Influence of Sound on Sensory Perception

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Introduction

We live in a multisensory world in which the senses play an important role in our perception of the world around us. If one sense is dulled the overall experience of a product changes, if you take away the appearance of a product, the consumer has to rely on taste, smell, touch and sound to experience the product. Appearance plays a massive role in consumer perception, if a product doesn't look very nice then consumers are less likely to want to eat it, hence the saying *'we eat with our eyes'*. Taste, smell and touch also play a large role in consumer perception; if one sense is dimmed then other senses are heightened to enhance the sensory experience. Most people experience reduced sense of taste and smell when they have a cold and are usually aware of the impact this has on their experience of the overall flavour of a food product. However, slightly less well known is the affect sound has on sensory perception of food and drink products and consumers are typically unaware of this relationship (Spence, 2012a). Delwiche (2003) found that consumers ranked sound as the least important attribute impacting on flavour when compared to taste, smell, temperature, texture, colour and appearance.

This essay explores the interaction between sound and sensory perception of products in particular food. This essay will focus on three examples, the first two explore the relationship between sound and food including the effect sound has on perception prior to eating and its effect during eating. Finally, further research investigating how sound can enhance the multisensory experience will be discussed.

Sound – how do we hear?

Sound originates from the motion or vibration of an object. This causes sound waves to be transmitted through the air, into the ear, down the ear canal to the ear drum (tympanic membrane) which vibrates causing the three smallest bones in the body (hammer, anvil and stirrup), located in the middle ear, to vibrate and pass the vibrations on through lots of winding passages to the cochlea, a spiral shaped structure filled with fluid in the inner ear. The vibrations cause ripples in the fluid that transmits to tiny hairs on the basilar membrane; the movement of these hairs generates neural responses sending signals to the brain resulting in hearing (Lindstrom, 2005; Mather, 2009).

It's very difficult to switch hearing off, you can spit out food if you don't like the taste, hold your nose if you don't like the smell, close your eyes if you don't like what you see but sound travels a long way and even covering your ears doesn't fully block out sound. Therefore understanding the impact sound has on sensory perception could lead to some interesting, potentially life changing discoveries.

Relationship between Sound and Food

The relationship between sound and food includes two key areas, the sound emitted prior to eating a food product and the sound heard during the eating process.

Prior to eating

Prior to eating, many factors play a role in the overall perception of the product including: the sound of the packaging, for example, the pop of a can of coke or the scrunch of a crisp packet; the sound of a machine preparing the food or beverage, for example, boiling a kettle or the sound of a coffee machine; and also the sound of the environment in which the consumer is eating (Spence, 2012a).

Packaging

The sound of food packaging can instigate expectation in consumers that affects their sensory perception of the product. A consumer would expect a packet of crisps to be noisy when opening it, if there was no noise it would affect their experience of the product as they would not expect silence when opening a bag of crisps. Sensation transference may also play a role in consumer perception of a product, this assumes that regardless of any expectations a consumer may have about a food product, the sensory attributes of the packaging (and the consumer's feelings about those attributes) will affect the consumer's experience of the product itself (Spence, 2012a). For example, a louder rustle in a bag of crisps may make the consumer think the sample is crunchier than a quieter crisp packet sound. Interestingly, although the sound of packaging (especially opening) plays an important role in consumer expectation of a product, there are few brands that have a unique, distinctive opening sound, Pringles being one of the few with a perceived popping sound as you open the packet (Spence, 2012a).

Food Preparation

Sounds emitted during food preparation also create expectation in consumers. For example, the anticipation of receiving a cup of coffee is heightened when the consumer can hear the coffee machine grinding beans and steam swooshing in the background. Likewise in a restaurant with an open kitchen, the senses are stimulated by the sound of steak sizzling on the grill or a sauce bubbling in a pan. These sounds can influence the consumer's perception of the food. Spence (2011 & 2012a) suggests an interesting area of future research could be to see whether the sound of a 'sizzling' steak (or other noisy food product) would modulate salivary flow in a similar manner to the conditioning of Pavlov's dog (Pavlov, 1927).

Environment

Seo and Hummel (2011) found that the aroma of potato chips was perceived to be significantly more pleasant after listening to the sound of someone else consuming potato chips compared to white noise. In a second experiment, playing pleasant (baby laughing or jazz drum) or unpleasant (baby crying or scream) sounds to participants whilst presented with different odours (unpleasant or pleasant); it was found that the more participants liked the sound, the more pleasant the odour was rated (Seo and Hummel, 2011). These results may help explain why at the sea side the smell of fish and chips appears to be more pleasant than the smell of a chip shop on the high street in town. It could be partly due to the environment, the sound of the sea and happy tourists (laughter and general excitement) and the sound of other people eating their fish and chips. This is an important concept that should be considered by café and restaurant owners as the research suggests their food may be enjoyed more if there are no screaming babies and the background music is carefully chosen. Some restaurants already manage this by having child friendly areas separate from the main dining area.

The sound of a word, i.e. the name of a food brand or product, can also play a role in the perception of that product. As humans, when we hear the sound of a word we attach meaning to it (Krishna, 2012), which can lead to association of certain words with certain attributes (Favilli et al., 2013). For example, the brand name 'Frosh' for an ice cream was believed to be creamier than the brand name 'Frish' purely from participants hearing or reading the name (Yorkston and Menon, 2004). This is beyond the scope of this essay but it proposes some very interesting questions about the importance of the name chosen for a food product and the fact that this could manipulate the consumer's perception of that product. For more examples see Spence (2012b).

During Eating

Sound and texture

Various sounds have been related to the texture of foods, namely crispness, crunchiness and crackliness (Duizer, 2001), of these three textures, 'crispness' is considered to be the most important in terms of consumer acceptability of foods (Szczesniak, 1990). In the consumer's mind crispness is related to freshness (Szczesniak, 2002). A soggy biscuit or stale bread is not normally enjoyed. If a consumer didn't hear the expected crisp sound when biting into a piece of lettuce advertised as 'fresh, crisp, lettuce', they would think there is something wrong with the product, that it may have gone off and therefore could have health implications. In this case consumers relate sound to product quality (Duizer, 2001). Certain products have more rigid tolerances in terms of texture, for example, crisps have a narrower tolerance of texture variation compared to cottage cheese. However, it is important to note that texture is often taken for granted and consumers do not normally comment on texture unless there is something wrong with the food product or they are specifically asked about the texture (Szczesniak, 2002).

Consumers are able to discriminate between crispiness and crunchiness due to the difference in sound. In their research on fruit and vegetables, Fillion & Kilcast (2002) found that 'crispy' was described as a short, high-pitched sound when force is applied mainly during the first bite, whereas 'crunchy' was a loud, lower pitched sound that is repeated over several chews. Although these differences are picked up by consumers they can be difficult to define (Saeleaw & Schleining, 2011; Chen et al., 2005; Roudaut et al., 2002) and are often the topic of discussion in trained panel sessions. Overall the sound heard, in combination with the textural properties felt in-mouth as food is eaten, contribute to the crispness and crunchiness perceived by the consumer (Spence, 2012b).

If the sound a consumer hears when eating a crispy product is altered then this can affect their perception of that products texture. In research carried out by Zampini and Spence (2004), consumers were served potato chips of identical freshness, shape and homogeneity and were asked to bite the crisp sample once whilst wearing headphones that fed-back the sound of the bite to the consumer. The sound that was fed back to consumers was manipulated by increasing or decreasing the frequency. Results showed the potato chips were perceived to be crispier and fresher when the overall sound level was increased or when the high frequency sounds (2 kHz – 20 kHz) were amplified. A similar study was carried out by Luisa Demattè et al., (2014) using apples as the food product. Results were in agreement with Zampini and Spence (2004), showing that crispness of the apples was significantly lower when a reduction in the frequency fed back to the consumer was applied or when no filter to the sound was in place (0 dB). In addition, they found that the attribute 'hardness' was perceived to be significantly lower when a global sound reduction was applied, compared to unfiltered sound being fed back to consumers. This was an interesting finding as it was previously thought that hardness was predominantly a mechanical property and not a contributor to sound (Luisa Demattè et al., 2014).

Another important sound in the food and beverage industry is that observed in carbonated beverages. The sound of the fizz, i.e. bubbles bursting within the sample prior to drinking, may influence a consumer's perception of the products carbonation properties (how fizzy they believe the product will be). Zampini and Spence (2005) investigated how perception of the level of carbonation is affected by modifying the loudness and/or frequency of sound feedback from sparkling water samples. The water samples were reported to be more carbonated when the high frequency components (2 – 20 kHz) of the water sound were amplified and/or the overall sound level was increased. Participants also perceived water samples to be significantly more carbonated when held near their ear (where the sound of the bubbles could be heard more clearly) compared to samples held further away from their ear, thus confirming the role sound plays in a consumer's judgement of the level of carbonation in a carbonated beverage.

Sound and flavour

As well as affecting texture, manipulating sound can also affect the flavour perceived. Woods et al., (2011) compared the effect background noise has on consumer perception of gustatory food properties (sugar and salt level), food crunchiness and food liking. Results showed that loud background noise (75 – 85 dB compared to quiet 45 – 55 dB) resulted in foods tasting less intense for sweetness and saltiness. Crunchiness was reported to be higher when background noise was present and the liking of food was affected by the consumer's liking of the sound itself. It is also possible that the presence of sound is distracting to the consumer, making it harder to concentrate and therefore this could affect their judgement of the overall flavour and properties of the product (Spence, 2012a). Results from this study may offer advice to people struggling with obesity, for example, simply asking someone to eat their meal without the television or radio on in the background could potentially increase their perception of the flavours within the food they are eating so there will be no need to add additional salt or sugar to the meal.

Instrumental research on the sound of food

The importance of sound in texture has led to the development of many sophisticated instrumental measurements, including texture analysis and acoustic measurements of texture (Stable Micro Systems, 2014) that can be used to quantify the textural properties of products such as how crispy a crisp is. This can help ensure the quality of a product is maintained, for example, the sound the 'snap' of a biscuit makes is the characteristic sound expected by the consumer. These instrumental techniques are cheaper than using sensory panels so multiple measurements can be efficiently made on multiple batches of products to ensure quality is maintained (Saeleaw & Schleining, 2011). However, such measurements should be 'qualified' with a sensory panel and consumer research to ensure that the ultimate sound of the 'snap' is that which the consumer likes, creating the ideal crispiness or crunchiness of the product with a competitive edge.
It is also important to consider that the sound created by an instrumental measurement may differ to that heard by the consumer. Bone- and air- conducted vibrations play an important role in the overall auditory stimuli relating to crispness (Roudaut et al., 2002; Pocztaruk et al., 2011) and can help a consumer discriminate between other textural attributes such as crackle and crunchiness (Dacremont, 1995).

Sound and Marketing

Sound can also be used to help market products. Kellogg's understood the importance of sound during eating and spent years working on the sound of the crunch when you eat cornflakes and how that affects taste. The result of this work has identified a unique crunch that only Kellogg's cornflakes have

and distinguishes them from all other brands (Lindstrom, 2005). Likewise, the signature 'snap, crackle and pop' sound of Rice Krispies is recognised throughout the world and used in advertising to market this product. If the consumer didn't hear the sound following addition of milk they would think something was wrong with the product, potentially that it had gone stale or that they had purchased a fake version of the product.

Another more bizarre marketing strategy has been adapted by a bogeda in Murcia who have researched the affect playing music to wine can have on its flavour, the wine is subjected to 59 hours, 35 minutes and three seconds of music. Apparently it is clear from the taste of the wine that the music has done the trick *'caressing the tannins into a silky smoothness'* (Baker, 2014). Although this idea is ridiculous it is clearly a good marketing strategy. The improved wine flavour is most likely to be produced from treating the wine with care and respect – obviously a wine that has been stored in the best possible environment is going to taste better than one that has been left on a window sill in the sunshine.

Use of sound to enhance the multisensory experience

Background music

Music can be used to influence people's shopping or eating behaviour, fast music will speed people up (potentially minimising their spending) whereas slower music has been shown to slow people down allowing them to spend more time in the shop or restaurant which in turn leads to more purchasing or eating (Lindstrom, 2005; Stroebele and de Castro, 2004 & 2006). The type of music can also influence shopping behaviour; Areni & Kim (1993) found consumers purchased more expensive wine when classical music was played in a wine store compared to when top-forty music was played; Jacob (2006) found that in a bar setting customers spent more time and money in the bar when drinking songs were played compared to top-forty music or cartoon music. Andersson et al., (2012) have found that volume and tempo of music are important in terms of customer satisfaction in retail stores, and that preference for music styles differ between male and female consumers.

The choice of music listened to while eating a meal (tempo, pitch, timbre or interval) can affect consumer perception of the meal (Crisinel & Spence, 2009). Background noise can also affect perception, research carried out by Ferber & Cabanac (1987) showed that loud background noise can instigate stress, causing consumers to eat more food and prefer the sweet stimuli. This could be classed as 'emotional eating'. Fiegel et al., (2014) investigated the affect changing the background music has on consumer acceptance of emotional (milk chocolate) and non-emotional (bell peppers) foods. Interestingly they found that jazz music significantly enhanced the participants liking of the food stimuli compared to hip hop music. Although this study only looked at four genres of music, it is exciting to discover that the type of background music listened to can have a large influence on consumer liking of products. This suggests that restaurants and café's should invest time in selecting the background music they choose to play as it could have a large impact on the profit they make in terms of consumers repeat buying and consumer ratings on sites such as trip advisor.

Sound is also used in Michelin star restaurants to enhance the overall sensory experience of eating. Heston Blumenthal serves his fish course at the Fat Duck in Bray with an ipod that plays 'Sounds of the Sea'. The music is designed to spark memories of the seaside in the diners imagination and as they listen while eating the fish course this helps to heighten their perception and the fish will taste 'fishier' and 'fresher' (Jones, 2010). Diners at the Fat Duck have had many positive things to say about this dish. It is thought that the music intensifies the flavour of the dish and the act of wearing headphones focuses the diner's attention to the dish and the accompanying sound of the sea (Spence, 2012a). This

is just one example of cross-modal interaction. Other senses can also trigger memories – think of the smell of sun tan lotion that reminds people of their holidays, these memories that we draw on can enhance the sensory experience improving the consumer's enjoyment of food and other experiences. Perhaps such interaction could be used by parents to encourage children to eat their vegetables. It would be interesting to investigate whether playing music that triggers a happy memory in children will help them enjoy food that they would normally refuse?

Pitch

Certain sounds can impact on the overall flavour perceived. Crisinel and Spence (2010) discovered that high pitched sounds are associated with sweet and sour taste while lower pitched sounds are associated with bitter and umami taste. Further research was carried out by Crisnel et al., (2012), who served cinder toffee to consumers while playing different sound tracks aimed to enhance sweetness (higher pitched track with piano) and bitterness (lower pitched track with brass instruments). Results showed that the toffee was perceived to be significantly less sweet when the 'bitter' sound track was played. This research is rather interesting and could be useful in hospitals when giving medicine to patients, if the sweet sound track was played it may help patients "stomach a bitter pill".

However, in the research carried out in 2012 by Crisnel & Spence, the brass low pitched sounds were also associated with 'unpleasantness' whereas the high pitched piano sound was considered to be more pleasant. This may explain the association of unpleasant sound with bitterness (not liked) and the liked taste, sweetness, with the high pitched sound. Further research is required to see whether these associations are just related to liking or whether further implications are implied. If you listen to the soundtrack used in this experiment (Jones, 2014) the high pitched sound is more tuneful and therefore more pleasant than the low pitched sound track, which may explain its association with sweetness. Perhaps if this experiment used a more tuneful lower pitched brass sound compared to a less tuneful high pitched sound (harsh piccolo or violin), consumers would then alter their results and associate the more mellow brass sound with sweetness and the harsh high pitched sound with bitterness.

In a different paper, Crisinel & Spence (2009) found an association of high pitched sounds with sourness and lower pitched sounds with bitterness. They suggest that lower pitched sounds are often related to larger objects and may therefore signal danger e.g. a large predator. Higher pitched sound can also be associated with alarms signalling danger, and sourness is associated with low pH and potential danger (Crisinel & Spence, 2009). The association between sourness and high pitched sounds is easier to understand – hearing a high pitched sound can cause your face to scrunch up in a similar manner to eating a really sour orange. Likewise to produce a high pitched sound on a wind instrument such as the clarinet, you need to tense (tighten) your embouchure to reach the higher notes. Although lower pitched sounds may be related to danger, for example, the growl of a lion or the rumble of thunder. Lower pitched sounds tend to be less grating to hear and perhaps in many cases more pleasant than a high pitched sound. To produce a lower sound on the clarinet (and many other wind instruments) you need to relax your embouchure thus allowing freer movement of air around the instrument and the opening of your throat to reach the lower notes, in contrast the tingle of bitterness on a tongue causes tensing of muscles in the mouth and the unpleasant sensation leads to the need to spit the food out. This lack of similarity between relaxing the throat to product lower sounds and the tensing of the mouth that arises from bitter foods, suggests the relationship between bitterness and low pitch is not as clear.

In further, currently unpublished work, Spence (2014) found that simple changes in background colour and sound can affect the taste of wine by up to 10 per cent. Results showed that red light and 'sweet' music increased enjoyment of the wine by 9 per cent, whereas green light and 'sour' music reduced

the intensity of the wine by 14 per cent and increased the overall freshness perceived. Music selected for this research included a high pitched piccolo with choppy and staccato notes for 'sourness' (Superscriptio by Brian Ferneyhough) and a legato, soft, flowing piano music for 'sweetness' (Trois Gymnopédies, No. 2 Lent et triste by Erik Satie). This research emphasises the affect background music can have on a person's enjoyment of a glass of wine as well as the impact of colour in the multisensory experience (Woollaston & O'Callaghan, 2014).

Conclusion

It is clear that sound has an effect on sensory perception of food and drink products. The sound of the packaging or food preparation method prior to eating causes anticipation in the consumer and provides an expectation of potential properties that the product may have. The sound heard during eating plays a large role in the perception of the overall texture of the product experienced. In particular, the quality of the crispness, crunchiness or carbonation is subconsciously measured during eating, enabling the consumer to determine whether the product is fresh and safe to eat or stale and past its best. In addition to the sounds directly related to the food or drink product, further background noise or music playing can enhance the sensory experience, stimulating happy memories that can heighten the flavours perceived in food products or loud noises can reduce the intensity of flavours experienced.

Overall the relationship between sound and sensory perception is not yet fully understood. Further research is required to help understand which sounds can be used to manipulate the sensory experience and whether initial findings relating music to the increase or decrease in perception of sweet or bitter flavour could have beneficial implications such as: helping the nation deal with obesity; reducing food waste in restaurants; improving patient acceptability of medicines or children's acceptability of fruit and vegetables; and improving profitability of restaurant or café owners.

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