture products, as opposed (H1b) to crunchy texture products.

Along with these sensory level effects, the general argument is that a pre-purchase affect, which is triggered by distinctive features such as colour, affects perceptions of product experience (Seva, Duh, & Helander, 2007). Because of this, we propose that as a person’s cross-modal sensitivity increases, their desire for product interaction will increase. In particular, the effects of red versus blue colour in relation to haptic sensitivity play an important role in perception of pleasure (H2a), purchase intent (H2b) and quality (H2c) of food products. Thus, as colour moves from red to blue, pleasure, purchase and quality intent will decrease. Given that this study will also be manipulating product textures, the potential change in perceived texture presents an interesting possibility. The current literature would indicate that, of the two food textures to be employed in this study, creaminess, as opposed to crunchiness, is more often matched with the concept of pleasure (Antmann, Ares, Salvador, Varela, & Fiszman, 2011). As a result, we believe that the effects of colour on pleasure will be mediated via perceptions of creamy texture. Specifically, we propose that perceived texture will mediate the effect of colour on ratings of pleasure (H3a), purchase intent (H3b), and quality (H3c). We base these expectations on the cross-modal interaction of colour and texture, while engaging the person’s hedonic, experiential desires.

**Material and Methods**
Participants in the experiment were undergraduate and postgraduate students from various schools of a major university. The final sample contained data from 464 participants. 55.2% of whom were female. The mean age of the respondents was 22.1 years (SD = 3.1); ages range from 18 to 41 years. Using a 2 x 2 between subjects factorial design, we manipulated the texture (creamy versus crunchy) and the colour (red versus blue) of the snacks. To examine the effect of colour on perceived texture we measured the intensity of creaminess and the intensity of crunchiness for each snack. To examine the effect of colour on typical marketing metrics, we measured the intensity of perceived pleasure (Sweeney & Soutar, 2001), quality (Yoo, Donthu, & Lee, 2000), and the intention to purchase (Baker & Churchill Jr, 1977) of each of the snacks.
Results

H1a and H1b hypothesized that changing the dye colour from red to blue will lead to reduced sensitivity to the texture of food, and in particular the effect will be stronger in the case of creamy snacks. Full factorial repeated measures GLMM (including dye colour and food texture as factors) revealed no significant main effects of dye colour on the perceived creaminess measure ($\beta=-25.69$, $F(1,1849)=0.57$, $p=0.451$), or the perceived crunchiness measure ($\beta=-35.75$, $F(1,1849)=1.18$, $p=0.277$). Interestingly, we also found no main effects of actual texture on the perceived creaminess measure ($\beta=-53.232$, $F(1,1849)=2.44$, $p=0.119$), or the perceived crunchiness measure ($\beta=-48.66$, $F(1,1849)=2.19$, $p=0.139$). Instead, we find the hypothesized interaction effect of dye colour and food texture on the perceived creaminess measure ($\beta=110.95$, $F(1,1849)=4.94$, $p=0.026$), such that changing the dye colour from red (M=68, SD=1.34) to blue (M=62, SD=1.43) significantly reduces perceived creaminess of the creamy products, in support of H1a. We find a similar effect on the perceived crunchiness measure ($\beta=121.67$, $F(1,1849)=6.38$, $p=0.012$), where changing the dye colour from red (M=36, SD=1.29) to blue (M=31, SD=1.32) significantly reduces perceived crunchiness of the creamy products, in support of H1b. In the case of the crunchiness measure, we also observe a significant reduction in perceived crunchiness of the crunchy products as we change the dye colour from red (M=41.50, SD=1.32) to blue (M=37.71, SD=1.33). We illustrate the interaction effect in figure 1.

![Figure 1. The interaction of effect of dye colour and actual texture on perceived texture of food.](image)

To test the marketing effects in this model (H2a-c & H3a-c), we used structural equation modelling based on partial least squares method (PLS). By including the marketing metrics (perceived pleasure, quality and intention to purchase) in the following PLS analysis we aim to answer the “so what?” question. In the PLS analysis we focused on the marketing implications of colour. We tested hypotheses 2 and 3 with PLS structural equation modelling. In testing hypothesis 2, we found that colour change (from red to blue) has negative effect on pleasure (Model 1, $\beta=-0.05$, $t=2.06$) and purchase intent (Model 1, $\beta=-0.04$, $t=2.03$), supporting hypotheses 2a and 2b, respectively. The findings also show that colour has no significant effect on quality (Model 1, $\beta=-0.04$, $t=0.88$), thus hypothesis 2c is not supported. In Hypothesis 3, we hypothesized that creaminess mediates the effect of colour on pleasure, purchase intent, and quality, but crunchiness does not, respectively. Colour has significant effects on creaminess (Model 2, $\beta=0.05$, $t=2.04$), which also has significant effects on pleasure (Model 2, $\beta=0.16$, $t=7.34$) and choice (Model 2, $\beta=0.16$, $t=7.44$).
### Table 1
Test of hypothesized relationships: beta coefficients and t-values

<table>
<thead>
<tr>
<th>Exogenous variables</th>
<th>Hypothesis 2a,b,c Model 1</th>
<th>Hypothesis 3a,b,c Model 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pleasure</td>
<td>Purchase Intent</td>
</tr>
<tr>
<td>Colour</td>
<td>-0.05*</td>
<td>-0.04*</td>
</tr>
<tr>
<td></td>
<td>(2.06)</td>
<td>(2.03)</td>
</tr>
<tr>
<td>Creaminess</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crunchiness</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control (Texture)</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Sobel t-test:

Hypothesis 3a: $SE_{indirect\text{ effect}} = 0.004$; z-score = 2.14, p < 0.01
Hypothesis 3b: $SE_{indirect\text{ effect}} = 0.004$; z-score = 2.15, p < 0.01

*t-values reported in parentheses; *p<0.01.

Comparing Model 1 and Model 2, we found that the significant effects of colour on pleasure and purchase intent in Model 1 become insignificant in Model 2 (Model 2, $\beta$=-0.04, t=1.81; $\beta$=-0.03, t=1.60, respectively) after creaminess entered Model 1, in support of hypotheses 3a and 3b, respectively. The Sobel (1987) test also showed that the mediating variable (creaminess) carried the effect of the colour on pleasure and choice. As reported above, colour has no significant effect on quality (Model 1), so we could not test the mediation effect of creaminess on the relationship between colour and quality, and thus hypothesis 3c is not supported. With respect to crunchiness, colour has significant effect on crunchiness (Model 2, $\beta$=-0.07, t=2.95), which however has no significant effect on pleasure (Model 2, $\beta$=-0.04, t=1.71), purchase intent (Model 2, $\beta$=-0.03, t=1.19), and quality (Model 2, $\beta$=-0.02, t=0.62). Thus crunchiness is not a mediator of the relationship among colour, pleasure, purchase intent, and quality. The purpose of the PLS analysis was twofold: testing the direct effect of color change (from red to blue) on marketing metrics (i.e. pleasure, purchase intent, and quality); and mediation effects of creaminess and crunchiness on the direct effect of color change. In particular, changing color from red to blue negatively affects consumers’ perception of pleasure. Likewise, we also found that in our context consumers were less likely to purchase blue products. This seems natural, since red more than blue is a color associated with food products; and provides preliminary evidence to the questions raised in the Labrecque, Patrick, and Milne (2013) review in relation to unexpected food colour and colour associations (RQ11, RQ13 p.199). Interestingly, we could not find any empirical evidence to support the effect of changing colors from red to blue on product quality. This non-significant effect is contrary to prior studies that show associations of blue color with product quality. However, in the context of our food products it is not surprising. The important finding is with respect to the mediation effects of creaminess and crunchiness. The findings show that creaminess mediates the effect of color on perceived pleasure and purchase intent. Here we extend our findings in hypothesis 1, which shows the presence of a cross-modal effect (between color and creaminess), and the two marketing metrics are configured according to a fit-as-mediation model. In contrast, we found that unlike creaminess, crunchiness did not matter in the relationship among color, perceived pleasure, and purchase intent.
Discussion and Conclusion
Labrecque, Patrick, and Milne’s (2013) review of literature on the effects of colour in consumer psychology suggested the need to investigate the role of synaesthesia (cross-modal sensory interaction) in relation to altered food colours. In line with this call to research, we explored the cross-modal effect of colour hue (red or blue) on perceptions of oral somatosensory texture and considered the moderating role of consumer’s haptic sensitivity on this cross-modal effect. We also wanted to highlight the connection between the sensory effects of colour and the typical marketing metrics, such as product quality, pleasure, and intention to purchase. Our findings show that colour of lunch snacks affected the oral somatosensory perception of their texture. Importantly, the effect appears to be cross-modal. That is, a change in colour from red to blue reduced sensitivity to perceived texture. Interestingly, the effect was stronger in the case of the creamy (as opposed to crunchy) snacks. Conceptually, we postulated excitation of haptic sensitivity by colour red and the creamy texture, which enhance cross-modal transfer of the effect to oral somatosensory perception of the texture. Furthermore, as colour of the snacks changed from red to blue we observed a reduction in perceived pleasure and intention to purchase. Importantly, this effect was mediated by the perceived texture of the snacks (i.e. creaminess), which suggested the importance of the cross-modal sensory effects in the marketing context. In the PLS analysis, we found that colour and actual texture affect the perceived texture, and that perceived texture mediates the effect of colour on the key marketing metrics of pleasure and intention to purchase. In sum, the findings across the two sets of analyses contribute to the literature within consumer behaviour, psychology and marketing management on colour, texture, and cross-modal information processing.

Our study provides opportunities for future research. Since multiple sensory inputs are necessary to form the typical marketing evaluations such as product satisfaction, quality or intention to purchase, investigation of the cross-modal effects in different sensory modalities suggests new ways marketing stimuli may be related with consumer behaviour. In this study, we demonstrated the interaction between colour and actual texture on perceptions of texture. However, in many retail settings (especially where food products are involved) texture is inferred from cues other than actual texture; such as shape and size of labels or packaging, language, and/or sounds used during marketing communications. At this stage, we do not know if cross-modal interactions persist in settings where direct sensory information is not available, and must be inferred from secondary cues. A future study of when selective sensory information can be removed or included will help us better understand the nature of cross-modal interactions. Additionally, our analyses find the effect of colour and texture of the product. However, colour perception in particular is sensitive to the colour of the background context (Jameson & Hurvich, 1972). In our study, the context was primarily black and white: White laboratory desk, white plastic spoons, white sheets of paper to cover the spoons; and black computer peripherals. Most real world settings are not so clinical. In fact vibrant colour is used extensively as background in retail settings (e.g. grocery and department stores), and consumption settings (e.g. restaurants) (Bellizzi and Hite 1992). Our results have several managerial implications. We provide evidence that perception of food texture changes with the change in colour hue. In addition, the consumer’s haptic sensitivity affects the processing of such cross-modal interactions. The decision for selecting the colour of a product, therefore, should consider both the consumer’s underlying sensory integration processes, and the market segment that the product is the intended for. In particular, we demonstrated that perceived texture mediates the effects of colour on the extent to which consumers like the product, and their intentions to purchase the product. The effect of cross-modal information processing on
marketing metrics is an underexplored domain that provides a fascinating link between marketing stimuli, consumer behaviour, and marketing outcomes.

Reference List


James, W. (1884). What is an emotion? *Mind, 9*(34), 188.


