

RUNNING HEAD: THE MULTISENSORY DESIGN OF PHARMACEUTICALS

The multisensory design of pharmaceuticals and their packaging

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IN PRESS: *Food Quality & Perception*

DATE: JANUARY, 2021

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ABSTRACT

People's expectations concerning the functional properties and efficacy of pharmaceuticals are influenced by a wide variety of product-extrinsic factors, such as the colour (of both product and pack), form (e.g., tablet vs. capsule), and shape (e.g., round, oval, or diamond-shaped) of medicines, and the multisensory design of the product packaging. The sound symbolic properties of a medicine's brand name, as well as its processing fluency, have also been shown to exert a significant influence over people's expectations. However, given that non-adherence has long been a key issues with medical treatment, further research is urgently needed in order to determine the extent (albeit likely limited) to which these various product-extrinsic factors influence non-compliance, while at the same time avoiding the confusion that has been caused by the proliferation of look-alike/sound-alike drugs in the marketplace in recent years. Further research is also needed in order to help establish the cross-cultural consensuality of the meanings that are attached by consumers to these various different product-extrinsic sensory cues (especially colour) in the pharmaceutical category, and to firmly establish the robustness of any colour-based placebo effects. At the same time, however, it is currently unclear which cue (or cues) dominate(s) when multiple product attributes are manipulated simultaneously given that the influence of colour, shape, sound symbolism, etc., have typically only been studied individually to date. The multisensory design of pharmaceuticals and their packaging therefore constitutes a particularly intriguing, not to mention important, applied area for food/sensory scientists, marketing researchers, and cognitive neuroscientists.

KEYWORDS: MEDICATION; COLOUR; SHAPE; SOUND SYMBOLISM; FORM.

1. Introduction

The market for pharmaceuticals is huge. To give a sense of its size, in 2003, more than \$450 billion were spent on medicines worldwide (IMS Health, 2004, as cited in Rouillet & Droulers, 2005), equating to something like \$700 per capita in the USA. Over the counter (OTC) medication, sold in pharmacies, groceries, and even convenience stores, is another huge and intriguing category (Global Market Insight, 2019). In 2018, the global OTC drug market exceeded \$125 billion, and was forecast to grow to \$185 billion by 2025 (Global Market Insight, 2019). Given that the OTC market is somewhat less regulated than prescription medications (and/or hospital medicines), there is more scope to adapt and extend insights from the fast-moving consumer goods (FMCG), food and beverage (F&B), and home and personal care (HPC) sectors. At the same time, however, it is important to bear in mind here that pharmaceutical products should neither be too sensorially appealing, nor should they be too easily confusable with regular food and beverage or confectionary products (as will be highlighted later). While direct-to-consumer (DTC) marketing of medications has been rejected in Europe (see Cassels, 2003; Cozens, 2002), recent years have seen a significant growth of this sector in the US (Erlich, 1995), with many campaigns showing images of the medications themselves (Fritch, 2006; Matheson & Justus, 2009), as well as, of course, the brand name, thus offering further scope for multisensory marketing interventions.

There has been a lot of research on the impact of the colour of medications and somewhat less on the meaning and implications of pill shape/format (e.g., Wan, Woods, Velasco, Salgado-Montejo, & Spence, 2015). The multisensory packaging of pharmaceutical packaging also constitutes an increasingly important emerging area for sensory design research (e.g., Roulette & Droulers, 2005). While most researchers have chosen to focus on the colour and other visual appearance cues, it is worth noting that the feel and even the sound (e.g., of opening and closing the packaging, or the sound associated with using the pharmaceutical product) may also play a subtle role in helping to set a consumer's, or patient's, product-related expectations (e.g., Day, 1985; Dichter, 1971; Velasco & Spence, 2019a).

The naming of pharmaceuticals has been extensively studied from both a commercial and academic standpoint, involving research on everything from sound symbolism (e.g., Erlich, 1995; Park, Motoki, Pathak, & Spence, in press; cf. Begley, 2002) through to processing fluency (Dohle & Siegrist, 2014). Processing fluency refers to the inferred subjective ease with which new external information can be processed (e.g., Alter & Oppenheimer, 2009; Okuhara,

Ishikawa, Okada, Kato, & Kiuchi, 2017). Fluently processed stimuli tend to be associated with positive judgments (e.g., liking, confidence). For example, Song and Schwarz (2008) demonstrated that participants were more willing to incorporate exercises with easily readable instructions into their daily routines than when the instructions happened to be more difficult to read.

Branding (Branthwaite & Cooper, 1981) and pricing (Shiv, Carmon, & Ariely, 2005; Waber, Shiv, Carmon, & Ariely, 2008) also influence people's product-related expectations, and even to affect the magnitude of the placebo effect (see Ashar, Chang, & Wager, 2017, for a review of the brain mechanisms underlying the latter). However, detailed discussion of branding and pricing falls outside the scope of this review. It has often been suggested that the choice of the appropriate pharmaceutical colour can help to deliver a colour-based placebo effect though, as will see in the next section, the evidence supporting such claims is currently rather weak.

People's sensory and product-related expectations are important too (see Piqueras-Fiszman & Spence, 2015, for a review), as is any cognitive dissonance that might be elicited by pharmaceuticals and/or their multisensory packaging. Indeed, cognitive dissonance has been suggested as a major cause of non-compliance (see Buckalew, 1982). It turns out that much like the FMCG, F&B, and HPC categories, effectively managing people's product-related expectations in the pharmaceutical category, and making sure to set the right ones, is key. That is, it is crucial to ensure that the expectations are as congruent with the desired properties of the medications in question as possible (e.g., De Craen, Roos, de Vries, & Kleijnen, 1996; Shiv et al., 2005; Tao, Wang, & Wang, 2016; Tao, Wang, Wang, & Qu, 2018; see Piqueras-Fiszman & Spence, 2015, for a review of the literature on expectations). By appropriately managing people's multisensory expectations (e.g., in the pharmaceutical category), the chances of avoiding the normally negatively-valenced cognitive dissonance must surely be increased (Buckalew, 1982). In the next section, I review the evidence concerning the colour-function associations that have been documented in the pharmaceutical category in recent years, and discuss some of the key cognitive mechanisms that may underpin them.

1.1. Review outline

In this article, the literature on the multisensory design of pharmaceuticals and their packaging is reviewed, with the focus being primarily on orally-ingested pills, tablets, and capsules.

Section 2 reviews the evidence concerning the colour of pharmaceutical medicines, focusing on the expectations that many consumers have with the colour of pharmaceuticals, and the consequences that these expectations may have for the placebo effect. These associations with particular colours are discussed in terms of the emerging literature on crossmodal correspondences. In **Section 3**, the research investigating the associations that people have with particular shapes/sizes and formats (e.g., pills and capsules) of pharmaceuticals is reviewed. Thereafter, **Section 4** summarizes the multisensory influence of product packaging (looking, in particular, at the roles of visual, tactile, and auditory cues), an area that has until recently, been little studied. In **Section 5**, I review the evidence concerning the science of naming medicines, focusing on the role of sound symbolism and processing fluency. In **Section 6**, I highlight the growing problems of non-adherence and confusion of drugs that are becoming increasingly similar, before concluding and offering some important directions for future research (**Section 7**). Taken together, I hope to demonstrate just how important it is to design multisensory medicines and their packaging so that they not only engage the customer/patient on an emotional level (Blazhenkova & Dogerlioglu-Demir, 2020), but also help to support adherence, while minimizing the confusion between similar looking product offerings that is currently such a widespread problem in the market.

2. The colour of medicines

2.1. Colour-based placebo effects

There has long been a preference for coloured over white pharmaceuticals (see Brieger, Salami, & Oshiname, 2007; Grainger, 1958; though see also Chamings, 1958). In fact, colour is probably the single most widely studied sensory attribute of pharmaceuticals and their packaging (though this hasn't always been the case; see Buckalew & Ross, 1981; Hussain, 1972; Lasagna, 1955). (Note that in other product categories, it has also been suggested that packaging colour is by far the most important single sensory cue influencing consumer behaviour; Spence & Velasco, 2019). Over the last 60 years or so, evidence of the placebo effect (e.g., Bensing & Verheul, 2010; Humphrey, 2002; Moerman & Jonas, 2002; Shapiro, 1970) specifically linked to the colour of medication has sometimes been reported. Gruber (1956) conducted one of the first published studies of capsule colour in which 11 patients were administered red and white placebo pills on alternate nights for 10 successive days. The patients were all informed that the

red capsules would help them to sleep, while the white medication would keep them awake. There was, however, absolutely no difference in the patients' self-reported sleep quality as a function of the colour/supposed function of the medication that they had been given. (Given subsequent research showing that most people ascribe stimulant properties to red pills, one can only wonder whether Gruber would have obtained different results had the colour-function mapping been more intuitive.) Subsequently, Schindel (1962) asked patients about their liking for red and blue pills, and then gave them placebos of either their preferred or non-preferred colour. The results revealed the preferred colour placebos to be more effective than those of the non-preferred colour at treating menstrual pain, sleeplessness, and a variety of other disorders.

Frankenhaeuser, Järpe, Svan, and Wrangsjö (1963) gave placebos introduced as either a white "sedative" (depressant) or a "pink" stimulant drug to 16 healthy female participants on separate occasions, separated by about a week. Taking the sedative placebo led to increases in self-reported sleepiness of almost 40% amongst the participants, as well as a 30% reduction in self-reported alertness, and a significant 5-10% decrease in blood pressure and pulse-rate. Slightly smaller effects were reported in the opposite direction following the administration of the placebo stimulant. However, since the colour and function of the placebos were confounded (i.e., the stimulant was always pink, never white), it is not possible to separate the effects of mere suggestion (of pharmaceutical effectiveness) from the influence of capsule colour (white vs. pink).

A few years later, Nagao, Komiya, Kuroyanagi, Minaba, and Susa (1968) conducted a large double blind trial of an analgesic given after dental surgery. In this case, 79% of the patients experienced adequate pain relief with red tablets, as compared to just 73% with white pills. In 1970, Shapira, McClelland, Griffiths, and Newell assessed the impact of tablet colour in the treatment of anxiety states. The 48 psychiatric outpatients in this study were given the same dose of a minor tranquiliser (oxazepam). They were given pills of each colour for one week, and told that the purpose of the study was to determine which of the three pills was most effective in terms of relieving their symptoms. The participants were thus presumably alerted to the relevance of colour, since that is the most obvious thing that varied between the pills that were provided in different weeks. The experimenters assessed both weekly physicians' ratings and daily self-ratings. The symptoms of anxiety were most improved in response to the green rather than the red or yellow tablets, whereas depressive symptoms appeared to respond a little better to the yellow tablets. It is, though, important to stress here that the only response measure to show a significant effect of pill colour was the small number of phobias, as assessed by

physicians' ratings. In this case, the symptoms were most improved when the patients took the green tablets.

Cattaneo, Lucchelli, and Filippucci (1970) investigated the effect of blue vs. orange placebo capsules on the self-reported sleep quality (and pill preference) of 120 Italian inpatients awaiting minor surgery on their varicose veins over two nights. One might also wonder whether the 'first night effect' was controlled for in this study (Agnew, Jr., Webb, & Williams, 1966; Rubin, 2016), namely, the fact that our sleep tends to be disrupted in our first night sleeping in a new location. A somewhat complicated pattern of results emerged from this double blind crossover study. The male participants exhibited a borderline-significant preference for the second treatment and orange capsules, whereas the female participants preferred the first treatment with blue capsules instead. It is, though, rather challenging to draw any simple conclusions concerning the possible impact of the colour of placebo medications from these results. Meanwhile, Blackwell, Bloomfield, and Buncher (1972) gave 56 medical students either one or two pink or blue placebo pills as part of a class demonstration. When questioned an hour later, 66% of the participants given the blue capsules reported that they felt less alert as compared to only 26% given the pink capsules. Meanwhile, 72% of the students felt drowsier after taking the blue capsules as compared to only 37% of those who had been given the pink capsules. Here, though, it is important to stress that the participants had been conditioned to expect either sedative or stimulant effects prior to taking the capsules, thus meaning that the influence of colour cannot easily be established.

According to Huskisson (1974a), soluble red placebo analgesic gave rise to greater pain relief (as assessed by self-report, 2-6 hrs after administration) in 22 patients suffering from rheumatoid arthritis than a soluble blue placebo, which, in turn, provided greater pain relief than either a green or yellow placebo. Meanwhile, Lucchelli, Cattaneo, and Zattoni (1978) conducted a study with 96 hospitalized insomniac patients awaiting elective surgery involving the presentation of a blue versus orange capsule containing either placebo or hypnotic medication (heptabarbital) on two consecutive nights. A significant main effect of colour was reported with the blue capsules being more effective at treating sleep problems (as assessed by a self-report questionnaire) than the orange capsules. There was also a non-significant trend for the blue placebo to result in a greater percentage of patients reporting a good night's sleep ($M=46\%$) as compared to following the administration of the orange pill ($M=31\%$). However, the presence of a number of interactions between the various factors (namely colour, sex, drug

vs. placebo, and 1st vs. 2nd night) once again complicated any simple interpretation of the findings.

2.2 Interim summary

Taken together, the various older studies that have just been reviewed would appear to support the view that colour-based placebo effects may well exist in the pharmaceutical category. However, that said, there do not appear to be any simple generalizations about which colours deliver the largest placebo effects for a given ailment/condition. What is more, it is important to stress that the sample sizes in many of these early studies were likely much too low to support any robust conclusions regarding the efficacy of the placebo manipulations reported. What is more, as has just been highlighted, various methodological issues also compromise the interpretation of the majority of the studies that have been conducted in this area to date (de Craen et al., 1996). As such, the evidence in support of colour-based placebo effects is currently pretty weak. What is therefore currently needed to fully resolve the issue are adequately powered double-blinded empirical studies of colour-based placebo effects. However, in order to know which colours are likely to deliver the largest colour-based placebo effects, one first needs to establish the nature of the crossmodal associations that consumers have with specific colours in the pharmaceutical category, as these are likely to determine expected efficacy.

2.3. Colour-based associations with pharmaceutical function

In a study conducted in New Orleans, USA, Jacobs and Nordan (1979) had their participants (N = 100) classify the expected drug associations with different preparation colours (red, yellow, green, blue, black, and white) presented in prescription pill bottles, each containing ten gelatin capsules of the same colour. The participants classified each bottle into one of three categories: Depressant/tranquilizer, stimulant/antidepressant, or hallucinogen. The blue capsules were significantly associated with a depressant/tranquilizer effect (61% of participants), while red and yellow capsules were significantly associated with a stimulant/antidepressant effect (46% & 45%, respectively). The white capsules apparently had no particular associations, or at least not amongst the three response options that the participants had available to them. Meanwhile, Buckalew and Coffield (1982a) reported that

people expect white capsules to be analgesic, lavender pills to be hallucinogenic, and orange and yellow pills to act as stimulants. Sallis and Buckalew (1984) reported that red and black capsules were considered highly potent while white capsules were seen as weak in a group of 20 people who ranked seven capsules, including five of highly saturated hues (blue, red, green, orange, and yellow) as well as white and black capsules, for perceived strength/potency of the medication contained within. According to Sebellico (1989), light colours tend to be associated with anti-anxiety and sleep-induction drugs whereas bright colours are associated with an anti-depressant function instead.

The associations that people have with pharmaceutical colours are often suggested to result from associative learning (e.g., Köteles, Fodor, Cziboly, & Bárdos, 2009; Leslie, 1954). According to such a view, colours are associated with various types of applications as a result of people's prior use of medicinal products. According to such a logic, therefore, it makes sense to study those medications that are already in the marketplace in order to determine whether any systematic patterns (i.e., statistical regularities in terms of colour-function relationships) might emerge. Along just such lines, De Craen et al. (1996) assessed whether in The Netherlands commercial anti-depressant drugs were coloured differently from hypnotic, sedative, and anxiolytic drugs. The latter three classes of drug were more likely to be green, blue, or purple than were the antidepressants. Meanwhile, their systematic review of 12 published studies suggested that red, orange, and yellow drugs were generally associated with a stimulant function, while blue and green drugs were associated with a tranquilizing effect instead. De Craen et al. (1996, p. 1626) therefore concluded that: *"The colour of a drug seems to influence its effectiveness, but consistent trends are not apparent"*, before going on to suggest that further research was warranted. Here, of course, one might also want to add that simply establishing the associations that consumers hold with specific pharmaceutical colours does not, in-and-of-itself, imply that a colour-based placebo effect will necessarily be demonstrated.

Focus group and in-depth interview research amongst drug sellers and consumers in rural Nigeria revealed that white pills were considered more appropriate for pain relief, red for building-up the blood, blue for aiding sleep, and yellow for the treatment of malaria (Brieger et al., 2007). Intriguingly, those quizzed in this particular study suggested that yellow was an appropriate colour for an anti-malaria medication because it matched the yellow of the eyes, not to mention the yellow urine, of those suffering from the disease. Such suggestions therefore

raise the intriguing possibility that colour associations in the pharmaceutical category might sometimes be based on the colour that people happen to associate with the illness, or else with the distinctive colour of the part of the body that is targeted by the treatment.

Systematic analysis of the central nervous system therapeutics listed in the 2009 Physicians' Desk Reference by Khan Bomminayuni, Bhat, Faucett, and Brown (2010) revealed no cases in which more than 50% of the pills (of a given indication) had a colour classed as either stimulating (orange, yellow, or red) or calming (green, blue, and purple). White and grey pills were considered neutral. According to Khan et al., their expectation had been that stimulants and antidepressants would primarily come in bright colours, while those medications with calming properties (e.g., anxiolytics, sedatives (and hypnotics), anti-panic, anti-mania, and anti-psychotic agents) would be darker in colour. However as Khan et al. (2010, p. 116) noted: *"In no instances did the colors of over 50% of any medications correspond with the expected drug action."* (see **Table 1**). They continue: *"In fact, doses of several medications were a variety of colors. For example, antidepressant bupropion doses are available in yellow, red, blue, purple, pink, and white tablets. Antidepressant/anxiolytic paroxetine is available in yellow, pink, blue, and green tablets and additionally as an oral solution. Anti-psychotic/anti-mania treatment aripiprazole doses come in green, blue, pink, yellow, and white tablets. These are but a few examples of medications with multiple doses made with different, sometimes contradicting, colors"* (Khan et al., 2010, p. 116). Adding to the problem of establishing a clear colour-function relationship, many manufacturers use different colours to indicate different doses (and so hopefully reduce the likelihood of dosing errors) while, at the same time, several of the medications that Khan et al. (2010) studied were approved for multiple indications.

Table 1. Number (percentage) of stimulating, calming, and neutral pills by drug class (Khan et al., 2010, Table 1).

Drug class	Doses	Red, orange, yellow (stimulating)	Blue, purple, green (calming)	White/gray (neutral)	Not tablet or capsule
Anti-anxiety	16	6 (38)	8 (50)	1 (6)	1 (6)
Anti-depressant	48	22 (46)	10 (21)	10 (21)	6 (12)
Anti-mania	43	16 (37)	10 (23)	13 (30)	4 (9)
Anti-panic	21	8 (38)	6 (29)	6 (29)	1 (5)
Anti-psychotic	45	22 (49)	7 (16)	8 (17)	8 (17)
Sedative	12	3 (25)	4 (33)	3 (25)	2 (17)
Stimulant	41	19 (46)	11 (27)	7 (17)	4 (10)
Totals ^a	176	75 (43)	40 (23)	41 (23)	20 (11)

^a Drugs approved for multiple indications counted once in the column totals.
 Bold denotes number (percentage) of doses corresponding with expected medicinal action.

Köteles, Komsa, and Bárdos (2010) conducted a study designed to assess the expected associations between colour and function (or indication) in a group of 181 Hungarian students. Five pictures of different tablets were shown to the participants to represent each of three effect groups (*analgesic–antipyretic*, *sedative–hypnotic*, and *spasmolytic*). The participants had to imagine a situation in which they needed a medicine with the given effect and to rate the estimated probability of their choosing each tablet. White tablets were generally preferred in the analgesic–antipyretic category. Meanwhile, small, round, white and blue tablets were rated most attractive in the sedative–hypnotic group, while small, round, red and yellow tablets were preferred in the spasmolytic group.

2.4. Cross-cultural similarities/differences in the meaning of pharmaceutical colour

Colour is perhaps the one attribute above all others (e.g., such as shape or form – see **Section 3**) where more cross-cultural research has been conducted (e.g., Adams & Osgood, 1973; Aslam, 2006; Courtney, 1986; Jacobs, Worthley, & Ghymn, 1991; Lechner, Simonoff, & Harrington, 2012; Madden, Hewett, & Roth, 2000; Wheatley, 1973). And while much of this research has tended to assess the meaning of colour in the abstract (i.e., when presented out of any specific context), several studies have now explicitly looked at any culture-specific similarities/differences in the meaning of colour specifically in the pharmaceutical category. So, for example, Wan et al. (2015) conducted two online studies designed to assess the expected properties of medicines as a function of the shape and colour of the pills shown on screen. In total, more than 450 participants were recruited from the USA, China, and Colombia. They had to rank pills of seven colours (red, blue, green, white, pink, yellow, and orange) and three shapes (circular, oval, and diamond-shaped) in a simple placement task. In total, each participant completed four trials, by placing each of the 21 randomly arrayed pills that were shown at the top of the screen in the box below as a function of the question asked (see **Figure 1**). The four questions assessed the expected bitterness of the pills, their expected alerting, or stimulating, properties, their expected efficacy at treating a headache, and the expected

difficulty of swallowing the pills. Note that the participants had to make their rankings based solely on the visual appearance of the pills.

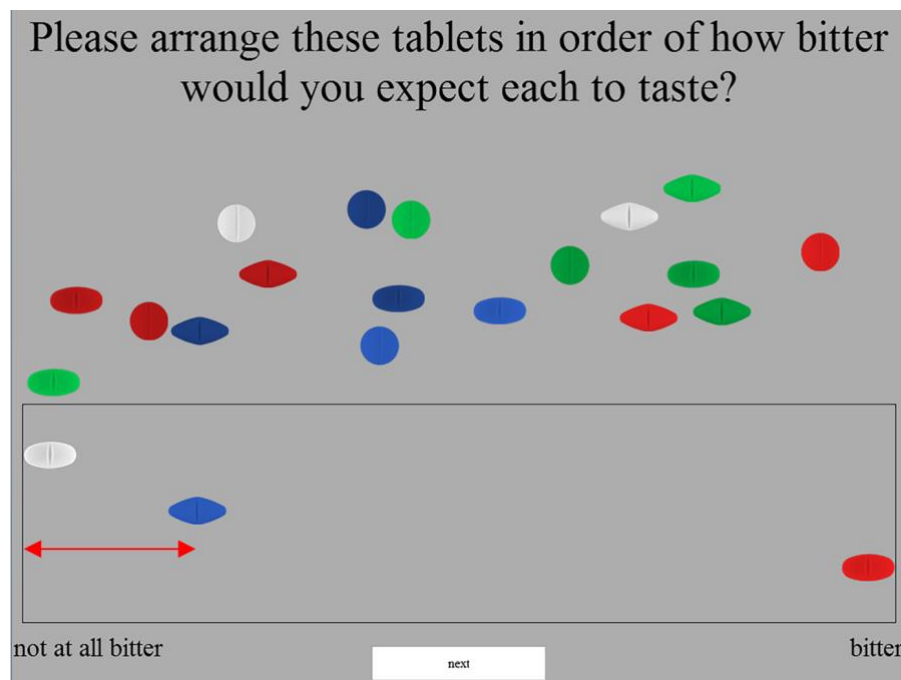


Figure 1. An illustration of the placement task used by Wan et al. (2015, Experiment 1). The red line in this figure was not shown to participants.

Amongst a number of other findings, Wan et al. (2015) observed that the colours of the pills influenced expected bitterness (that is, blue and yellow pills were expected to taste more bitter than white or red pills), expected alertness (red pills were associated with alertness, blue or white and yellow pills with its opposite), and the expected efficacy of the pills in dealing with the symptoms of a headache. The white pill, in particular, was associated with headache relief (presumably as a result of a learned association with Aspirin which is itself also white). And despite a few cross-cultural differences being documented, the pattern of results across the three countries studied by Wan et al. were all broadly in agreement, thus suggesting a reasonably high degree of cross-cultural agreement in the ‘meaning’ of (or rather, people’s associations with) pharmaceutical colour.



Figure 2. The 13 coloured capsules examined in the two studies reported by Tao et al. (2016, 2018) in which participants from mainland China were quizzed about their expectations concerning the type of effect (Tao et al., 2016, 2018) and strength of medicines (Tao et al., 2018).

The 80 Chinese participants in Tao et al.'s (2016) study had to assign pictures of 13 capsules (see **Figure 2**), including each of seven single colour capsules (white, black, red, orange, yellow, blue, and green) and six two-coloured capsules (consisting of white paired with each of the other six colours) into one of four categories, representing the typical effects of psychoactive drugs: Stimulant, analgesic, hallucinogenic, and depressant. The data were then compared to the results obtained from four other cultural groups that had been reported previously (see **Table 2**). This cross-group comparison revealed consistent red-stimulating, blue-depressant associations when these appeared as capsule colours. In terms of people's interpretation of the 'meaning' of the two-colour capsules, the white-red combination was classified as an analgesic, the white-orange as a depressant, while both the white-blue and white-black capsule combinations were associated with a hallucinogen.

Table 2. Comparison of perceived therapeutic effects of coloured drugs for five population groups. [Reprinted from Tao et al. (2016, Table IV).]

Color	Population group				
	Chinese	Italian	White American	Black American	General American
Red	Stimulant	Stimulant	NA	NA	Stimulant
Yellow	Hallucinogenic	Stimulant	Stimulant	Hallucinogenic	Stimulant
Orange	Analgesic	Stimulant	Stimulant	Stimulant	NA
Green	Depressant	Depressant	Analgesic	Depressant	
Blue	Depressant	Depressant	Depressant		Depressant
White	Depressant	Depressant	Analgesic	Stimulant	
Black	Hallucinogenic	NA	Stimulant	Analgesic	

NA, data were not available because the study did not examine the colour. The table includes only those classifications that were indicated by significant chi-square values ($\alpha < 0.05$) and that had the highest observed frequency. The data for the Chinese participants were reported by Tao et al. (2016), the Italian data comes from Sebellico (1989), the white American data from Buckalew and Coffield (1982a), the black American data from Buckalew and Coffield (1982b), and the general American data from Jacobs and Nordan (1979). It should be noted that several of these studies were conducted around four decades ago, and hence it should be born in mind that certain of the associations that people hold with pharmaceutical drug colours might have changed in the interim (cf. Tao et al., 2016)

Similar results were subsequently reported in a study by Tao et al. (2018) in which a larger sample of 224 Chinese participants was tested using the same approach, while this time also asking about the expected efficacy of the drug. In terms of the expected strength of the medication, red and black came out top, while in terms of the two-colour pills, white-red came top and white-blue bottom (cf. Woods, Marmolejo-Ramos, Velasco, & Spence, 2016; Woods & Spence, 2016, on crossmodal correspondences between the four basic tastes and colour pairs). It is, though, important to stress that the consensuality of the match (in these, as in the other studies that have been reviewed thus far) does not necessarily say anything about how strongly held such expectations might be (Spence, 2019b). That is, the consensuality of the colour mappings are presumably at least to some degree independent of the strength of the associations that people may hold with specific colours.

2.5. Pharmaceutical colours for children

Somewhat different rules regarding the use of colour apply in the case of those medications that are targeted specifically at children (see Bryson, 2014). Trying to make medications as palatable as possible is thought to be especially important in this age group, given the problems of non-compliance that have been documented (Baguley, Lim, Bevan, Pallet, & Faust, 2012).

Hence, some commentators have suggested that children's medicines should look sweet. Relevant here, then, both pink and red tend to be associated with sweetness (see Spence Wan, Woods, Velasco, Deng, Youssef, & Deroy, 2015, for a review) in the context of confectionary, drinks, and food. According to More and Srivastava (2009; Srivastava & More, 2010), the same also appears to be true in the case of medications. Unless one is careful though, there is a very real danger here that children might end-up confusing medicines with sweets. In an attempt to address this worrying possibility, researchers have studied children's preferences for different tablet colours in the hope of identifying the least appealing ones amongst children (Grainger, 1958; Jolly & Forrest, 1958).

For instance, Jolly and Forrest (1958) tested more than 600 children from the UK aged 1-8 yrs, presenting them with lactose tablets in a range of colours: blue, black, brown, orange, white, yellow, pink, green, wine, and magenta. At that time, by far the most popular colour to children was magenta, followed by pink. Meanwhile, in another UK study, Grainger (1958) gave children Smarties of different colours (red black, green, orange, pink, mauve, brown, yellow, and specially manufactured white ones). In this case, children were twice as likely to take a red as compared to a yellow sweet (these were the most and least chosen, colours, respectively). There are, in other words, competing demands around the optimization of the visual design of pharmaceuticals when thinking specifically about children. On the one hand, there is a desire to make medicines appear tasty (and so hopefully encourage compliance) while, on the other, there is also a desire to make sure that any medicines for adults look as unappealing as possible to children.

2.6. Signature pharmaceutical colours

Over the years, a few pharmaceutical products have managed to establish a distinctive signature colour for themselves, such as, for example, bright Pepto-Bismol pink (Worthington, 2007), or the distinctive blue of Pfizer's little blue pill Viagra (Worthington, 2007): "*And who can forget how AstraZeneca successfully got ahead of the patent expiration curve by migrating millions of Prilosec users to Nexium on the backs of the colour purple (Prilosec: "The Purple Pill" became Nexium: "Today's Purple Pill").*" (Worthington, 2007, p. 38; see also Fritch, 2006; Matheson & Justus, 2009). In such cases, one might consider the distinctive colour to be something of a signature sensory feature associated with a given brand. That said, though, the

pharmaceutical companies have typically struggled to protect such signature sensory features under trade dress legislation (see Greene & Kesselheim, 2011).

Indeed, most of the recent attempts to protect a specific colour by means of trade-dress have failed. It should be noted here that while patents last for 20 years, the term of protection for trade dress can be indefinite (Greene & Kesselheim, 2011). It has, in other words, proved next to impossible for the drugs companies to protect the colour and/or shape of the majority of their branded pharmaceutical products (Matheson & Justus, 2009). Currently, there would appear to be little trade-mark (or ‘trade dress’ – defined as the characteristic visual appearance of a product or its packaging that signifies to consumers the source of a product) protection, even for those pharmaceutical products that might seem to have a distinctive shape colour, or size, as AstraZeneca found out when trying to register their round yellow tablet design for the shape and colour of the company’s felodipine pills some years ago (e.g., Steele, 2002). These pills used to treat hypertension, are sold under the name Plendil. In this case, the North American courts ruled that these sensory features were simply not distinctive enough to merit trade-dress protection, nor has it proved easy for the pharmaceutical companies to demonstrate that such combinations of shape colour, and/or size have acquired a ‘secondary meaning’ either. Secondary meaning in this case refers to colour’s use as a distinguisher of brand and/or category or psychological impact.

In order to qualify as trade dress, a sensory attribute must meet three criteria: It must be non-functional, it must lead to confusion (or deception) if imitated, and it must have a secondary association with the product for the consumer. According to Greene and Kesselheim (2011, p. 83): *“Functionality is key in pharmaceutical-related trade dress, because if a company with a brand-name drug owned exclusive rights over a functional attribute of that drug, a competitor could not offer a truly equivalent generic version.”* One example of functionality being used to reject a claim for trade dress protection comes from Greene and Kesselheim (2011, p. 84), who write about how: *“...in the 1950s, the Second Circuit Court of Appeals held that the “soothing” pink color of Pepto-Bismol provided “therapeutic value” in treating upset stomachs and was therefore not protectable as trade dress”.*

2.7. Interim summary

The evidence reviewed in the last four section highlights the fact that colours are weakly associated with specific functions in the pharmaceutical category. So, for example, the results of cross-cultural comparisons would appear to suggest that there is broad agreement that red, and possibly yellow, pills are generally considered as stimulating whereas blue pills are associated with a depressing, or tranquilizing, function instead (De Craen et al., 1996; Tao et al., 2016). What is more, over and above any associations that consumers may have with specific hues, there may also be associations with the saturation or brightness of the colour too (e.g., Lechner et al., 2012; Sebellico, 1989). At the same time, however, the colour of pills may also be associated with a specific taste (e.g., pinkish-red associated with sweetness; Levitan, Zampini, Li, & Spence, 2008; Spence et al., 2015), and not just with functional properties. One might, I suppose, consider this in terms of Elliott and Maier's (2012) colour-in-context theory – namely that the meaning attached to colour depends on the context in which that colour appears.

Complicating matters somewhat, though, a growing number of capsules now present two colours (e.g., Tao et al., 2016, 2018), with the functional associations of the pharmaceutical being determined by the particular combination of colours that happen to be incorporated in the capsule. As yet, however, crossmodal correspondences research on the basic tastes that people associate with specific colours suggests that there is no simple way of predicting people's association with colour pairs, given knowledge of the associations they may have with individual colours (see Woods et al., 2016; Woods & Spence, 2016; though see also Fateminia, Ghotbabadi, & Azad, 2020).

It is often assumed that crossmodal correspondences between colour and function are based on the associative learning of the statistics of the pharmaceutical marketplace, as experienced by individuals. That is, the claim is that functions that are associated with specific colour in the pharmaceutical category are learnt as a result of people's prior exposure to medicines (Köteles & Bárdos, 2009; Köteles et al., 2009; Leslie, 1954). Though, as Gruber (1956) noted early on, one also needs to be careful to control for experimenter expectancy effects. It turns out, however, that there is actually surprisingly little evidence of colour being associated consistently with specific pharmacological functions (see De Craen et al., 1996; Khan et al., 2010). As such, one perhaps needs to look elsewhere for an explanation as to where such colour associations may originate. Perhaps, then, people's functional associations with specific colours may sometimes emerge from a consideration of prototypical exemplars (e.g., the

association of white with analgesics because of Aspirin, and, of course, the latter has a distinctive form) rather than the average colour properties of all the pharmaceutical drugs within a particular category – however, that category may be defined by the researchers concerned (note here also the fact that it is by no means clear that consumers/patients necessarily organize/segment different classes of drug action in quite the way that the researchers choose to do).

At the same time, however, people's associations with colours may, in certain cases at least, be based on more abstract connotative associations between colours and connotative meaning (e.g., as established by early research on the semantic differential technique). Indeed, some have argued that there may be universal, that is cross-culturally shared, meanings attached with colours (Adams & Osgood, 1973; see also Labrecque & Milne, 2012). Though, as Khan et al. (2010, p. 117) note: *“Whether the universality of these attributes of color arises from innate physiological responses to these colors, shared environmental associations (e.g., blue sky and green plants are good, darkness is more dangerous than light) or common cultural beliefs is as yet unclear.”*

It is, then, actually rather unclear, as to what meaning(s) people associate with the colour of pharmaceutical pills, and moreover, to what extent they consider colour to be diagnostic of the functional category (cf. Zellner, Greene, Jimenez, Calderon, Diaz, & Sheraton, 2018). As we will see later, colour is also used to distinguish one product from its competitor brands, or else to distinguish between different strengths of medication. Indeed, sometimes the choice of colour, and even the very decision to go for colour rather than a traditional white non-coated application, may be driven more by a desire to support a particular brand personality than anything else. For, as Lechner et al. (2012, p. 61) note: *“...drugs claiming to be innovative or cutting edge are likely to be produced in different colors than ones positioned as reliable or calming.”* At the same time, however, the drugs companies themselves have sometimes deliberately changed the visual appearance of their drugs in order to make it harder for counterfeiters to fake them, or else to prevent smugglers from shipping medicines from cheaper markets to more expensive ones (Isaacs, 2005; Murray-West, 2003).

Note that we will return a little later to the various meanings attached to colour once we have had the opportunity to consider the uses, and meaning, of pharmaceutical packaging colour (see **Section 4.1**). One of the other justifications for the choice of the most appropriate colour for medicines that have occasionally been mentioned/documentated in the literature is in terms

of matching the colour of the medicine to the part of the body that is affected/relevant (e.g., Brieger et al., 2007; cf. Buckalew & Ross, 1991; Roullet & Droulers, 2005). Such examples, should they be common, might then be taken to imply that the consumers' rationalization for the use of colour may not necessarily always be the same as that of the manufacturer, thus further confusing matters.

It has recently been suggested that historically, medicine was much more dependent on the senses than its contemporary counterpart (Ahnfelt, Fors, & Wendin, 2020). Certainly, in the present era, colour is rarely present in pharmaceuticals as a result of the colour of the active ingredients themselves. Rather, colour is deliberately added to pharmaceuticals for one of a number of functional/signifying reasons. However, given that, as we have just seen, the many different possible reasons as to why pharmaceuticals might have a particular colour, it is perhaps no wonder that crossmodal functional associations with colour have proved rather more elusive than in, say, the case of food or drink colour (see Spence, 2015, for a review).

3. The form, shape, and size of pharmaceuticals

It has long been noted that different product forms and/or delivery methods (e.g., tablet vs. injection; cf. Fallowfield, Atkins, Catt, Cox, Coxon, Langridge, Morris, & Price, 2006) are associated with different degrees of efficacy/desirability in the minds of patients (e.g., Hussain & Ahad, 1970; Köteles & Bárdos, 2009; Sims, 1986). For instance, Hussain (1972) conducted a study with 44 participants (outpatients) being treated for anxiety by means of capsule or tablet. The participants had two weeks on each form of medication. They were alerted by the experimenter to the fact that the trial was designed to determine which format of medication worked best in terms of relieving their symptoms. The results revealed a trend toward a better outcome when the chlordiazepoxide happened to be administered via capsules: In particular, the participants' self-ratings of their anxiety, irritability, phobias, and broken sleep all improved significantly more in those taking capsules than when presented with pills, while similar trends were also reported on physicians' ratings. These early results therefore suggest that the form in which a medication is presented can indeed affect the treatment outcome, at least in those who happen to be suffering from anxiety. Meanwhile, the participants in a study conducted by Buckalew and Coffield (1982a, b) in Alabama (USA) believed that capsules were stronger than pills. However, whether the same results would necessarily be obtained were these studies to

be repeated nowadays must remain a question for future research though, given the potentially changing associations that people may have with specific forms/shapes over time (e.g., as ‘new’ formats becomes more familiar in the marketplace).

According to the results of Wan et al.’s (2015) study, mentioned earlier, people nowadays expect that diamond-shaped pills will be harder to swallow than round or oval pills. Such results concerning ease of swallowing are presumably less likely to change over time. There was little evidence of any interaction between colour and shape in Wan et al.’s dataset, except perhaps amongst those participants from mainland China. As might have been expected given the above, Khan et al. (2010) also failed to establish any consistent patterns in the use of pills vs. tablets as a function of the drugs (i.e., stimulating vs. calming) in the marketplace (at least as represented in the Physicians’ Desk Reference, 2009).

There is an important question here concerning the size of medicinal products such as pills and tablets (see Vallet, Michelon, Orlu, Jani, Leglise, Laribe-Caget, Piccoli, Le Fur, Liu, Ruiz, & Boudy, 2020). Given that the active ingredient(s) in many medications often constitute only a small percentage of total product volume, one would imagine there to be marketing opportunities around variations in product size/volume. Indeed, several early researchers reported that the sedative/stimulant and side effects of placebos were often increased simply by doubling the dose (e.g., Blackwell et al., 1972; Buckalew & Coffield, 1982a; Gruber, 1956; though see Buckalew & Coffield, 1982b). At the same time, however, concerns about the ease of swallowing are also relevant (see also Anon., 2015). In fact, many of the attempts by the drugs manufacturers of generics to increase the size of their medicines have been rejected in the past for just this reason.

Recently, Blazhenkova and Dogerlioglu-Demir (2020) conducted three studies in which their participants imagined swallowing various different round vs. angular pills and report on the emotions and bodily sensations that they thought would follow. The results revealed that angular pills were associated with the idea of energizing effects whereas rounded pills were more associated with a calming effect instead. At the same time, however, angular pills were also more associated with the idea of bodily effects. These imagined/expected effects associated with different pill shapes also carried over to influence people’s performance on a timed cognitive task as well, thus suggesting a shape-based placebo effect.

Looking to the future, there is growing interest in the effect of geometry on drug release from 3D printed tablets (Goyanes, Martinez, Buanz, Basit, & Gaisford, 2015). Hence, there may soon be further developments in pill format that go beyond the traditional forms (think pill vs capsule). Just as for the case of colour studies in the preceding section, the associations (and hence expectations) that consumers internalize between specific pharmaceutical format (e.g., pill versus capsule) / shape (e.g., round, oval, diamond-shaped, etc.) and function are thought to reflect associative learning of the statistical regularities of the marketplace, rather than some more fundamental (i.e., possibly innate) association (see also Obrist, Comber, Subramanian, Piqueras-Fiszman, Velasco, & Spence, 2014; Velasco, Beh, Le, & Marmolejo-Ramos, 2018).

4. Packaging medicines

Packaging represents a key part of the product proposition in many categories (e.g., FMCG, F&B; HPC; see Hine, 1995; Velasco & Spence, 2019a). It is, according to certain commentators, the fifth “P” in the marketing mix (Nickels & Jolson, 1976). According to Day (1985), distinctive packaging may be especially important for generic medicines. In the case of the packaging of pharmaceuticals, however, difficult to open, and smaller pack sizes have sometimes been required by law. Indeed, changes in format (i.e., from bottle to individual blister packs; Pilchik, 2000) have led to a demonstrable reduction the incidence of people using pills to try and commit suicide by overdosing on analgesics (Chan, 2000). A similar reduction in self-poisonings was also reported in the UK after legislation was introduced in 1998 to limit pack sizes for OTC analgesics (e.g., Hawton, Simkin, Deeks, Cooper, Johnston, Waters, Arundel, Bernal, Gunson, Hudson, Suri, & Simpson, 2004).

Making the product packaging more difficult to open was also one of the solutions introduced to help prevent people from consuming medicines/cleaning products by accident (e.g., as in the case of the household cleaning product Fabuloso; Bakalar, 2006). While traditionally the main function of the packaging of medications would have been to ensure a sterile environment for the product, it has been suggested that the entry of companies such as Colgate-Palmolive and Procter & Gamble into the healthcare market in the 1970s helped to usher in a growing realization amongst many marketing professionals of the importance of the packaging to the consumer’s/patient’s total product experience (see Williams, 1981). That is, they started to realize that packaging could go beyond mere functionality to constitute a core component of

the marketing mix. This realization has gone hand-in-hand with the marketing opportunities resulting from the explosive growth of generics, not to mention OTC and DTC sales (as we will see later).

However, while the art and science of packaging design has undoubtedly come on a long way in the FMCG, HPC, and F&B categories, progress has thus far been much slower in the case of pharmaceuticals, where delivering a sterile packaging environment (together with a legible label) has long been the key attribute(s) against which product packaging was typically judged. As Kenagy and Stein (2001, p. 2040) note: *“There are dozens of drugs whose names are quite different but whose packages look alike. This creates the potential for error when people “see” what they expect to see on the label.”*

4.1. Packaging colour

Rouillet and Droulers (2005) conducted one of the few published studies to have examined the effect of variations in packaging colour on expected pharmaceutical effects. They manipulated the colour of the packaging of a commercial analgesic (see **Figure 3**) – i.e., hue/brightness: red, yellow, green, blue, orange, brown, and grey. In total, 150 participants were shown one of seven packaging exemplars on a computer monitor, which they had to assign to one of eight therapeutic classes, namely: heart/blood pressure (cardiac), digestion/liver (heartburn etc.), inflammation/fever (antipyretics), pain/migraine (analgesics), respiratory system, depression/anxiety (psychotropic/stimulant), insomnia (hypnotics/sleep pill), and skin. The French participants who took part in this study also rated how potent they thought the medication would be, while at the same time rating various other dimensions on 7-point semantic differential scales.



Figure 3. Fictitious brand analgesic packaging presented to participants in a study by Roullet and Droulers (2005).

Roullet and Droulers' (2005) results revealed that the brown and red packaging exemplars were rated as significantly more potent than either the green or yellow packaging. At the same time, however, the dark packaging (red, blue, and brown) was also rated as containing a drug that would act more rapidly, was more expensive, more susceptible to side effects, and more curative than light-hued packaging (yellow, green, orange and grey). It turned out that both the darkness of the colour and the hue category were associated with specific meanings, while a linear regression revealed a significant relation between the brightness of the packaging and perceived drug potency. Several non-significant trends were also reported, such as that between reddish hues (brown and red) and heart drugs while yellow was linked to skin medicines (cf. Buckalew & Ross, 1991).

When thinking about packaging colour, it is worth noting the interest that there has been in both the home and clinical setting, in the use of colour coding to try and help avoid medical dosing errors (e.g., Frush, Luo, Hutchinson, & Higgins, 2004; Hellier, Edworthy, Derbyshire, & Costello, 2006). For instance, in the UK, pressurised aerosols containing bronchodilator drugs are conventionally presented in blue whereas inhaled steroids are mostly found in brown-bodied inhalers (thus hopefully helping to avoid confusion between two similar looking applicators; Horn & Cochrane, 1986). Red, for example, is often used to indicate a high degree of hazard as with the red packaging and labelling that is recommended for use with neuromuscular blocking agents (Filiatrault, 2009). Meanwhile black-cap packaging has been stipulated for potassium chloride in certain countries in order to avoid solutions that are too concentrated from being administered to patients by accident. However, that said, to date, it is not altogether clear that the introduction of colour coding has necessarily helped to reduce medical errors in any but a very narrowly-restricted set of domains such as, for example, anaesthesiology and ophthalmology (e.g., see Filiatrault, 2009; Hyland, 2009; Kenagy & Stein, 2001).

Part of the problem for the widespread use of colour coding is the relatively small number of distinct hues that are available (c. 10) as compared to the very large number of medicinal distinctions that one might wish to draw by means of colour differentiation (cf. Labrecque &

Milne, 2013). This can lead to confusion, especially if healthcare professionals are required to rely on their memory for hues when making decisions about whether or not to use a particular medicine (see Hyland, 2009). Indeed, the opinion of medical professionals appears to be split between those who see the use of colour coding as a potentially dangerous shortcut to reading what is on the labels (e.g., Bothma & Oosthuysen, 2004; Wildsmith, 2002), and those who appreciate its value as a redundant cue (e.g., Baba & Ravalia, 2004). Others, meanwhile, have looked at how colour and shape can be used to differentiate drug strength, using computer-based visual search tasks (Filik, Purdy, & Gale, 2005; Hellier, Tucker, Kenny, Rowntree, & Edworthy, 2010).

Taken together, therefore, it would seem clear that various aesthetic considerations are important in terms of the visual design of OTC and DTC pharmaceuticals (e.g., Matheson & Justus, 2009; More & Srivastava, 2009; Srivastava & More, 2010). At the same time, however, business competitiveness considerations are obviously also relevant here, together with the widespread strategy of distinguishing different doses of a given drug by means of different colours (to help avoid accidental dosing errors). Of course, given the multiple roles played, or signalled, by the use of colour in the pharmaceutical category, it should not, then, perhaps come as a surprise to find that few systematic associations have been documented in the marketplace, no matter whether it be for the product itself (as we saw in **Section 2**) or its packaging (see **Section 4.1**).

There is also a potentially important distinction to be highlighted here between product and brand colour. Think only of how brands such as Tiffany use their distinctive brand colour for the packaging of their products (i.e., rather than for the products themselves; see Baxter, Ilicic, & Kulczynski, 2018). Meanwhile, Jin, Yoon, and Lee (2019) have argued that having a distinctive brand colour identity can give rise to a significant positive effect on brand association and loyalty amongst consumers. Of course, over-and-above the establishment of a brand colour that is distinctive (or recognizable), many of the most successful examples of brand colour have also involved colours that happens to have the appropriate connotative, or affective meaning too (Labrecque & Milne, 2012), or else provide colour contrast with the contents (see Spence, 2016). Though, as noted by Baxter et al. the meanings that consumers come to associate with a specific brand colour may also reflect the results of associative learning. Given the emerging literature from the world of food and drink showing that packaging colour can sometimes influence taste/flavour perception (see Spence, 2018, for a

review), one might also wonder whether any colour-based placebo effects might be elicited by the colour of the packaging as much as by the colour of the pharmaceutical product itself.

Beyond the colour of the packaging, it is worth noting that the shape properties of labels and the shape (e.g., angularity / roundness, and thickness) of the typeface on the packaging also exert a subtle influence on a consumer's expectations, and thus possibly also on their behaviour. While, to date, this has only been demonstrated in a range of other product categories/situations (e.g., de Sousa, Carvalho, & Pereira, 2020; Rolschau, Wang, & Otterbring, 2020; Venkatesan, Wang, & Spence, 2020), there would seem little reason to believe that the same would not also be true for the typeface used in the packaging of OTC and DTC products (see Velasco & Spence, 2019b). At the same time, however, there are also grounds for stipulating legibility for the typeface used in labelling (cf. Soller & Lightwood, 2007). In fact, one successful example of patient-centred packaging design comes from Target Pharmacy's ClearRx packaging in The States which has been compared favourably with conventional prescription drug packaging and labelling (Soller & Lightwood, 2007). The use of colour rings and large type face for medication name helps consumers to easily distinguish among bottles of ClearRx and so avoid medication mix-ups (see **Figure 4**). Shoppers tested in two suburban Californian shopping malls, were questioned about their preference for ClearRx bottles with conventional cylindrical prescription bottles (both were labelled as containing fluoxetine). They also were asked their opinions on three ClearRx bottles (labeled as containing albuterol, amoxicillin, or atenolol) with different color rings corresponding to three fictitious family members. The majority of consumers (85%) preferred the ClearRx packaging and labelling over the conventional format (10%; with 5% of the respondents being uncertain). They described distinct differences between the packaging and labelling formats, with ClearRx being mentioned as having the better design as far as safety, easier to read (cf. Song & Schwarz, 2008, on the importance of being easy to read to enhancing processing fluency), and having better organized warnings with larger type size. Furthermore, the ClearRx patient information card was rated by more than 90% of the respondents as being easy or very easy to access, important to retain as a reference during use, and helpful for improving medication safety.

Notice, though, how in this case, different colours have not been introduced because of any functional, or signature, association, but rather simply as a means of helping to discriminate between different bottles (e.g., for different members of the family, and so hopefully reduce

confusion). Looking to the future, it would be interesting to know whether drugs mix-ups have, in fact, been reduced as a result of the introduction of this innovative packaging solution.



Figure 4. Target Pharmacy's innovative patient-centred design solution for prescription packaging and labelling, showing the different coloured neck rings designed to help identify pill packaging for different family members. [Figure reprinted from <https://adlerdesign.com/project/clear-rx-medication-system/>.]

4.2. Tactile aspects of pharmaceutical packaging

Alli, a fat-blocking pill from GlaxoSmithKline (approved by U.S. Federal Drug Administration; FDA) came to market in a reinvented pillbox called the 'shuttle' According to Johnson (2007): *"It has a unique shape, can be opened with one hand and is made with soft rubber and careful texturing that is pleasing to the touch."* (see also Anon., 1999; Spence, 2019a, on the tactile/haptic aspects of product packaging). There is undoubtedly scope here to consider whether 'image molds' operate in the OTC space. The notion of image molds, first introduced by Meyers (1981), refers to the fact that certain arbitrary packaging shapes (or forms) come to be associated with a particular brand or category of product (see Parise & Spence, 2012; Velasco & Spence, 2019a). Here, one needs only consider how brands such as

Coca-Cola and Heinz tomato ketchup, not to mention Wish-Bone salad dressing, have managed to establish their own distinctive packaging shapes (i.e., image molds) over the years. Could the same outcome be achieved in the case of pharmaceutical packaging? Or, in this case, should one only think in terms of the shape of the pill itself? Think here, for example, only of Viagra's distinctive blue diamond-shape, as a possible example of the latter, and the packaging of Alli (just mentioned) as a potential contender in the former category. Relevant here, Parise and Spence (2012) conducted a series of studies showing that the silhouette (i.e., the shape profile) of the packaging of two popular brands of mouthwash (namely Scope and Listerine) were associated with different attributes in a modified version of the Implicit Association Test (IAT). In other product categories, the aim is ideally to develop an image mold whose shape properties are consistent with the brand attributes.

Given the oft-documented association between weight and quality (Piqueras-Fiszman & Spence, 2012a), it would be interesting to know whether consumers/patients expect those medications that happen to be dispensed from heavier packaging to be more expensive and/or efficacious than those dispensed from lighter packaging instead (Kaspar, 2013; cf. Kampfner, Leischnig, Ivens, & Spence, 2017; Piqueras-Fiszman & Spence, 2012b). The lightweight plastic and cardboard packaging that is currently in widespread use in pharmaceutical packaging, would certainly seem to suggest that there may be plenty of scope to differentiate a premium product based on the weight of its packaging. Kaspar (2013; Study 4) presented 97 participants with either a light or heavy drug package to handle – note that the heavier package was three times heavier though visually identical – in this between-participants study. The participants were instructed to estimate the drug's effectiveness and the severity of any side effects. Two drugs were evaluated, one to increase muscle mass, the other to help reduce weight. The participants estimated that non-weight related medications would be slightly, but significantly more effective, but with no more side effects (6.35 vs. 5.96, respectively, for the effectiveness ratings on 10-point scale, $p < .05$, and 2.4 vs. 2.56 for side effects, n.s.). No effect of packaging weight was observed for the weight-reduction drug though in Kaspar's Study 4, but such an effect was observed in a follow-up study (Study 5).

By analogy with what is seen in other categories, one could also imagine how brand name drugs ought to be presented in heavier packaging than their cheaper generics (see Velasco & Spence, 2019a). Thus far, though, the feel, or texture, of the packaging would seem to have been little studied in the pharmaceutical category (Spence, 2019a). That said, research with

various other products suggests that consumers tend to associate rougher packaging with a stronger product (e.g., in the case of the alcohol content of a drink – e.g., with higher alcohol vodka matching a rougher-feeling texture; see Spence & Piqueras-Fiszman, 2012). Soft touch plastics have been successful in the toothbrush category (Anon., 1999; Spence, 2019a), thus hinting at some of the possibilities in this space.

4.3. Auditory marketing of pharmaceutical products

Bayer Pharmaceuticals has long used sound to convey its claims of fast action in the case of Alka-Seltzer tablets in the long-running jingle: “*Plop, plop, fizz, fizz, oh what a relief it is.*” (Worthington, 2007). High-end cosmetics manufacturers are also starting to pay more attention to ensuring that their products (e.g., mascaras) deliver a reassuring sound of secure closure (see Byron, 2012). Given that the spraying sound of deodorant aerosols has been shown to set expectations concerning their efficacy (Spence & Zampini, 2007), one might consider whether there are any opportunities around the psychoacoustic properties of pressurised aerosol inhalers for asthma, for example (Horn & Cochrane, 1986). Who knows, perhaps these two classes of inhaler (containing bronchodilator drugs or inhaled steroids) should not only look different (blue vs. brown) but also sound different to support their multisensory differentiation? Again, potentially relevant here, Zampini, Guest, and Spence (2003) have previously demonstrated the impact of the sound of the electric motor on the behaviour of those using an electric toothbrush.

4.4. Interim summary

In recent years, there has been a growing realization of the potential of multisensory packaging to help sell the product. What is more, given the problems that many drugs companies have had in recent decades in terms of protecting the sensory properties of their medications (i.e., the colour shape or size) themselves, it has been suggested that they might have more chance of protecting their trade dress if they were to introduce distinctive (i.e., signature) packaging solutions (see Matheson & Justus, 2009, on this point) such as, for example, blister packs rather than generic pill bottles. There are various arguments as to why the additional packaging costs in the case of such bespoke solutions might actually be money well spent, at least in the case

of brand name drugs. To date, packaging colour has been the most widely studied aspect of packaging design (Kauppinen-Räsänen & Luomala, 2010; Spence & Velasco, 2019), though published studies specifically in the area of pharmaceutical packaging are still surprisingly few and far between. When contemplating multisensory packaging design for pharmaceuticals it is interesting to ask whether certain shapes attract our attention, or are certain colours more fundamentally associated with meaning, beyond what can be explained by the associative learning account (Riley et al., 1982)?

5. Sound symbolism and pharmaceutical naming

Branding plays an important part in terms of setting people's expectations regardless of the product category that one happens to be talking about (Martin, 1990), and the world of pharmaceutical drugs would appear to be no different in this regard (e.g., Branthwaite & Cooper, 1981). There are, in fact, a number of factors at play in terms of setting product expectations by means of a well-chosen brand name. These range all the way from the influence of 'processing fluency' (Dohle & Siegrist, 2014) through to sound symbolism (Erich, 1995; Park et al., in press), not to mention any specific attributes/qualities that may be attached to particular letters (e.g., Erlich, 1995; McNeil Jr., 2003; Pathak, Velasco, & Spence, 2020; Schloss, 1981; Van Doorn, Paton, & Spence, 2016).

According to Kenagy and Stein (2001, p. 2039): *"The most critical issue in drug name selection is that one name should not be easily confused with another. This applies to both generic and brand names. A name must neither sound like that of another drug (which leads to errors when oral orders are given) nor look like another drug name when it is written out by hand. From the industry's standpoint, the challenge is to find a name that is intriguing and appropriate for the connotation desired, safe, and not already trademarked."* At the same time however, as Erlich (1995) notes: *"There are only 26 letters in the alphabet. So when the Du Pont Merck Pharmaceutical Corporation needed to change the name of a drug called Trexan – needed a new name that's easy to remember, has no more than seven letters and doesn't look or sound like Prozac (or one of the estimated 500,000 pharmaceutical trademarks registered worldwide) – they hired professionals."* According to Lambert, Chang, and Lin (2001), the modal U.S. brand name actually contains eight letters.

Erlich (1995) goes on to suggest that: *“Pharmaceutical firms now pay consultants upward of \$100,000 to coin snappy trademarks -- names that may be meaningless but sound medicinal and appealing, and are memorable enough that they become synonymous with the product.”*

That figure is undoubtedly much higher today: For instance, in 2001, Kenagy and Stein were already estimating \$100,000-700,000 for a consultation with a naming company to screen possible names for trademark incompatibilities and offer alternative suggestions. According to Lambert (1997), there were 15,000 drug names in use in the United States at the time of writing. It has been estimated that a thorough global name search might require comparison with as many as 1.2 million registered names worldwide.

5.1. Sound symbolism

Sound symbolism refers to the fact that certain speech sounds have been shown to connote, or be associated with, specific object properties (see Nuckolls, 1999; Spence, 2012). It is frequently suggested that the principles of sound symbolism are widely used in the drugs industry when coming up with new brand names. For instance, according to Kenagy and Stein (2001), at least 66 drug brand names start with ‘Z’, a letter that is thought to connote efficacy (see Erlich, 1995; Klink, 2001; McNeil Jr., 2003). In support of such a claim, Abel and Glinert (2008) assessed the incidence of voiced versus voiceless consonants in 60 frequently-used cancer-related drugs on the market, and compared this to a reference database of standard English usage. It turned out that voiceless consonants (/p/, /t/, /k/, /f/, /s/) appeared significantly more frequently than expected, with this tendency being especially marked for the trade (or generic) names of hormonal and targeted therapy cancer medicines. Note that, according to the literature on sound symbolism, voiced consonants (/b/, /d/, /g/, /v/, /z/) tend to be associated with slowness and heaviness, whereas voiceless consonants are more likely to be associated with fastness and lightness instead (according to Abel & Glinert, 2008) – the latter presumably being what many patients are looking for in their cancer medicines.

Park et al. (in press) recently followed-up on this research, demonstrating that the sound symbolism of brand names potentially provides a useful framework when developing pharmaceutical brand name. Four fictitious brand names were created using a voiceless and voiced fricative (i.e., [f], [v]) and a voiceless and voiced stop (i.e., [p], [b]), while controlling for other sounds in the names. The four hypothetical names were: FANTEC, VANTEC,

PANTEC, and BANTEC. Across three online experiments involving more than 1,000 Japanese participants, those hypothetical brand names that incorporated voiced (vs. voiceless) consonants led to an increase in the expected efficacy of a medicine (for anti-allergy, painkiller, or stomach relief, depending on the experiment). Further analysis of the data revealed that the sound symbolic properties of perceived potency and activity mediated the effect of voiced sound on medicine's expected qualities.

While commercial research on sound symbolism and brand name design is undoubtedly intriguing, it is currently unclear on the basis of the academic research that has been published to date (see Lockwood & Dingemanse, 2015; Sidhu & Pexman, 2018, for reviews), which of the many associations that specific letters, or speech sounds, have will end-up dominating when a person comes to evaluate a new drug, say. For, as we have just seen, the letter 'Z' is not only associated with efficiency (Erlich, 1995), but also with slowness/heaviness (given its status as a voiced consonant; Abel & Glinert, 2008). At the same time, however, it is apparently also associated with drugs from Glaxo (while drugs from Upjohn are associated with the letter X instead, at least according to Kenagy & Stein, 2001, p. 2036; see also McNeil Jr., 2003). At the same time, it should also be noted that certain speech sounds might also affect the expected taste, such as the bitterness, of a pharmaceutical product (Pathak & Calvert, 2020). Though it is doubtful that sound symbolic approaches would necessarily replace more direct taste masking strategies (Faisal, Farag, Abdellatif, & Abbas, 2018).

5.2. Processing fluency of medicine names

Separate from any effects of sound symbolism, Dohle and Siegrist (2014) investigated the impact of the processing fluency associated with hypothetical brand names on expected hazardousness, assumed side effects, and willingness to buy pharmaceutical drugs. Dohle and Siegrist conducted three studies showing that those drugs given a more complex name were perceived to be more hazardous than those having a 'simple' name (Song & Schwarz, 2009). Giving a hypothetical drug a more complex name also exerted a negative influence over people's willingness to pay/buy for the drug. The three studies were all at least partially within-participant designs, with the participants asked to evaluate drugs (given nothing more than their names) on a number of 7-point scales, including hazardousness, effectiveness, how willing they would be to buy the drug concerned, and whether they believed that the drug would have

(m)any side effects or not). According to the authors, in their first experiment: “*participants judged 10 fictitious drugs that had either a simple (Fastinorbine, Calotropisin, Tonalibamium, Zionialosium and Allotoneline) or a complex name (Cytrigmcmium, Nxungzictrop, Ribozoxtlitp, Hnegripitrom and Fluthractnip).*” (Dohle & Siegrist, 2014, p. 1243). Dohle and Siegrist’s so-called ‘simple’ drug names are still very complex (e.g., just compare with actual successful drug names such as Xanax or Prozac), though the ‘complex’ names are undoubtedly harder to pronounce (cf. Pinkstone, 2021). In fact, it is questionable whether a number of them even are pronounceable at all, this being one of the practical constraints on the actual naming of drugs (see Lambert et al., 2005, on this point). Two subsequent studies obtained similar results using different subsets of these fictitious pharmaceutical names.

Some of the consultancy companies helping the drugs companies to come up with globally meaningful brand names for new drugs would appear to combine elements of sound symbolism with a sensitivity to processing fluency, favouring, for example, palindromes, such as, for example, the 1970s tranquilizer, Xanax. Note here that symmetry has been shown to enhance processing fluency (Reber, Schwarz, & Winkielman, 2004). According to David Placek, the President of branding firm Lexicon Naming who “*...has developed a research program called Sounder, which tries to predict how various sounds will affect the consumer.*” (Erllich, 1995). Writing in *The New York Times*, Erllich continues: “*"Our study validates that Z is faster [to say] than P," Placek says. "So if we want a name that connotes the idea of speed, we'd say 'zorek' is faster than 'porek.' There are faster letters, bolder letters, more dependable letters. We know from our Sounder program that the letter P, that nice, full, hard consonant, communicates dependability, compactness, and is consistent with something fast. B suggests durability and reliability." DARAD A completely coined name, with no meaning or signals at all. But Darad is a palindrome, so it looks good -- or at least symmetrical. "The look of a name is as important as anything else," "*” The science of naming is, in other words, big business. And perhaps nowhere is that more true than in the world of branding new pharmaceutical drugs.

5.3. Semantic naming of pharmaceuticals

One of the other ways in which brand names can work to support the product that they are associated with is by semantically priming the relevant notion. Perhaps the most famous example of recent years is Viagra which “*evokes images of vigour as well as the Niagara*

Falls—useful for a drug indicated for male impotence.” (Berman, 2004, p. 11). This drug, note, launched in 1998, was one of the first to be heavily promoted in North America following the expansion of DTC advertising in 1997 (see Greene & Kesselheim, 2011).

When thinking about the name of medicines, one could also consider what the Haagen Dazs of pharmaceutical branding might be (LeClerc, Schmitt, & Dubé, 1994). Haagen Dazs, note, is an American ice cream that is made by Pillsbury, headquartered out of Minneapolis. After all, the use of foreign branding has been shown to be an effective means of biasing the consumers’ impression/product expectations (regarding hedonic and utilitarian association) in various product categories (e.g., yoghurt). Hence, it would be interesting to know whether consumers have any particular semantic associations between specific countries and pharmaceutical excellence/effectiveness? In the case of cosmetics, fine fragrance, and other beauty products, a French name would seem to carry a certain cachet. The relevant question here is therefore whether any country is currently widely associated with pharmaceutical excellence.

5.4. Interim summary

Choosing the most suitable name for a new pharmaceutical product is big business. Just like the choice of the product’s colour, its name can be used to bias the expectations that will be evoked in the mind of the consumer/patient. Sound symbolism and processing fluency are both highly relevant concepts here. However, while specific speech sounds may well be associated with a range of different attributes (both positive and negative), it is unclear which attributes will be top of mind for the patient/consumer (cf. Kaspar, 2013). It should be noted that the appropriateness of different brand names for drugs has likely also changed over the decades. Just take the following comment from one executive working in the naming/branding industry: *“Both Zantac and Xanax are “second generation” drug names, designed to compete with their 70’s predecessors, Tagamet and Valium, which people in the business refer to as traditional pharmaceutical names: three-syllables, and a consonant/vowel/consonant structure. Now two-syllable names heavy on the X’s and Z’s -- Zolof, Lasix, Lozol -- have become passe. “They’re 80’s names””* (Erlich, 1995).

6. Multisensory design to minimize the problems of non-adherence and confusability

One of the key issues with pharmaceutical medicines is the problem of non-adherence, sometimes referred to as non-compliance (e.g., see Buckalew & Sallis, 1986, for a review). According to Osterberg and Blaschke (2005, p. 487): *“The word “adherence” is preferred by many health care providers, because “compliance” suggests that the patient is passively following the doctor’s orders and that the treatment plan is not based on a therapeutic alliance or contract established between the patient and the physician.”* That is, patients failing to complete their treatment, resulting in reduced efficacy of treatment etc. To give some sense of the scale of the problem, it has been estimated that 25% of patients do not adhere to the recommendations (e.g., DiMatteo, 2004; Lau, 2008). Meanwhile, according to Cutler and Everett (2010), as many as half of all patients fail to adhere fully to their prescription medication regimes. Osterberg and Blaschke (2005, p. 488) write that: *“Of all medication-related hospital admissions in the United States, 33 to 69 percent are due to poor medication adherence, with a resultant cost of approximately \$100 billion a year.”* One of the key challenges for the multisensory design of pharmaceutical products and their packaging has, therefore, to be to try to promote adherence, in part by minimizing cognitive dissonance (Buckalew, 1982; Buckalew & Sallis, 1986) and maximizing processing fluency (e.g., Song & Schwarz, 2008).

At the same time, however, there are also increasing problems in terms of errors prescribing, dispensing, and taking medications (e.g., Kohn, Corrigan, & Donaldson, 2000; Rettner, 2017; see also Brown, 2001; Glod, 2000; Lau, 2008; Leape, Brennan, Laird, Lawthers, Localio, Barnes, et al., 1991). As Greene (2011) notes, there is a great possibility for confusion, given that by 1962 there were already almost 5,000 forms of oral medication in the US. In fact, it has been estimated that up to 6.5% of patients admitted to hospitals suffer a serious error with their medication (i.e., one that has the potential to cause injury; Bates, Culler, Laird, Petersen, Small, Servi, et al., 1995). The estimated annual US health care cost of drug-related morbidity and mortality in the case of ambulatory care was estimated at approximately \$177 billion by Ernst and Grizzle (2001). This more than doubles the cost of what have euphemistically been referred to as drug-related problems (DRPs) since the estimates made by Johnson and Bootman (1995) for the early 1990s. According to Medical Errors (2008), more than 7000 drug-related deaths occur each year, and 1.3 million people are injured, due to preventable medication errors in the US alone. It has been suggested that the increasingly complex, and yet often very similar, pharmaceuticals that are available nowadays is partly to blame for this confusion.

6.1. Drug confusability and the rise of generic medicines

The growing complexity of the contemporary pharmacopoeia (see Greene, 2011, on this point) has resulted, at least in part, from the explosion of generic drugs available on the market (including authorized generics; Appleby, 2015; Engelberg, 2011; Tuleu, Hughes, Clapham, Vallet, & Ruiz, 2020). Indeed, generics now make up in excess of 70% of prescriptions that are dispensed (Greene, 2011; Kesselheim, Misono, Shrank, Greene, Doherty, Avorn, & Choudhry, 2013). Given that the majority of older people tend to be on multiple medicines at the same time, they may be especially vulnerable to confusion due to generalized cognitive decline. If one assumes a conservative estimate of five medicines a day made by each of five generic manufacturers with the generic supplier changing each month, then at least according to Greene (2011), an elderly patient can expect to be subjected to as many as 3000 different combinations when filling their pill box in any given week with what are, chemically-speaking the same medicines. No wonder that people get confused, especially those who may be suffering from cognitive/visual decline, and those who are less medically literate (Stegemann, 2005). Perhaps unsurprisingly, there has been growing interest in developing sensory strategies designed to enhance adherence amongst older individuals (e.g., see Shariff, Dahmash, Kirby, Missaghi, Rajabi-Siahboomi, & Maidment, 2020).

As Greene (2011, p. 120) puts it: *“Why, then, don’t generic manufacturers market drugs to also look the same as the proprietary drugs? Why, instead, do we retain a system in which pills with similar contents can look so different, and pills with different contents can look so similar?”* According to Greene and Kesselheim (2011, p. 83): *“This variation in the appearance of generic drugs has its roots in U.S. intellectual-property law. In the past, drug manufacturers successfully claimed exclusive ownership of the physical aspects of their products — including the size, shape, color, texture, aroma, and flavor — as private property under a subset of trademark law called “trade dress.” (Newman, 1994; Stinson, 1982). Such a practice constrained the ability of generic-drug manufacturers to design follow-on products that reproduced the physical appearance of the innovator brands.”* However, as we saw earlier (see **Section 2.6**), trade dress protection in the pharmaceutical category has increasingly been eroded in recent decades with the repeal in many US states the of anti-substitution legislation that once prohibited pharmacists from dispensing any manufacturer's drug product other than the one specifically named on the prescription (see Stinson, 1982). There has also been an

increasing push towards the use of generics to help reduce healthcare costs (Engelberg, 2011). All this has conspired to help create confusion amongst consumers/patients as well as amongst those healthcare professionals whose job it is to prescribe the right medicine.

According to Berman (2004), as many as a third of all medication errors are attributable to confusion in terms of packaging and/or labelling confusion between similar looking/sounding medicines (that are also packaged similarly). Here, though, it is worth noting that a surprisingly large number of people are also poisoned annually because of having confused HPC products with foods that sometimes share much of the same products imagery (e.g., with pictures of fruit – so-called food imitating products FIPs; Basso, Robert-Demontrond, Hayek, Anton, Nazaian, Roth, et al., 2014). In one well-publicized case, a large number of North American consumers were turning up at A&E a few years ago after accidentally drinking some of the Colgate-Palmolive household cleaning product *Fabuloso*. At the time, the latter looked and smelled much like a soft drink (Bakalar, 2006; Miller, Levsky, Masneri, & Borys, 2006).

6.2. *The growing problem of look-/sound-alike brand names*

Problems associated with confusable drug brand names are also both a common and potentially serious occurrence. Indeed, the confusability of similar-looking and/or similar-sounding medications is a significant problem that has frequently been commented upon in the literature (e.g., Frush et al., 2004; Kenagy & Stein, 2001; McCoy, 2005). For instance, according to McCoy (2005, p. 41): “*In 31,932 reports submitted to U.S. Pharmacopeia’s MEDMARX® from January 2000 to March 2004, the causes of error listed were related to look-alike or sound-alike drug product names, packaging, and labeling.*” (see U.S. Pharmacopeia, 2004). In fact, according to Berman (2004), as many as a quarter of all medication errors are specifically attributable to confusion in terms of naming. Berman goes on to note that several thousand pairs of medications that have been reported as having been confused, this despite the fact that the FDA apparently rejects a third of all names submitted, in part to avoid confusion of sound-alike/look-alike names (e.g., Losix/Lasix, Erlich, 1995; vincristine/vinblastine, Kenagy & Stein, 2001; This pair of examples were eventually distinguished by capitalizing the differing letters –vinCRISTine and vinBLAstine (Kenagy & Stein, 2001); Keppra® and Kaletra®, Indocid® and Endocet®, from Lambert, Lin, & Tan, 2005; FEMHRT and FEMARA, and DIPRIVAN and DITROPAN, as mentioned by Berman, 2004) that might lead to prescription

errors, especially when written by hand (e.g., as in the case of Norvasc and Navane; see Kenagy & Stein, 2001). Hence, there is a very real problem associated with the naming of drugs (Lambert et al., 2005), as well as a great opportunity for sound symbolic and fluent brand naming (discussed earlier). According to Berman (2004, p. 17): *“The recent proliferation of manufacturers, medications, formulations, and doses appears to be a major part of the problem.”*

Part of the problem here also relates to the fact that the same drugs are often marketed under a bewildering variety of different brand names. For instance, just take verapamil, a prescription drug for high blood pressure as well as assorted heart conditions that was being marketed in Germany in 2001 under a wide range of different brand names including *“AZUPAMIL, DURASPOTIN, FALICARD, ISOPTIN, JENAPAMIL, VERA, VERABETA, VERAGAMMA, VERAHEXAL, VERALICK, VERAMEX, VERANORM SS, verapamil, VERASAL, and VEROPTINSTADA.”* Berman (2004, p. 13). The concept of ‘semantic neighbourhood density’ (Fieder, Wartenburger, & Abdel Rahman, 2019) might provide one means of more objectively assessing, the issue of confusability, and thus potentially helping to identify brand names that have a high chance of being confused.

6.3. Interim summary

While the multisensory design of pharmaceuticals and their packaging may help, in some small way, to address the major problem of non-compliance, there is also a very real, and seemingly growing, problem of people confusing medicines, thus leading to a worrying rise in DRPs. Hence, when evaluating the success of any multisensory design intervention in the case of pharmaceutical products and their packaging one important element is that they help to minimize the risk of confusion.

7. Conclusions

The multisensory design of pharmaceutical products and their packaging is a hugely important topic (both in terms of its market size, and also because of the cost/consequences incurred when things go wrong, as when look-/sound-alike drugs are inadvertently confused). While some

aspects of pharmaceutical design are clearly well-developed, there is a sense in which progress in this sector has flagged behind that of others, such as FMCG, HPC, F&B (e.g., Khan et al., 2010; Velasco & Spence, 2019a). While there are undoubtedly a number of unique challenges to working in the area of pharmaceuticals, there are also many opportunities from a multisensory approach to the design of OTC and DTC pharmaceutical products and their packaging (see Matheson & Justus, 2009; Worthington, 2007). And, although not the specific focus of this review, it may be worth noting that many of the same multisensory design principles are likely to have an important role to play in the hospital setting too (see Williams, 1981, for a review). Intriguingly, while colour is perhaps the single most studied sensory cue in pharmaceutical marketing research, it does not appear as though the pharmaceutical companies themselves are necessarily making the most of what colour has to offer (see Labrecque, Patrick, & Milne, 2013; Spence & Velasco, 2019). Indeed, as Khan et al. (2010, p. 113) put it a decade ago: *“Our study did not confirm the hypothesis that pharmaceutical companies color and formulate the shape of drugs to enhance the treatment response.”*

A growing body of research now demonstrates the effect that various product extrinsic cues, such as the colour and shape/format of the product, and the sound symbolism (Abel & Glinert, 2008; Erlich, 1995; Park et al., in press) and processing fluency (Dohle & Siegrist, 2014) of the brand name, etc., can have on people’s product expectations regarding the efficacy and properties/effects of pharmaceuticals (prescription medicines, OTC, and, in some markets, DTC sales; see also Shiv et al., 2005). That being said, further research is undoubtedly still required in order to assess whether such expectations necessarily also influence health outcomes. For instance, it has yet to be determined whether any cognitive expectations that may be elicited by sound symbolic brand naming are powerful enough to influence treatment outcomes (be they subjectively or objectively assessed), or to elicit any of the other changes in behaviour that have been documented recently as a result of taking certain pharmaceuticals (cf. Keaveney, Peters, & Way, in press). That is, we do not yet know whether the effects of sound symbolism are capable of influencing the placebo effect (cf. Ashar et al., 2017, for a review of the brain mechanisms underlying the placebo effect). Clearly though, researching the health and well-being consequences of multisensory design features is much more time-consuming and (ethically) challenging to pursue than merely simply assessing, for example, the functional associations that consumers have with pharmaceutical colours and/or shapes/formats. This, along with the fact that pharmaceutical companies have struggled to protect the signature

sensory design features (such as the colours) of their products may also mean that they see less benefit in funding the requisite research necessary to properly resolve this issue.

7.1. Future research

Further research on putative cross-cultural similarities/differences in the meaning (or associations) of various cues in the pharmaceutical category will also be helpful (see also Brieger et al., 2007; Buckalew & Coffield, 1982b; Lechner et al., 2011; Shapira et al., 1970; Tao et al., 2016; Wan et al., 2015). Note also that early observations of racial differences in the expected action of different pill colours established in a couple of small studies conducted by Buckalew and Coffield (1982a, b), raise the uncomfortable possibility that the semiotics of pill colouring may be implicitly ‘racist’. Gender differences have sometimes also been reported (e.g., Cattaneo et al., 1970; Lucchelli et al., 1978; Tao et al., 2016, 2018; see also Ruiz et al., 2019) raising the possibility that colour schemes may align better with the expectations of one sex rather than the other (see Spence, 2019c, on the colour codes for food, drink, and nutritional supplements for men and women). However, as well as any cross-cultural differences in meaning, one also needs to be aware that the customers’ positive response to product innovation (e.g., as seen with the introduction of capsules; Hussain, 1972) may dissipate once that particular ‘novel’ packaging format delivery mechanism becomes familiar in the marketplace. It is also possible to imagine that the meaning of other semiotic cues might also change as the years go by (Erlich, 1995; Tao et al., 2018), though this has been little studied to date (though see Spence et al., 2015).

As this review of the literature has hopefully made clear, there is plenty of scope to enhance the design of those products lying at the border between HPC and OTC medication (Edwards, 1977). Here, one might think of sexual health, mouthwash, and ‘cosmaceuticals’ (as the cross between pharmaceuticals and cosmetics has been called, Worthington, 2007) as but a few of the examples where there are likely to be fruitful avenues to pursue in the field of multisensory design (see also Buchan, 2018). As Worthington (2007, p. 37) noted some years ago: *“Pharmaceutical marketers would be well served to study and emulate some of the formulation directions and marketing communications used by cosmetics and personal care manufacturers.”* continuing that: *“In the end, the challenge for developers and marketers of some drug products is overcoming a negative sensory attribute to improve patient*

acceptability. This represents the minority of all drug products, however. The larger opportunity is to discover the sensory attributes that can be leveraged for the many drug products differentiated solely by price (generics) or that offer little in the way of an emotional connection to the patient.” One other question that has yet to be fully answered is the extent to which those manipulations that have been shown to be effective in the case of foods and their packaging are also effective in the case of orally ingested medications (cf. Grainger, 1958; Rozin, Spranca, Krieger, Neuhaus, Surillo, Swerdlin, & Wood, 2004).

Another critical issue that is currently under-researched concerns the nature of the relationship between a prescription medication’s sensory/product-extrinsic properties and the serious issue of (non-) adherence/compliance (e.g., see Buckalew & Sallis, 1986, for a review; Hussain, 1972; Kesselheim et al., 2013; Worthington, 2007). As Buckalew and Sallis (1986, p. 51) note: *“...differences between patient subjective expectations and prescribed or pharmacological intent of a drug preparation may produce cognitive dissonance that can lead to illogical behavior such as noncompliance. For instance, if a patient subjectively perceives/expects a medication to produce Effect A, though it is pharmacologically active and prescribed to yield Effect B, acceptance and responsivity (compliance) may be jeopardized seriously.*” This is the cognitive dissonance that was mentioned earlier, see Buckalew, 1982). As Bakalar (2012) notes, the switching from branded to generic medications also sharply reduces adherence, all the more reason then to try and avoid the confusing range of colours that many patients are currently faced with (given the explosion of generic formulations on the market, and the historical status of trade dress law; Stinson, 1982). Relevant here, Buckalew and Sallis (1986, p. 49) once presciently talked of trying to enhance compliance through ‘perceptual engineering’. That said, it is currently unclear to what extent the same factors that have been shown to influence an individual’s product-related expectations will necessarily also affect the likelihood of their adherence/compliance. This is an especially important issue to address given that according to the World Health Organization (2003), as few as 50% of all drug regimens for the treatment of chronic diseases are adhered to optimally.

One of the special features of the pharmaceutical category is the potential dangers that may be associated with confusing pharmaceutical products (as reviewed in **Section 6**). As we saw earlier, surprisingly frequent confusion has been documented as a result of the use of similar colours, shapes/forms, or the similar look and/or sound of the brand name. Given the frequency with which medical dosing errors are reported in the literature, some have argued for the need

to standardize the appearance of bioequivalent medications, so as to try and avoid such confusions (Engelberg, 2011). Others, meanwhile, have looked at using colour and shape to differentiate drug strength by lay people on OTC medicines (Hellier et al., 2010; see also Braun & Silver, 1995; Buckalew & Ross, 1981). As we saw earlier, a similar approach has been successfully introduced by Target Pharmacy's TargetRx packaging (Soller & Lightwood, 2007). It has also been suggested that the literature on warning signal design might be relevant here too (Braun & Silver, 1995; Edworthy & Adams, 1996; Hellier et al., 2006; Riley, Cochran, & Ballard, 1982; Schneider, 1977; Wogalter, DeJoy, & Laughery, 1999). That said, using colour coding to enhance the design of drug labels has often not delivered the desired improvements in health outcomes that were hoped for (Shrank, Patrick, Gleason, Canning, Walters, Heaton, Jan, et al., 2009).

Finally here, it is important to note that the majority of studies of multisensory design in the pharmaceutical category that have been published to date have tended to focus in on just a single attribute (be it product or packaging colour, product form or shape, and/or the brand name). As such, there is a very real danger that a particular attribute may be overemphasized if that is the only feature that is manipulated (especially in a within-participants design), where the feature that varies from one trial to the next may attract more attention than would normally be the case (cf. LeClerc et al., 1994). Given that any commercial pharmaceutical product will normally incorporate a host of sensory features, it would certainly be interesting to know more about whether packaging colour dominates over product colour, say, or whether form (or shape) is more important than the processing fluency of the brand name in the mind of the consumer (Gmuer, Siegrist, & Dohle, 2015; Kaspar, 2013; Klink, 2003; Köteles, Fodor, Cziboly, & Bárdos, 2009). Answering such questions will, though, undoubtedly require a lot more research in the years ahead.

Further research is needed to help establish the cross-cultural consensuality of the meanings that are attached by consumers to these various different product-extrinsic sensory cues in the pharmaceutical category. At the same time, however, the question of which cue (or cues) dominate(s) when multiple product attributes are manipulated simultaneously is currently unclear, given that the various cues (i.e., colour, shape, sound symbolism, etc.) have typically only been studied individually to date. The multisensory design of medicine and its packaging therefore constitutes a particularly intriguing, not to mention important, applied research area for food/sensory scientists, marketing researchers, and cognitive neuroscientists.

Declarations

- *Ethics approval and consent to participate*: Not applicable.
- *Consent for publication*: The author confirms that he has consent to publish this work.
- *Availability of data and material*: Not applicable.
- *Competing interests*: There are no competing interests to declare.
- *Funding*: No funding was received for the completion of this work.
- *Authors' contributions*: The author wrote all parts of this manuscript.
- *Acknowledgements*: None.

REFERENCES

- Abel, G. A., & Glinert, L. H. (2008). Chemotherapy as language: Sound symbolism in cancer medication names. *Social Science & Medicine*, **66**, 1863-1869.
- Adams, F. M., & Osgood, C. E. (1973). A cross-cultural study of the affective meanings of color. *Journal of Cross-Cultural Psychology*, **4**, 135-156.
- Agnew, H. W., Jr., Webb, W. B., & Williams, R. L. (1966). The first night effect: An EEG study of sleep. *Psychophysiology*, **2**, 263-266.
- Ahnfelt, N.-O., Fors, H., & Wendin, K. (2020). Historical continuity or different sensory worlds? What we can learn about the sensory characteristics of early modern pharmaceuticals by taking them to a trained sensory panel. *Berichte zur Wissenschaftsgeschichte*, **43**, 412-429. DOI: 10.1002/bewi.202000009.
- Alter, A. M., & Oppenheimer, D. M. (2009). Uniting the tribes of fluency to form a metacognitive nation. *Personality & Social Psychology Review*, **13**, 219-235.
- Anon. (1999). Touch looms large as a sense that drives sales. *BrandPackaging*, **3(3)**, 39-41.
- Anon. (2015). *Size, shape, and other physical attributes of generic tablets and capsules: Guidance for Industry*. U.S. Department of Health and Human Services Food and Drug Administration Center for Drug Evaluation and Research (CDER). June.
- Appleby, J. (2015). The rise and rise of generic prescribing. *BMJ*, **20(351)**:h5507.
- Ashar, Y. K., Chang, L. J., & Wager, T. D. (2017). Brain mechanisms of the placebo effect: An affective appraisal account. *Annual Review of Clinical Psychology*, **13(1)**, 73-98.
- Aslam, M. M. (2006). Are you selling the right colour? A cross-cultural review of colour as a marketing cue. *Journal of Marketing Communications*, **12**, 15-30.
- Baguley, D., Lim, E. J., Bevan, A., Pallet, A., & Faust, S. N. (2012). Prescribing for children – taste and palatability affect adherence to antibiotics: A review. *Archives of Disease in Childhood*, **97**, 293-297.
- Baba, R., & Ravalia, A. (2004). International color coding of syringe labels: A survey. *Anaesthesia*, **59**, 1033.
- Bakalar, N. (2006). With a product for sudsing, some accidental sipping. *The New York Times*, **October 17th**. <https://www.nytimes.com/2006/10/17/health/17bak.html>.

- Bakalar, N. (2012). The confusion of pill coloring. *The New York Times*, **December 31st**. <http://well.blogs.nytimes.com/2012/12/31/the-confusion-of-pill-coloring/>.
- Basso, F., Robert-Demontrond, P., Hayek, M., Anton, J., Nazaian, B., Roth, M., et al. (2014). Why people drink shampoo? Food imitating products are fooling brains and endangering consumers for marketing purposes. *PLoS ONE*, **9:9**, e100368.
- Bates, D. W., Cullen, D., Laird, N., Petersen, L. A., Small, S. D., Servi, D., et al. (1995). Incidence of adverse drug events and potential adverse drug events: Implications for prevention. *JAMA*, **274**, 29-34.
- Baxter, S. M., Ilicic, J., & Kulczynski, A. (2018). Roses are red, violets are blue, sophisticated brands have a Tiffany hue: The effect of iconic brand color priming on brand personality judgments. *Journal of Brand Management*, **25(4)**, 384-394.
- Begley, S. (2002). StrawBerry is no BlackBerry: Building brands using sound. *Wall Street Journal*, **August 26th**, B1.
- Bensing, J. M., & Verheul, W. (2010). The silent healer. The role of communication in placebo effects. *Patient Education and Counseling*, **80(3)**, 293-299.
- Berman, A. (2004). Reducing medication errors through naming, labeling and packaging. *Journal of Medical Systems*, **28**, 9-29.
- Blackwell, B., Bloomfield, S. S., & Buncher, C. R. (1972). Demonstration to medical students of placebo responses and non-drug factors. *Lancet*, **1**, 1279-1282.
- Blazhenkova, O., & Dogerlioglu-Demir, K. (2020). The shape of the pill: Perceived effects, evoked bodily sensations and emotions. *PLoS ONE*, **15(9)**:e0238378. <https://doi.org/10.1371/journal.pone.0238378>
- Bothma, P., & Oosthuysen, S. (2004). Read the label—blue may have become red. *South African Journal of Medicine*, **94**, 142.
- Branthwaite, A., & Cooper, P. (1981). Analgesic effects of branding in treatment of headaches. *British Medical Journal*, **282**, 1576-1578.
- Braun, C. C., & Silver, N. C. (1995). Interaction of signal words and color on warning labels: Differences in perceived hazard and behavioural compliance. *Ergonomics*, **38**, 2207-2220.
- Brieger, W. R., Salami, K. K., & Oshiname, F. O. (2007). Perceptions of drug color among drug sellers and consumers in rural southwestern Nigeria. *Research in Social and Administrative Pharmacy*, **3(3)**, 303-319.
- Brown, C. (2001). A new prescription for medical errors. *The Washington Post*, **March 18th**. <https://www.washingtonpost.com/archive/politics/2001/03/18/a-new-prescription-for-medical-errors/0c2cbc86-5947-438f-9c9f-5c960e98a49d/>.
- Bryson, S. P. (2014). Patient-centred, administration friendly medicines for children - an evaluation of children's preferences and how they impact medication adherence. *International Journal of Pharmacology*, **469**, 257-259.
- Buchan, M. J. (2018). Book review: The genius within: Smart pills, brain hacks and adventures in intelligence. *Frontiers in Psychology*, **9**:1930. doi: 10.3389/fpsyg.2018.01930.
- Buckalew, L. W. (1982). A cognitive dissonance perspective on the patient compliance problem. *Psychology Bulletin*, **3**, 28-33.

Buckalew, L. W., & Coffield, K. E. (1982a). An investigation of drug expectancy as function of capsule color and size and preparation form. *Journal of Clinical Psychopharmacology*, **2**(4), 245-248.

Buckalew, L. W., & Coffield, K. E. (1982b). Drugs expectations associated with perceptual characteristics: Ethnic factors. *Perceptual and Motor Skills*, **55**, 915-918.

Buckalew, L. W., & Ross, S. (1981). Relationship of perceptual characteristics to efficacy of placebos. *Psychological Reports*, **49**, 955-961.

Buckalew, L. W., & Sallis, R. E. (1986). Patient compliance and medication perception. *Journal of Clinical Psychology*, **42**(1), 49-53.

Byron, E. (2012). The search for sweet sounds that sell: Household products' clicks and hums are no accident; Light piano music when the dishwasher is done? *The Wall Street Journal*, **October 23rd**.
http://online.wsj.com/article/SB10001424052970203406404578074671598804116.html?mod=googlenews_wsj#articleTabs%3Darticle.

Cassels, A. (2003). Europe rejects pitch for direct-to-consumer drug ads. *CMAJ: Canadian Medical Association Journal*, **168**(2), 209.

Cattaneo, A. D., Lucchelli, P. E., & Filippucci, G. (1970). Sedative effects of placebo treatment. *European Journal of Clinical Pharmacology*, **3**, 43-45.

Chamings, A. (1958). Coloured tablets. *Lancet*, **272**, 45.

Chan T. Y. (2000). Improvements in the packaging of drugs and chemicals may reduce the likelihood of severe intentional poisonings in adults. *Human & Experimental Toxicology*, **19**(7), 387-391. <https://doi.org/10.1191/096032700678816142>.

Courtney, A. J. (1986). Chinese population stereotypes: Color associations. *Human Factors*, **28**, 97-99.

Cozens, C. (2002). Europe rejects drug advertising. *The Guardian*, **October 23rd**.
<https://www.theguardian.com/media/2002/oct/23/advertising.marketingandpr#:~:text=Control%20plans%20to%20allow%20drug,thrown%20out%20by%20Euro%20DMPs.&text=Any%20information%20direct%20to%20consumers,agreement%20with%20the%20Consumer%20Association>.

Cutler, D. M., & Everett, W. (2010). Thinking outside the pillbox – Medication adherence as a priority for health care reform. *New England Journal of Medicine*, **362**(17), 1553-1555.

Day, K. (1985). Packaging emerges as a key selling tool from cigarettes to candy, designers prove that looks rival content. *Los Angeles Times*, **March 17th**.
http://articles.latimes.com/1985-03-17/business/fi-35588_1_consumer.

De Craen, A. J. M., Roos, P. J., de Vries, A. L., & Kleijnen, J. (1996). Effect of colour of drugs: Systematic review of perceived effect of drugs and of their effectiveness. *British Medical Journal*, **313**, 1624-1626.

de Sousa, M. M. M., Carvalho, F. M., & Pereira, R. G. F. A. (2020). Do typefaces of packaging labels influence consumers' perception of specialty coffee? A preliminary study. *Journal of Sensory Studies*, **35**(5). <https://doi.org/10.1111/joss.12599>.

Dichter, E. (1971). The strategy of selling with packaging. *Package Engineering Magazine*, **July**, 16a-16c.

- DiMatteo, M. R. (2004). Variations in patients' adherence to medical recommendations: A quantitative review of 50 years of research. *Medical Care*, **42**, 200-209.
- Dohle, S., & Siegrist, M. (2014). Fluency of pharmaceutical drug names predicts perceived hazardousness, assumed sides effects and willingness to buy. *Journal of Health Psychology*, **19**, 1241-1249.
- Edwards, L. (1977). P&G tries lucrative health care field. *Advertising Age*, **48(52)**, 1.
- Edworthy, J., & Adams, A. (1996). *Warning design: A research prospective*. London, UK: Taylor & Francis.
- Elliot, A. J., & Maier, M. A. (2012). Color-in-context theory. *Advances in Experimental Social Psychology*, **45**, 61-125
- Engelberg, A. B. (2011). The case for standardizing the appearance of bioequivalent medications. *Journal of Managed Care Pharmacy*, **17(4)**, 321-323.
- Erlich, J. (1995). Giving drugs a good name. *The New York Times Magazine*, **September 3rd, (Section 6)**, 36-37. <https://www.nytimes.com/1995/09/03/magazine/giving-drugs-a-good-name.html>.
- Ernst, F. R., & Grizzle, A. J. (2001). Drug-related morbidity and mortality: Updating the cost-of-illness model. *Journal of the American Pharmacology Association*, **41**, 192-199.
- Faisal, W., Farag, F., Abdellatif, A. A. H., & Abbas, A. (2018). Taste masking approaches for medicines. *Current Drug Delivery*, **15(2)**, 167-185.
- Fallowfield, L., Atkins, L., Catt, S., Cox, A., Coxon, C., Langridge, C., Morris, R., & Price, M. (2006). Patients' preference for administration of endocrine treatments by injection or tablets: Results from a study of women with breast cancer. *Annals of Oncology*, **17(2)**, 205-210.
- Fateminia, M., Ghotbabadi, T. D., & Azad, K. M. (2020). Perceptions of the taste of colors in children and adults. *Color Research & Application*, 1-11. DOI: 10.1002/col.22503
- Fieder, N., Wartenburger, I., & Abdel Rahman, R. (2019). A close call: Interference from semantic neighbourhood density and similarity in language production. *Memory & Cognition*, **47**, 145-168. <https://doi.org/10.3758/s13421-018-0856-y>
- Filiatrault, P. (2009). Does colour-coded labelling reduce the risk of medication errors? The “pro” side. *Canadian Journal of Hospital Pharmacy*, **62(2)**, 154-155.
- Filik, R., Purdy, K., & Gale, A. (2005). The use of colour on the labelling of medicines. In D. de Waard, K. A. Brookhuis, R. van Egmond, & Th. Boersema (Eds.), *Human factors in design, safety, and management* (pp. 397-400). Maastricht, NL: Shaker Publishing
- Frankenhaeuser, M., Järpe, G., Svan, H., & Wrangsjö, B. (1963). Psychophysiological reactions to two different placebo treatments. *Scandinavian Journal of Psychology*, **4**, 245-250.
- Fritch, D. M. (2006). Should “the purple pill” by any other drug company still be as purple? The changing face of trade dress protection for pharmaceutical manufacturers. *Intellectual Property Law Review*, **51**, 171-201.
- Frush, K. S., Luo, X., Hutchinson, P., & Higgins, J. N. (2004). Evaluation of method to reduce over-the-counter medication dosing error. *Archives of Pediatric and Adolescent Medicine*, **158**, 620-624.
- Global Market Insight (2019). *Over-the-Counter (OTC) drugs market size by product*. <https://www.gminsights.com/industry-analysis/over-the-counter-otcdugs-market>.

- Glod, M. (2000). Prescription deaths bring call for checks. *The Washington Post*, **July 3rd**. <https://www.washingtonpost.com/archive/politics/2000/07/03/prescription-deaths-bring-call-for-checks/1fe5384e-2357-4d36-9d8b-2534cfe537e9/>.
- Gmuer, A., Siegrist, M., & Dohle, S. (2015). Does wine label processing fluency influence wine hedonics? *Food Quality and Preference*, **44**, 12-16.
- Goyanes, A., Martinez, P. R., Buanz, A., Basit, A. W., & Gaisford, S. (2015). Effect of geometry on drug release from 3D printed tablets. *International Journal of Pharmaceutics*, **494(2)**, 657-663. <https://doi.org/10.1016/j.ijpharm.2015.04.069>.
- Grainger, H. S. (1958). Coloured tablets. *Lancet*, **271**, 1335-1336.
- Greene, J. A. (2011). The substance of the brand. *Lancet*, **378(9786)**, 120-121.
- Greene, J. A., & Kesselheim, A. S. (2011). Why do the same drugs look different? Pills, trade dress, and public health. *New England Journal of Medicine*, **365(1)**, 83-89.
- Gruber, C. M. (1956). Interpreting medical data. *Archives of Internal Medicine*, **98**, 767-773.
- Hawton, K., Simkin, S., Deeks, J., Cooper, J., Johnston, A., Waters, K., Arundel, M., Bernal, W., Gunson, B., Hudson, M., Suri, D., & Simpson, K. (2004). UK legislation on analgesic packs: Before and after study of long term effect on poisonings. *BMJ Online First*, doi:10.1136/bmj.38253.572581.7C.
- Hellier, E., Edworthy, J., Derbyshire, N., & Costello, A. (2006). Considering the impact of medicine label design characteristics on patient safety. *Ergonomics*, **49(5-6)**, 617-630. doi: 10.1080/00140130600568980.
- Hellier, E., Tucker, M. Kenny, N., Rowntree, A., & Edworthy, J. (2010). Merits of using color and shape differentiation to improve the speed and accuracy of drug strength identification on over-the-counter medicines by laypeople. *Journal of Patient Safety*, **6(3)**, 158-164.
- Hethcock, J. M. (1978). Similarities in color-coded drug product packages. *American Journal of Hospital Pharmacy*, **35(8)**, 901.
- Hine, T. (1995). *The total package: The secret history and hidden meanings of boxes, bottles, cans, and other persuasive containers*. New York, NY: Little Brown.
- Horn, C. R., & Cochrane, G. M. (1986). Colour coding for bronchodilator inhalers. *Lancet*, **327**, 165. [https://doi.org/10.1016/s0140-6736\(86\)92308-1](https://doi.org/10.1016/s0140-6736(86)92308-1).
- Humphrey, N. (2002). *The mind made flesh: Essays from the frontiers of psychology and evolution*. Oxford, UK: Oxford University Press.
- Huskisson, E. C. (1974). Simple analgesics for arthritis. *British Medical Journal*, **4**, 196-200.
- Hussain, M. Z. (1972). Effect of shape of medication in treatment of anxiety states. *British Journal of Psychiatry*, **120**, 507-509.
- Hussain, M. Z., & Ahad, A. (1970). Tablet colour in anxiety states. *British Medical Journal*, **3**, 466.
- Hyland, S. (2009). Does colour-coded labelling reduce the risk of medication errors? The “con” side. *Canadian Journal of Hospital Pharmacy*, **62(2)**, 154-155.
- Isaacs, D. (2005). GSK aims to stop Aids profiteers. *BBC News*, **February 21st**. <http://news.bbc.co.uk/1/hi/business/4285745.stm>.
- Jacobs, C. K., Worthley, R., & Ghymn, K.-I. (1991). Cross-cultural colour comparisons: Global marketers beware. *International Marketing Review*, **8(3)**, 21-30.

- Jacobs, K. W., & Nordan, F. M. (1979). Classification of placebo drugs: Effect of color. *Perceptual and Motor Skills*, **49**, 367-372.
- Jin, C., Yoon, M., & Lee, J. (2019). The influence of brand color identity on brand association and loyalty. *Journal of Product & Brand Management*, **28**(1).
- Johnson, A. (2007). *Tactile branding leads us by our fingertips* - CTV News, Shows and Sports - Canadian Television.
http://www.ctv.ca/servlet/ArticleNews/print/CTVNews/20070803/tactile_branding_070803/20070804/?hub=MSNHome&subhub=PrintStory.
- Johnson, J. A., & Bootman, J. L. (1995). Drug-related morbidity and mortality: A cost-of-illness model. *Archives of Internal Medicine*, **155**, 1949-1956.
- Jolly, H., & Forrest, T. R. W. (1958). Accidental poisoning in children: An experimental approach to prevention of poisoning by tablets. *Lancet*, **271**, 1308-1309.
- Kampfer, K., Leischnig, A., Ivens, B. S., & Spence, C. (2017). Touch-flavor transference: Assessing the effect of packaging weight on gustatory evaluations, desire for food and beverages, and willingness to pay. *PLoS ONE*, **12**(10).
<https://doi.org/10.1371/journal.pone.0186121>.
- Kaspar, K. (2013). A weighty matter: Heaviness influences the evaluation of disease severity, drug effectiveness, and side effects. *PLoS ONE*, **8**(11): e78307.
 doi:10.1371/journal.pone.0078307.
- Kauppinen-Räsänen, H., & Luomala, H. T. (2010). Exploring consumers' product-specific colour meanings. *Qualitative Market Research*, **13**(3), 287-308. <https://doi.org/10.1108/13522751011053644>.
- Keaveney, A., Peters, E., & Way, B. (in press). Effects of acetaminophen on risk taking. *Social Cognitive and Affective Neuroscience*. <https://doi.org/10.1093/scan/nsaa108>.
- Kenagy, J. W., & Stein, G. C. (2001). Naming, labeling, and packaging of pharmaceuticals. *American Journal of Health-System Pharmacy*, **58**(21), 2033-2041.
- Kesselheim, A. S., Misono, A. S., Shrank, W. H., Greene, J. A., Doherty, M., Avorn, J., & Choudhry, N. K. (2013). Variations in pill appearance of antiepileptic drugs and the risk of nonadherence. *JAMA Internal Medicine*, **173**(3), 202-208.
- Khan, A., Bomminayuni, E. P., Bhat, A., Faucett, J., & Brown, W. A. (2010). Are the colors and shapes of current psychotropics designed to maximize the placebo response? *Psychopharmacology (Berl)*, **211**(1), 113-122.
- Klink, R. R. (2001). Creating meaningful new brand names: A study of semantics and sound symbolism. *Journal of Marketing: Theory and Practice*, **9** (Spring), 27-34.
- Klink, R. R. (2003). Creating meaningful brands: The relationship between brand name and brand mark. *Marketing Letters*, **14**, 143-157.
- Kohn, L. T., Corrigan, J. M., & Donaldson, M. S. (Eds.). (2000). *To err is human: Building a safer health system*. Washington, DC: Institute of Medicine and National Academy Press.
- Köteles, F., & Bárdos, G. (2009). A gyógyszerek perceptuális jellemzői és potenciális hatásai [Perceptual characteristics of drugs and their potential effects]. *Psychiatria Hungarica: A Magyar Pszichiatriai Tarsaság tudományos folyóirata*, **24**(4), 282-295.

- Köteles, F., Fodor, D., Cziboly, Á., & Bárdos, G. (2009). Expectations of drug effects based on colours and sizes—The importance of learning. *Clinical and Experimental Medicine Journal*, **3**(1), 99-107.
- Köteles, F., Komsa, I., & Bárdos, G. (2010). The effect of perceptual characteristics of tablets upon patient's choice. *Clinical and Experimental Medical Journal*, **4**(1), 99-104. DOI: 10.1556/CEMED.4.2010.1.10.
- Labrecque, L. L., & Milne, G. R. (2012). Exciting red and competent blue: The importance of color in marketing. *Journal of the Academy of Marketing Science*, **40**, 711-727.
- Labrecque, L. L., & Milne, G. R. (2013). To be or not to be different: Exploration of norms and benefits of color differentiation in the marketplace. *Marketing Letters*, **24**, 165-176.
- Labrecque, L. L., Patrick, V. M., & Milne, G. R. (2013). The marketers' prismatic palette: A review of color research and future directions. *Psychology & Marketing*, **30**, 187-202.
- Lambert, B. L. (1997). Predicting look-alike and sound-alike medication errors. *American Journal of Health-System Pharmacy*, **54**, 1161-1171.
- Lambert, B. L., Chang, K. Y., & Lin, S. J. (2001). Descriptive analysis of the drug name lexicon. *Drug Information Journal*, **35**, 163-172.
- Lambert, B. L., Lin, S. J., & Tan, H. (2005). Designing safe drug names. *Drug Safety*, **28**, 495-512.
- Lasagna, L. (1955). Placebos. *Scientific American*, **193**, 68-71.
- Lau, D. T. (2008). Consumer medication management and error. *Clinical Therapy*, **30**(11), 2156-2158. doi:10.1016/j.clinthera.2008.11.010.
- Leape, L. L., Brennan, T. A., Laird, N., Lawthers, A. G., Localio, A. R., Barnes, B. A., et al. (1991). The nature of adverse events in hospitalized patients: Results of the Harvard Medical Practice Study II. *New England Journal of Medicine*, **324**, 377-384.
- Lechner, A., Simonoff, J. S., & Harrington, L. (2012). Color-emotion associations in the pharmaceutical industry: Understanding universal and local themes. *Color Research and Application*, **37**, 59-71.
- LeClerc, F., Schmitt, B. H., & Dubé, L. (1994). Foreign branding and its effects on product perceptions and attitudes. *Journal of Marketing Research*, **31**, 263-270.
- Leslie, A. (1954). Ethics and the practice of placebo therapy. *American Journal of Medicine*, **16**, 854-862.
- Levitan, C., Zampini, M., Li, R., & Spence, C. (2008). Assessing the role of color cues and people's beliefs about color-flavor associations on the discrimination of the flavor of sugar-coated chocolates *Chemical Senses*, **33**, 415-423.
- Lockwood, G., & Dingemanse, M. (2015). Iconicity in the lab: A review of behavioral, developmental, and neuroimaging research into sound-symbolism. *Frontiers in Psychology*, **6**:1246.
- Lucchelli, P. E., Cattaneo, A. D., & Zattoni, J. (1978). Effect of capsule colour and order of administration of hypnotic treatments. *European Journal of Clinical Pharmacology*, **13**, 153-155.
- Madden, T. J., Hewett, K., & Roth, M. S. (2000). Managing images in different cultures: A cross-national study of color meanings and preferences. *Journal of International Marketing*, **8**(4), 90-107.

- Martin, D. (1990). The impact of branding and marketing on perception of sensory qualities. *Food Science & Technology Today: Proceedings*, **4**(1), 44-49.
- Matheson, J. A., & Justus, M. R. (2009). Eye candy. *Medical Marketing and Media*, **44**(4), 55-58.
- McCoy, L. (2005). Look alike sound drug review. *Journal of Quality and Patient Safety*, **31**, 41-53.
- McNeil, D. G., Jr. (2003). The science of naming drugs (sorry 'Z' is already taken). *The New York Times*, **December 28th**, 10.
- Medication errors. (2008) [US Food and Drug Administration Web site]. <http://www.fda.gov/cder/handbook/mederror.htm>.
- Meyers, H. M. (1981). Determining communication objectives for package design. In W. Stern (Ed.), *Handbook of package design research* (pp. 22-38). New York, NY: Wiley Interscience.
- Miller, M., Levsky, M., Masneri, D., & Borys, D. (2006). FABULOSO®: A cleaning product that tastes and smells good enough to drink. *Annals of Emergency Medicine*, **48**, 81.
- Moerman, D. E., & Jonas, W. B. (2002). Deconstructing the placebo effect and finding the meaning response. *Annals of Internal Medicine*, **136**, 471-476.
- More, A. T., & Srivastava, R. K. (2009). Aesthetic considerations for pharmaceutical OTC (over the counter) products. *Oxford Business & Economics Conference*. June 24-26, St. Hugh's College, Oxford.
- Murray-West, R. (2003). Glaxo takes on smugglers by changing drug's colour. *The Telegraph*, **December 27th**.
- Nagao, Y., Komiya, J., Kuroyanagi, K., Minaba, Y., & Susa, A. (1968). Effect of the color of analgesics on their therapeutic results. *Shikwa Gakuho*, **68**, 139-142.
- Newman, S. (1994). Kill the "mere color" rule: Equal protection for color under the Lanham Act. *University of Chicago Law Review*, **61**, 1595-1626.
- Nickels, W. G., & Jolson, M. A. (1976). Packaging – the fifth "p" in the marketing mix? *Advanced Management Journal*, **41**(1), 13-21.
- Nuckolls, J. B. (1999). The case for sound symbolism. *Annual Review of Anthropology*, **28**, 225-252.
- Obrist, M., Comber, R., Subramanian, S., Piqueras-Fiszman, B., Velasco, C., & Spence, C. (2014). Temporal, affective, and embodied characteristics of taste experiences. In Proceedings of the 32nd annual ACM conference on Human factors in computing systems - CHI '14 (pp. 2853-2862). New York, New York, USA: ACM Press. doi:10.1145/2556288.2557007521.
- Okuhara, T., Ishikawa, H., Okada, M., Kato, M., & Kiuchi, T. (2017). Designing persuasive health materials using processing fluency: A literature review. *BMC Research Notes*, **10**:198. DOI 10.1186/s13104-017-2524-x.
- Osterberg, L., & Blaschke, T. (2005). Drug therapy – Adherence to medication. *The New England Journal of Medicine*, **353**, 487-497.
- Park, J., Motoki, K., Pathak, A., & Spence, C. (in press). A sound brand name: The role of voiced consonants in pharmaceutical branding. *Food Quality & Preference*.

- Pathak, A., & Calvert, G. A. (2020). Sounds sweet, sounds bitter: How the presence of certain sounds in a brand name can alter expectations about the product's taste. *Food Quality and Preference*, **83**:103918. <https://doi.org/10.1016/j.foodqual.2020.103918>.
- Pathak, A., Velasco, C., & Spence, C. (2020). An analysis of the initial phonemes of popular brand names. *Journal of Brand Management*, **27**, 339-354. [10.1057/s41262-019-00183-5](https://doi.org/10.1057/s41262-019-00183-5).
- Pilchik, R. (2000). Pharmaceutical blister packaging, Part I. Rationale and materials. *Pharmaceutical Technology*, **November**, 68-77.
- Pinkstone, J. (2021). The new tongue-twisting drugs that can 'cut the risk of death by up to 24%': Boris Johnson hails 'life-saving' arthritis drugs trial (after stumbling over how to pronounce them). *Daily Mail Online*, **January 7th**. <https://www.dailymail.co.uk/sciencetech/article-9122747/Two-arthritis-drugs-slash-risk-Covid-patients-ICU-dying-24.html>.
- Piqueras-Fiszman, B., & Spence, C. (2012a). The weight of the bottle as a possible extrinsic cue with which to estimate the price (and quality) of the wine? Observed correlations. *Food Quality & Preference*, **25**, 41-45. <http://dx.doi.org/10.1016/j.foodqual.2012.01.001>
- Piqueras-Fiszman, B., & Spence, C. (2012b). The weight of the container influences expected satiety, perceived density, and subsequent expected fullness. *Appetite*, **58**, 559-562. <http://dx.doi.org/10.1016/j.appet.2011.12.021>
- Piqueras-Fiszman, B., & Spence, C. (2015). Sensory expectations based on product-extrinsic food cues: An interdisciplinary review of the empirical evidence and theoretical accounts. *Food Quality & Preference*, **40**, 165-179.
- Reber, R., Schwarz, N., & Winkielman, P. (2004). Processing fluency and aesthetic pleasure: Is beauty in the perceiver's processing experience? *Personality and Social Psychology Review*, **8**, 364-382.
- Rettner, R. (2017). A growing number of people make mistakes when they take their medication. *The Washington Post*, **July 14th**. https://www.washingtonpost.com/national/health-science/a-growing-number-of-people-make-mistakes-when-they-take-their-medication/2017/07/14/a0196a28-6740-11e7-9928-22d00a47778f_story.html.
- Riley, M., Cochran, D., & Ballard, J. (1982). An investigation into the preferred shapes for warning labels. *Human Factors*, **24**, 737-743.
- Rolschau, K., Wang, Q. J., & Otterbring, T. (2020). Seeing sweet and choosing sour: Compensatory effects of typeface on taste expectations and choice. *Food Quality & Preference*, **85**, 103964. <https://doi.org/10.1016/j.foodqual.2020.103964>.
- Roulette, B., & Droulers, O. (2005). Pharmaceutical packaging color and drug expectancy. *Advances in Consumer Research*, **32**, 164-171.
- Rozin, P., Spranca, M., Krieger, Z., Neuhaus, R., Surillo, D., Swerdlin, A., & Wood, K. (2004). Preference for natural: Instrumental and ideational/moral motivations, and the contrast between foods and medicines. *Appetite*, **43**, 147-154.
- Rubin, R. (2016). Can't sleep your first night in a hotel? It's probably not due to jet lag or an uncomfortable bed. *Forbes*, **June 12th**. <https://www.forbes.com/sites/ritarubin/2016/06/12/cant-sleep-your-first-night-in-a-hotel-its-probably-not-due-to-jet-lag-or-an-uncomfortable-bed/#558bb9fa6378>.

- Ruiz, F., Keeley, A., Légli, P., Tuleu, C., Lachuer, C., Rwabihama, J.-P., et al. (2019). Sex differences in medicine acceptability: A new factor to be considered in medicine formulation. *Pharmaceutics*, **11**, 368. doi:10.3390/pharmaceutics11080368.
- Sallis, R. E., & Buckalew, L. W. (1984). Relation of capsule color and perceived potency. *Perceptual & Motor Skills*, **58**(3), 897-898.
- Schindel, L. E. (1962). Placebo in theory and practice. In O. Gsell (Ed.), *Antibiotica et Chemotherapia, Advances* [Antibiotics and Chemotherapy] (Basel, Karger), **10**, 398-430. doi: 10.1159/000386723
- Schloss, I. (1981). Chickens and pickles. *Journal of Advertising Research*, **21** (December), 47-49.
- Schneider, K. C. (1977). Prevention of accidental poisoning through package and label design. *Journal of Consumer Research*, **4**, 67-74.
- Sebellico, A. (1989). Il colore de farmaco: inchiesta preliminare [The color of drugs: A preliminary survey]. *Bolettino Societa Italiana Biologia Sperimentale*, **65**(7), 685-687.
- Shariff, Z. B., Dahmash, D. T., Kirby, D. J., Missaghi, S., Rajabi-Siahboomi, A., & Maidment, I. D. (2020). Does the formulation of oral solid dosage forms affect acceptance and adherence in older patients? A mixed methods systematic review. *Journal of the American Medical Directors Association*, **21**(8), 1015-1023. <https://doi.org/10.1016/j.jamda.2020.01.108>.
- Shapira, K., McClelland, H. A., Griffiths, N. R., & Newell, D. J. (1970). Study on the effects of tablet colour in the treatment of anxiety states. *British Medical Journal*, **2**, 446-449.
- Shapiro, A. K. (1970). Placebo effects in psychotherapy and psychoanalysis. *Journal of Clinical Pharmacology*, **10**, 73-78.
- Shiv, B., Carmon, Z., & Ariely, D. (2005). Placebo effects of marketing actions: Consumers may get what they pay for. *Journal of Marketing Research*, **42**, 383-393.
- Shrank, W. H., Patrick, A., Gleason, P. P., Canning, C., Walters, C., Heaton, A. H., Jan, S., et al. (2009). An evaluation of the relationship between the implementation of a newly designed prescription drug label at Target pharmacies and health outcomes. *Medical Care*, **47**(9), 1031-1035. doi: 10.1097/MLR.0b013e3181a81181.
- Sidhu, D. M., & Pexman, P. M. (2018). Five mechanisms of sound symbolic association. *Psychonomic Bulletin & Review*, **25**(5), 1619-1643. <https://doi.org/10.3758/s13423-017-1361-1>.
- Sims, C. (1986). Despite “mystique” of capsules many drugs work in other forms. *The New York Times*. February 15th (Section 1), 30. <http://www.nytimes.com/1986/02/15/nyregion/despite-mystique-of-capsules-many-drugs-work-in-other-forms.html>.
- Soller, R. W., & Lightwood, J. M. (2007). Comparison of the packaging and labeling of Target ClearRx with conventional prescription drug packaging and labeling. *Journal of the American Pharmacists Association*, **47**(4), 484-490.
- Song, H., & Schwarz, N. (2008). If it’s hard to read, it’s hard to do: processing fluency affects effort prediction and motivation. *Psychological Science*, **19**(10), 986-988.
- Song, H., & Schwarz, N. (2009). If it’s difficult to pronounce, it must be risky. *Psychological Science*, **20**, 135-138.

- Spence, C. (2012). Managing sensory expectations concerning products and brands: Capitalizing on the potential of sound and shape symbolism. *Journal of Consumer Psychology*, **22**, 37-54.
- Spence, C. (2015). On the psychological impact of food colour. *Flavour*, **4**:21.
- Spence, C. (2016). Multisensory packaging design: Color, shape, texture, sound, and smell. In P. Burgess (Ed.), *Integrating the packaging and product experience: A road-map to consumer satisfaction* (pp. 1-22). Oxford, UK: Elsevier.
- Spence, C. (2019a). Tactile/haptic aspects of multisensory packaging design. In C. Velasco & C. Spence (Eds.), *Multisensory packaging: Designing new product experiences* (pp. 127-159). Cham, Switzerland: Palgrave MacMillan.
- Spence, C. (2019b). On the relationship(s) between colour and taste. *Experimental Psychology*, **66**, 99-111. <https://doi.org/10.1027/1618-3169/a000439>.
- Spence, C. (2019). Do men and women really live in different taste worlds? *Food Quality & Preference*, **73**, 38-45. <https://doi.org/10.1016/j.foodqual.2018.12.002>.
- Spence, C., & Piqueras-Fiszman, B. (2012). The multisensory packaging of beverages. In M. G. Kontominas (Ed.), *Food packaging: Procedures, management and trends* (pp. 187-233). Hauppauge NY: Nova Publishers.
- Spence, C., & Velasco, C. (2019). Packaging colour and its multiple roles. In C. Velasco & C. Spence (Eds.), *Multisensory packaging: Designing new product experiences* (pp. 21-48). Cham, Switzerland: Palgrave MacMillan.
- Spence, C., Wan, X., Woods, A., Velasco, C., Deng, J., Youssef, J., & Deroy, O. (2015). On tasty colours and colourful tastes? Assessing, explaining, and utilizing crossmodal correspondences between colours and basic tastes. *Flavour*, **4**:23.
- Spence, C., & Zampini, M. (2007). Affective design: Modulating the pleasantness and forcefulness of aerosol sprays by manipulating aerosol spraying sounds. *CoDesign*, **3** (Supplement 1), 109-123.
- Srivastava, R. K., & More, A. T. (2010). Some aesthetic considerations for over the-counter (OTC) pharmaceutical products. *International Journal of Biotechnology*, **11**(3/4), 267-283. DOI: 10.1504/IJBT.2010.036600.
- Steele, A. (2002). The colour and shape of a pharmaceutical tablet deemed not distinctive enough to warrant trade-mark registration, federal court rules. *Leger, Robic and Richard Lawyers*, Montreal, Quebec (<https://www.robic.ca/en/publications/the-colour-and-shape-of-a-pharmaceutical-tablet-deemed-not-distinctive-enough-to-warrant-trade-mark-registration-federal-court-rules/>).
- Stegemann, S. (2005). Colored capsules – a contribution to drug safety. *Pharmaceutical Industry*, **67**(9), 1088-1095.
- Stinson, N. K. (1982). Trademarks and “look-alike” drugs. *Indiana Law Review*, **15**, 733-764.
- Tao, D., Wang, T., & Wang, T. (2016). Effects of color on expectations of drug effects: A cross-gender cross-cultural study. *Color Research and Application*. **42**(1), 124-130. doi: 10.1002/col.22024.
- Tao, D., Wang, T., Wang, T., & Qu, X. (2018). Influence of drug colour on perceived drug effects and efficacy. *Ergonomics*, **61**(2), 284-294, DOI: 10.1080/00140139.2017.1349935.
- Thomson Reuters (2009). *Physicians’ desk reference* (63rd Ed.). Montvale: Thomson Reuters.

- Tuleu, C., Hughes, D. A., Clapham, D., Vallet, T., & Ruiz, F. (2020). Acceptability of generic versus innovator oral medicines: Not only a matter of taste. *Drug Discovery Today*. DOI: [10.1016/j.drudis.2020.11.008](https://doi.org/10.1016/j.drudis.2020.11.008).
- U.S. Pharmacopeia (2004). Look-alike/sound-alike drug products affect cognition. *Patient Safety CAPSLink™*, May. <http://www.usp.org/pdf/patientSafety/capsLink2004-05-01.pdf>.
- Vallet, T., Michelon, H., Orlu, M., Jani, Y., Leglise, P., Laribe-Caget, S., Piccoli, M., Le Fur, A., Liu, F., Ruiz, F., & Boudy, V. (2020). Acceptability in the older population: The importance of an appropriate tablet size. *Pharmaceutics*, **12**:746. <https://doi.org/10.3390/pharmaceutics12080746>.
- Van Doorn, G., Paton, B., & Spence, C. (2016). Is *J* the new *K*? A failure to replicate Schloss (1981). *Journal of Brand Management*, **23**, 666-678.
- Velasco, C., Beh, E., Le, T., & Marmolejo-Ramos, F. (2018). The shapes associated with the concept of 'sweet and sour' foods. *Food Quality and Preference*, **68**, 250-257. DOI: [10.1016/j.foodqual.2018.03.012](https://doi.org/10.1016/j.foodqual.2018.03.012).
- Velasco, C., & Spence, C. (Eds.). (2019a). *Multisensory packaging: Designing new product experiences*. Cham, Switzerland: Palgrave MacMillan.
- Velasco, C., & Spence, C. (2019b). The role of typeface in packaging design. In C. Velasco & C. Spence (Eds.), *Multisensory packaging: Designing new product experiences* (pp. 79-101). Cham, Switzerland: Palgrave MacMillan.
- Venkatesan, T., Wang, Q. J., & Spence, C. (2020). Does the typeface on album cover influence expectations and perception of music? *Psychology of Aesthetics, Creativity, and the Arts*. <http://dx.doi.org/10.1037/aca0000330>.
- Waber, R. L., Shiv, B., Carmon, Z., & Ariely, D. (2008). Commercial features of placebo and therapeutic efficacy. *Journal of the American Medical Association*, **299**, 1016-1017.
- Wan, X., Woods, A. T., Velasco, C., Salgado-Montejo, A., & Spence, C. (2015). Assessing the expectations associated with pharmaceutical pill colour and shape. *Food Quality & Preference*, **45**, 171-182.
- Wang, Q. (J.), & Spence, C. (2019). Sonic packaging: How packaging sounds influence multisensory product evaluation. In C. Velasco & C. Spence (Eds.), *Multisensory packaging: Designing new product experiences* (pp. 103-125). Cham, Switzerland: Palgrave MacMillan.
- Wheatley, J. (1973). Putting colour into marketing. *Marketing*, **October**, 24-29, 67.
- Wildsmith, J. (2002). Doctors must read drug labels, not whinge about them. *BMJ*, **324**, 170.
- Williams, J. H. (1981). Evaluating package effectiveness in hospitals. In W. Stern (Ed.), *Handbook of package design research* (pp. 387-398). New York, NY: John Wiley & Sons.
- Wogalter, M., DeJoy, D., & Laughery, K. (1999). *Warnings and risk communication*. London, UK: Taylor & Francis.
- Woods, A. T., Marmolejo-Ramos, F., Velasco, C., & Spence, C. (2016). Using single colours and colour pairs to communicate basic tastes II; Foreground-background colour combinations. *i-Perception*, **7**:5.
- Woods, A. T., & Spence, C. (2016). Using single colours and colour pairs to communicate basic tastes. *i-Perception*, **7**:4.
- World Health Organization (2003). *Adherence to long-term therapies: Evidence for action*. Geneva. http://www.who.int/chp/knowledge/publications/adherence_introduction.pdf.

Worthington, J. (2007). Let's talk about sense appeal. *Pharmaceutical Formulation and Quality (PFQ)*, **9(6)**, 32-38. <https://www.senopsys.com/wp-content/uploads/Formulation-Lets-Talk-about-Sense-Appeal-PFQ-Oct-07.pdf>.

Zellner, D. A., Greene, N., Jimenez, M., Calderon, A., Diaz, Y., & Sheraton, M. (2018). The effect of wrapper color on candy flavour expectations and perceptions. *Food Quality & Preference*, **68**, 98-104.

Zampini, M., Guest, S., & Spence, C. (2003). The role of auditory cues in modulating the perception of electric toothbrushes. *Journal of Dental Research*, **82**, 929-932.