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Food texture assessment and preference based on Mouth Behavior

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ABSTRACT

The research presented validates the hypothesis that Mouth Behavior drives food texture choice and preferences. During qualitative research, when given a wide array of food products to choose from, there were clear texture differences between Mouth Behavior groups in the food items that were chosen as "love" or "not worth buying". The textures chosen as "loved" were those whose texture most matched their Mouth Behavior (could be easily eaten with their desired Mouth Behavior); while those foods that were rejected had textures that did not allow them to be easily eaten with their primary Mouth Behavior. These differences were then validated quantitatively, where food texture preference were shown to significantly differ by Mouth Behavior group, not only in overall texture, but also in hardness and eating time. Additionally, in previous qualitative research, study participants were found to perceive the texture of the same foods differently. Individuals tried to manipulate the product into a texture that could be eaten as desired, and therefore the texture of a given food was perceived differently by each group. This research also demonstrates that texture is not static, and that texture changes over the eating experience. The way the texture changes is of primary importance in determining food product acceptance.

1. Introduction

It is well known that texture is important to product liking and preferences. Texture can be a major reason for food rejection (Drewnowski, 1997) and one of the strongest drivers of food aversion (Scott & Downey, 2007).

In trying to understand food texture preferences, a preponderance of research has focused on describing and measuring textural attributes sensorially and then relating the sensory textural attributes to liking. Much of the research to understand the textural drivers of liking has utilized highly trained panels to describe texture and then statistically relating those textural characteristics to consumer liking (for example, candy (Kalviainine, Schlich, & Tuorila, 2000), cheese (Murray & Delahunty, 2000), poultry (Sow & Grongnet, 2010), and liquid dairy (Richardson-Harmon et al., 2000)).

In many cases, texture is analyzed in conjunction with other sensory attributes for flavor (taste and aroma). This is because flavor and texture are both drivers of food acceptance and the perception of one can change the perception of the other (Chen & Engelen, 2012; Pacikora et al., 2003).

While a significant amount of research has been done to measure texture, to group consumers based on their texture preferences (for example using cluster analysis) and to measure which textural attributes may drive liking, none of this research has focused on understanding what drives differences in textural rejection or preference. Without this understanding, food product developers rely on mathematical models to drive product formulation, without ever having a true person based/consumer understanding of why products are succeeding or failing.

Additionally, most texture research assumes that products have a static texture that can be agreed upon and described by trained panelists. Panelists are trained on a variety of attributes using standards (Munoz, 1986). The general assumption is that the properties of the food can be assessed by an overall rating of the attribute (crunchiness, cohesiveness, etc.) across the bite. In these methods, phase change such as melting are assessed, but not as a time factor (Civille & Seltsam, 2014; Lawless & Heymann, 2010). While techniques such as Time Intensity and Temporal Dominance of Sensation (TDS) do measure changes in texture over time, these techniques are not the norm, but are beginning to appear more often in research (Cheong et al., in press; Foster et al., 2011; Hutchings, Foster, Grigor, Bronlund, & Morgenstern, 2014; Kuesten, 2014).

Separately, there is a growing body of research on the oral processes during mastication. This research has highlighted some

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important findings, showing that chewing behavior varies by individual (Lassauzay et al., 2000; Po et al., 2011) and eating style (Engelen & van Doorn (in Engelen and de Wijk (2012))). Brown and Braxton (2000) also found that individuals use different mechanisms for the oral breakdown of food so that at any point, different groups of individuals would experience the samples differently. Therefore, they suggested that individual differences in the ability to manipulate and manage the product in the mouth may be a key driver of liking and personal preferences. However, the only link found in their research was a correlation between chewing force and preference.

Research by Jeltema, Beckley, and Vahalik (2014, 2015) has shown that consumers can be typed by the way they manipulate food in their mouths (Mouth Behavior (MB)) and that these groups of individuals show differences in food texture preferences. The existence of Mouth Behavior groups was first hypothesized by Jeltema and Beckley during qualitative observational research in which they noticed that individuals varied in how they wanted to use products in their mouths – for example, only a small subset of individuals wanted to hold a hard candy in their mouths until it dissolved – many crunched it with little or no time sucking it. Determining the differences between individuals and the existence of groups of individuals, the number of groups and developing an in-depth understanding of these groups adaptively evolved over a 10 year period using a series of qualitative research initiatives (over 350 h of listening, observing, and evolving the insights through the understanding). An ipsative approach, which "digs into the soul of the individual as a customer, ferrets out our needs and wants" was used to understand the individual (Moskowitz et al., 2012). Idiographs (pathways build upon what is expressly stated by an individual during a discussion anchored with some sort of stimuli) were developed by individual, and then the Mouth Behavior groups were built based on similarity of individuals expression of the experiences (Beckley & Lopetcharat, 2012). This is a ground up approach based on first thoroughly understanding the individual, and then determining how many different groupings emerge. This approach utilizes the two qualitative traditions – phenomenology and grounded theory (Creswell, 1998).

This exploratory qualitative research included observational research as well as in-depth, face-to-face inquiry into the differences in the ways individuals interacted with food and snacks. For example, individuals were asked to respond to a variety of statements aimed at understanding how they preferred to manipulate food in their mouths. They were asked to sort the statements (physically presented on cards with one statement per card) into three groups: (1) This is exactly like me; (2) This is somewhat like me; and (3) This is not like me. Some of the statements used are shown below:

- I like to suck on hard candy until it fully dissolves
- I usually break up hard candy quickly and swallow it
- I prefer hard crunchy cookies to soft chewy cookies
- I prefer soft creamy candies to hard candies

Based on more of these qualitative listening and observation studies conducted over several years (more than 350 h of observation and listening), it was hypothesized that there were four major mouth behavior groups. The categorization of these four groups are: (1) Crunchers, (2) Chewers, (3) Suckers, and (4) Smooshers. These groups fell into two major modes of mouth actions. Mode one, represented by Crunchers and Chewers, were those who liked to use their teeth to break down foods. Crunchers were more forceful in their bite and preferred foods that broke up (fractured) on biting. Chewers liked foods that could be chewed longer (the length of time varied-there seemed to be "short" Chewers and "long" Chewers) and did not fracture on biting. Mode two, represented by Suckers and Smooshers, preferred to manipulate food between the tongue and roof of the mouth. They differed primarily in the hardness of preferred foods. Suckers liked harder foods (like hard candies and items that they could hold in their mouths) that could be sucked on for a long time. Smooshers preferred soft foods, such as creamy candies (like the wrapped candy called Cow Tales^{R} (Goetze Candy Co,) or puddings that did not require much mouth activity but would spread throughout the mouth and could be held in the mouth for a long time. The key behavioral differences between Mouth Behavior groups, such as principle needs, observed behavior, and mouth action, determined from these qualitative discussions can be found in Supplementary materials (Table 1 of supplementary materials).

While this research led to the ability to type an individual through qualitative discussion, it was not until the creation by Jeltema of the JBMB® Mouth Behavior Typing Tool (Fig. 1), that quantitative validation was possible. This tool is a visual algorithm that uses an elegantly simple pictorial pattern recognition method, allowing an individual to easily type themselves, by picking the group of pictures and description that is "most like them". The descriptions, for example, "I like foods that I can crunch" are followed by foods with textures that are easy to "crunch". The other descriptions are "I like foods that I can chew". I like foods that I can suck on for a long time and I often suck on them until they dissolve" and "I like foods that I can smoosh, I even smoosh foods that I could chew".

This tool, while simple to execute, was the result of an extensive amount of iterative research and was conceived after many failed attempts using more complicated, yet traditional survey tools (Jeltema, Beckley, & Vahalik, 2014, 2015). The pictures were carefully chosen to represent those products that would best differentiate between groups. Variations on a theme were used when possible to differentiate the groupings (e.g., variations on ice cream). While an individual will probably "like" some foods in each group, on the whole, they will find one group of foods, more "like them". The use of multiple products also avoids pitfalls with specific flavors or specific foods. The textures of the foods were chosen to be those that are most easily "manipulated" by each Mouth Behavior group in the desired way. This is critical, as individuals are unaware of how they manipulate food in their mouths – thus, food textures are used to aid in that association.

The final validation of the tool was done by conducting a quantitative survey (N = 500), where individuals were typed by the JBMB® typing tool and then asked a custom word based survey (67 questions) which included a variety of behavioral questions (e.g., eat ice cream out of freezer vs. let it soften) and textural preferences (chewy cookies vs. crunchy cookies).

Responses were first compared across groups using chi-square analysis to determine whether the different mouth behavior groups were answering the questions differently followed by a discriminant analysis, using the JBMB® typing tool mouth behavior classification as the Y variable and using the questions from the word survey as the X variables. This analysis demonstrated that there were indeed different groups of individuals that could be separated using the data ($p < 0.0001$). The development of the Mouth Behavior hypothesis, through the validation of the tool are described in detail in Jeltema et al. (2014, 2015).

As hypothesized by Brown and Braxton (2000), the early observational work did demonstrate that the Mouth Behavior groups show food preference differences and that there were food textures that fit "best" with each mouth behavior (the basis of the JBMB® typing tool and shown in the discriminant analysis used to validate that tool). The aim of this research was to understand more fully the drivers of these food preference differences in terms of the textures that these groups would most prefer vs. those that they might reject, and that differences in textures that drove preference