



SONIC LOGOS AND CONSUMER BEHAVIOUR

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SONIC LOGOS AND CONSUMER BEHAVIOUR

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Nanyang Business School

A thesis submitted to the Nanyang Technological University
in partial fulfilment of the requirement for the degree of
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2024

Statement of Originality

I hereby certify that the work embodied in this thesis is the result of original research, is free of plagiarised materials, and has not been submitted for a higher degree to any other University or Institution.

7 August 2023

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Supervisor Declaration Statement

I have reviewed the content and presentation style of this thesis and declare it is free of plagiarism and of sufficient grammatical clarity to be examined. To the best of my knowledge, the research and writing are those of the candidate with amendments, changes and improvements as suggested by me as the Supervisor. I confirm that the investigations were conducted in accord with the ethics policies and integrity standards of Nanyang Technological University and that the research data are presented honestly and without prejudice.

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Professor Gemma Calvert

Authorship Attribution Statement

This thesis contains material from seven papers published in the following peer-reviewed journals / from papers accepted at conferences in which I am listed as an author.

Chapter 2 is published as Techawachirakul, M., Pathak, A., & Calvert, G. A. (2022). That sounds healthy! Audio and visual frequency differences in brand sound logos modify the perception of food healthfulness. *Food Quality and Preference*, 99, 104544.

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The contributions of the co-authors are as follows:

- I co-designed the study with Prof Calvert and Prof Pathak and performed all the online experiments on Amazon Mechanical Turk (MTurk) platform. I also analyzed the data.
- I prepared the manuscript drafts. The manuscript was revised together with Prof Calvert and Prof Pathak

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masculine or feminine (meat vs. salad) nature of food products. *SCP Annual Conference 2022* (virtual).

The contributions of the co-authors are as follows:

- I co-designed the study with Prof Pathak and performed all the online experiments on Amazon Mechanical Turk (MTurk) platform. I also analyzed the data.
- I wrote the original draft of the manuscript. The manuscript was revised together with Prof Pathak, Prof Motoki and Prof Calvert.

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Summary of Studies

This thesis investigates the impact of sogo music on consumer perception and behaviors. The sogo elements were deconstructed into frequency (high vs. low), tempo (slow vs. fast), and instrumental timbre (masculine vs. feminine). The research findings reveal that, in Chapter 2, while tempo is not associated with healthfulness, higher-frequency (vs. lower-frequency) sogos are perceived to be more associated with healthier (vs. less healthy) foods. This effect can extend to analogous visual cues (i.e., high vs. low-frequency grating images). Additionally, sogos can increase purchase intention when they are congruent with food attributes (i.e., high frequency with healthy food and low frequency with filling food).

Chapter 3 demonstrates that consumers tend to associate feminine instruments with plant-based foods and masculine instruments with meat-based foods, although the feminine-plant association is more pronounced at an implicit level. Moreover, playing a sogo with a feminine instrument can enhance the perception of plant appeal in plant-based meat alternative food and subsequent brand selection due to semantic congruence.

Chapter 4 reveals the associations between instrument type, brand personality and semantic attributes. Specifically, sogos played by feminine instruments are perceived as sincere, which can be explained by the connotation of positive valence. Sogos played by masculine instruments are rated as rugged, which can be explained by the connotation of potency. Further, creating sogos with instruments that match a brand's personality evokes congruence of brand attributes, which in turn positively impacts brand attitude and purchase intention.

In summary, this thesis has demonstrated that exposure to a brief melodic tune of a few seconds duration is sufficient to influence consumer responses providing the sogo is congruent with product/brand attributes.

Research Question Development

Research to date has demonstrated that the presence of sogos results in a positive effect on consumer responses towards brands. That said, research investigating how a brand can craft a sogo to represent a product (e.g., healthfulness, meat/plant appeals) and/or brand attribute (e.g., brand personality) remains underexplored, leaving a potential research gap. This issue is fundamentally essential as brands need to ensure that sogos are perceived as congruent with the brand and/or product they represent to maximise sogo effectiveness. Thus, the main research question of the thesis is how sogos can convey product and brand attributes and influence consumer behaviour. The thesis aimed to bridge the gap by examining the role of sogo elements (e.g., frequency, timbre) on consumer perception and behaviour toward both food attributes (i.e., food healthfulness in Chapter 2 and plant/meat appeals in Chapter 3) and brand attributes (i.e., brand personality in Chapter 4) in three chapters. The core idea of the thesis is based on semantic correspondence between sogo features and product/brand attributes, and such congruence would positively influence consumer behaviours. Given that a sound feature and a food/brand can share a common connotation, the semantic congruence between them would play a role in establishing an association between a sogo feature and a food/brand attribute.

To illustrate, previous research has demonstrated that high-frequency sounds and healthy foods share a semantic meaning of lightweight. It would be plausible that the association between frequency and healthfulness may exist in consumers' minds. Thus, Chapter 2 was performed to investigate whether hearing a high-frequency sogo would activate the concept of healthfulness through the shared semantic link of lightweight.

Chapter 3, the association between instrumental timbre and meat/plant attributes, was initiated based on the observation that musical instruments and foods are similar in terms of gender-based stereotypes. That is, brasses, for instance, and meats are often perceived as

masculine whereas woodwinds and vegetarian/vegan foods are deemed as feminine.

Although gender equity is more of a concern in this modern world, gender stereotypes are still embedded in consumers' minds, as evidenced by the persistence of the selection of food that reinforces their identity. Given this, I hypothesized that the masculine instrumental sounds would be associated with meats, while feminine with plants. Chapter 3 was conducted to investigate the hypotheses.

Lastly, brand personality is another attribute that has been perceived as masculine and feminine. Chapter 4 was conducted to investigate the relationship between gendered instrumental sounds and brand personality through the semantic link of connotative meaning. Osgood's EPA (Evaluation, Potency, Activity) framework was adopted here. I hypothesized that if the sound of a masculine instrument connotes potency, as does ruggedness (i.e., a masculine personality), hearing a sogo played by a masculine instrument would activate the concept of ruggedness through the shared meaning of potency. Thus, the correspondence between the instrumental sounds and certain brand personalities would be observed.

CHAPTER 1

Introduction

1. Introduction

Sonic logos (or sogos) are a crucial part of audio branding. A sogo is a brief and distinctive melodic sound that is specifically customized for a brand (Bonde & Hansen, 2013), which also refers to a brand's sound signature. The significance of sogos, which other audio cues (e.g., background music, atmospheric sounds) find difficult to achieve, lies in the capability to carry a brand's identity and value and differentiate one brand from its competitor (Mas, Bolls, Rodero, Barreda-Ángeles, & Churchill, 2021; Melzner & Raghubir, 2022; Müller & Kirchgeorg, 2013; Puligadda & VanBergen, 2023). In the past decade, the number of brands using sogos has risen exponentially across industries and this trend seems set to continue (SoundOut, 2021). Specifically, in the past year alone, the number of sogos has reportedly increased by 22% (McCullough, 2021). Evidently, more and more brands are recognizing their importance and investing significant resources in creating their own sonic identity (McCullough, 2021; SoundOut, 2021), the cost of which can be as high as nearly a million US dollars (Appel, 2019).

The strategic use of sogos can provide positive consequences for brands. For instance, they are adjustable and flexible enough to express brand identity across multiple audible platforms and touchpoints, from webpages, apps, TVCs, radio ads, podcasts, retail stores, and even to points-of-sale. Sonic cues can speed up the visual search for congruent products in both in-store and online settings (Minsky & Fahey, 2014). By employing a sogo, a brand can emotionally connect with its target consumers, even when the brand is not visible, as sogos can affect emotions and attitudes (Scott, Sheinin, & Labrecque, 2022). Moreover, despite their

brevity, a distinctive melodic sound can be synced with the product value (Cook, 1998) and boost brand recognition (Wazir & Wazir, 2015). When the sogo is recognized, it makes a brand more valuable and in turn, increases return on investment (McCullough, 2021). Further, they build trust (Minsky & Fahey, 2014), increase willingness to pay (Krishnan, Kellaris, & Aurand, 2012), and purchase intention (Melzner & Raghurir, 2022).

Despite these advantages, it is surprising that research examining the role of sogos in signaling product attributes are sparse, particularly in the food domain. Although previous research demonstrated the effect of background music on the perception of food attributes (e.g., healthfulness) (Huang & Labroo, 2020; Motoki, Takahashi, Velasco, & Spence, 2022; Peng-Li, Mathiesen, Chan, Byrne, & Wang, 2021), sogos are different because they are considerably shorter in duration and more stylised. The effect of sogos thus may rely on mechanisms that differ from other auditory cues. Therefore, the primary purpose of this thesis is to investigate the influence of sogos on consumer perception and behaviour; specifically, the effect of frequency, tempo, and instrumental timbre on perceived product attributes (i.e., healthfulness and meat/plant attributes) and brand attributes (i.e., brand personality).

Chapter 2 involves the study of the influence of frequency and tempo in sogos on food healthfulness. Chapter 3 involves the study of the influence of timbre of musical instruments (feminine vs. masculine) on perceived meat/plant appeals. Chapter 4 describes how the type of musical instrument (feminine vs. masculine) can influence the perception of brand personality. Lastly, Chapter 5 provides an overall discussion of the three chapters.

2. Literature review and conceptual development

2.1. Auditory cues as a source of product information

Extant literature has extensively demonstrated the effect of visual cues, such as the front of package labels (Machín, Aschemann-Witzel, Curutchet, Giménez, & Ares, 2018; Plasek et al., 2020), food packaging (colour, shape, texture, and materials; Fenko, 2019; Marques da Rosa, Spence, & Miletto Tonetto, 2019; Ye, Morrin, & Kampfer, 2020), food shape (Wang, Zhang, & Jiang, 2022), aesthetics (Hagen, 2020), and price (Haws, Reczek, & Sample, 2017) on food perception. For example, food with lighter-coloured and less colour-saturated packaging is perceived as healthier than packaging containing vivid colours (Chan & Zhang, 2022). Also, consumers associate dark (Cavallo & Piqueras-Fiszman, 2017) and artificial colours (e.g., pink, celadon, purple) (Wąsowicz, Styśko-Kunkowska, & Grunert, 2015) with unhealthy products. Notably, this research stream has provided accumulated evidence of the influence of extrinsically visual cues.

Apart from visual indicators, auditory cues also potently influence food perception and choice intention. In the last decades, the association between different sound attributes and the perception of food products has been investigated extensively. For example, the intensity of biting sounds modulates the perception of the perceived crispness of foods (e.g., chips and apples). Participants perceived the foods as crispier and fresher when the biting sounds they heard as they ate were louder (vs. softer) or higher (vs. lower) in pitch (Demattè et al., 2014; Zampini & Spence, 2004). Other research has shown a robust association between the evaluation of tastes/flavors and distinct music attributes, including pitch and tempo (see Knöferle & Spence, 2012 for a review). For instance, high- (vs. low-) pitched musical note sounds were found to be associated with sour (vs. bitter) -tasting food names (Crisinel & Spence, 2009; Crisinel & Spence, 2010b). Music played at a faster (vs. slower) tempo induced the perception of sourness (vs. sweetness and bitterness) (Bronner, Frieler, Bruhn, Hirt, & Piper, 2012; Mesz, Trevisan, &

Sigman, 2011). Moreover, auditory experiences also influence purchase intention and actual purchasing decisions at the supermarket (Biswas, Lund, & Szocs, 2019; Reinoso-Carvalho et al., 2020). For example, participants exhibited greater purchase intention towards sweet food products when exposed to higher (vs. lower) pitched voiceover advertisements (Motoki, Saito, Nouchi, Kawashima, & Sugiura, 2019). Despite this, it is surprising that the role of sogos in communicating food attributes has been underexplored. Also, given that sogos are distinctive auditory cues, the mechanism that drives the effect of sogos on consumer responses possibly differs from other auditory cues.

2.2. Sonic logos

Why is research on sogos important? Firstly, distinct from ambient/background music, a sogo contains fewer melodic notes and is of shorter duration yet sufficiently represents the overall emotions a brand wants to convey to consumers (Scott et al., 2022). While background music is not specifically created for each brand, a sogo is personalised so as to embed the brand's key elements into consumers' minds (Bonde & Hansen, 2013). Secondly, a sogo is more flexible and adjustable as it lends itself better to presentation across different physical and digital touchpoints, including commercial ads, point of sales, public events, and branded playlists (Bonde & Hansen, 2013; Scott et al., 2022). Especially in the digital era when people use secondary devices like smartphones, tablets, and laptops for entertainment, shopping and even while watching TV, sogos become ever more important in keeping brands connected with consumers.

Lastly, sogos potentially play a role in branding and influence consumer responses (Mas et al., 2021; Melzner & Raghubir, 2022). For example, an fMRI study showed that sogos are associated with brand logos (Sung, Choi, Chung, & Kim, 2011). The study showed that when

consumers become familiar with a brand logo advertised in combination with its sogo, they can auditorily imagine that sogo just by seeing the familiar brand logo, as indexed by the activation of the superior temporal gyrus which has been implicated in auditory imagery (Sung et al., 2011).

Research into sogos has gained momentum in recent years according to the Scopus database. I retrieved articles published in the Scopus database using the search terms (“sonic logo” OR “sound logo” OR “audio logo”) AND (consumer behavio*) and looked for articles published between 2012 and 2024 with the terms in the title, the abstract or the keywords. 18 articles were identified. Seven articles were excluded: One review article, one conference paper, two articles on different areas (i.e., sound engineering and musical intelligence assessment), and three articles which are the products of this thesis (as reported in Chapters 2 - 4). Thus, 11 research articles remained (see Table 1).

Extant research demonstrated the positive effects of sogos on advertisements (e.g., Kemp, Cho, Bui, & Kintzer, 2023; Scott et al., 2022). For instance, a happy (vs. sad) sogo placed in an advertisement causes favourable attitudes towards the ad and brand (Scott et al., 2022). Advertisements embedded with a sogo (vs. no-sogo) can stimulate positive emotions, brand engagement and brand experience, especially in decision contexts where individuals are experiencing negative feelings (i.e., delay of payout from a car accident claim) (Kemp, Cho, et al., 2023). Moreover, the positive effect can extend to healthcare settings. Research showed that the presence (vs. absence) of a sogo in a healthcare commercial helps alleviate negative emotions in consumers and enhances trust in the provider. Even consumers who are less engaged in mental health are likely to perceive the provider as more competent and empathic compared to the no-sogo condition (Kemp, Kopp, & Bui, 2023). Also, a recent survey on commercial sogos (e.g.,

Whatsapp) demonstrated that sogos positively affect brand equity, in which brand awareness contributes most to brand equity (Das, Sandhu, & Mondal, 2022).

Further, variations of sogo elements (e.g., pace, intensity) can alter physiological states and pleasantness. For example, fast paced sogos increase physiological arousal, while slow paced ones decrease heart rate (Mas et al., 2021). Sogos with a slow pace and faded-up intensity (vs. fast and faded-down) are rated as simpler and more pleasant (Mas, 2019).

In recent years, research has revealed that manipulation of sogo elements (e.g., pitch, timbre) can also communicate brand personalities. For example, sogos with ascending pitch and faded-up (vs. descending pitch and faded-down) are less exciting and less aggressive (Mas, 2019). Sogos played with a rough (vs. smooth) sound influence the perception of ruggedness (vs. sophistication) (Melzner & Raghubir, 2022). Moreover, whether the sogos are played with familiar (e.g., piano) or distinct instruments (e.g., synth bass) also affects the perception of a brand's personality, specifically ruggedness and sophistication (Puligadda & VanBergen, 2023). The authors further posited that an instrument played in a sogo is as important as a visual logo's elements on brand personality perception (Puligadda & VanBergen, 2023).

The effect of sogos on consumer behaviour has also been well documented. Previous research has shown that when the sogo's attributes are congruent with the brand personality, it can enhance purchase intention for the associated products (e.g., rugged product advertised by a rugged sogo) (Melzner & Raghubir, 2022). This effect is driven by the semantic congruence between rugged sounds and a brand's personality of ruggedness (Melzner & Raghubir, 2022; Knöeferle, Knoeferle, Velasco, & Spence, 2016). Knöeferle et al. (2016) further explained that when the sogo is semantically congruent with the product, it leads consumers' attention towards the product and facilitates visual search for the product and the selection of it. Moreover, the

design of notes on sogos can influence willingness to pay (Krishnan et al., 2012). The author identified that the sogos composed of six (vs. three and nine) notes is optimal to influence willingness to pay. The effect is attributed to processing fluency. Although three-note sogos are the easiest to process, familiarity turns out to evoke feelings of ordinariness and therefore less willingness to pay (Krishnan et al., 2012). However, the fluency of processing the six-note sogos are at a moderate level which in turn facilitates willingness to pay, whereas willingness to pay towards the nine-note sogos decreases due to the chunking effect of human short-term memory (Krishnan et al., 2012).

In conclusion, research to date has demonstrated that the presence of sogos results in a positive effect on consumer responses (e.g., emotion and purchase intention) and brands (e.g., brand equity) in relation to advertisements that do not include a sogo. The manipulation of sogo elements affects physiological states and perception of brand personality. More importantly, a sogo that is crafted to be congruent with brand attributes can influence purchase intention and willingness to pay. While the positive effect of sogo has been documented, there is scant research investigating how a brand can design a sogo to represent a product (e.g., healthfulness, meat/plant appeals) and/or brand attribute (e.g., brand personality)¹. This issue is fundamentally essential as brands need to ensure that sogos are perceived as congruent with the brand and/or product they represent to maximise sogo effectiveness.

Thus, to address this gap, this study will examine the role of sogo elements (e.g., frequency, timbre) on consumer perception and behaviour toward both product and brand

¹ This note is to clarify the research gap on brand personality. At the time of conducting research and article submission, there were only articles of Mas et al. (2021) and Mas (2019) researching on brand personality. The articles of Melzner & Raghbir (2022) and Puligadda & VanBergen (2023) which examined Aaker's brand personality scale had been published after the article submission.

attributes. At the level of product attribute, this study focuses on the food attributes of healthfulness and plant/meat appeals; see Chapters 2 and 3, respectively). For brand attributes, this study focuses on brand personality (see Chapter 4). It is important to note that the current study differs from the extant literature on sogos and brand personality in several aspects. For example, Mas et al. (2021) used different brand personality scales (Geuens, Weijters, & De Wulf, 2009) while Aaker’s scale (1997) was used in connection with the studies reported in this thesis. While previous research (Melzner & Raghurir, 2022; Puligadda & VanBergen, 2023) investigated just two dimensions of Aaker’s brand personalities, this thesis explores these associations across all five dimensions. To avoid repetition, potential research gaps in each study will be discussed further in the corresponding chapters. Therefore, the purpose of this thesis is to enhance our knowledge about how brands can manipulate sogo elements (e.g., frequency, timbre) to communicate their product and brand attributes (see Figure 1 for research framework).

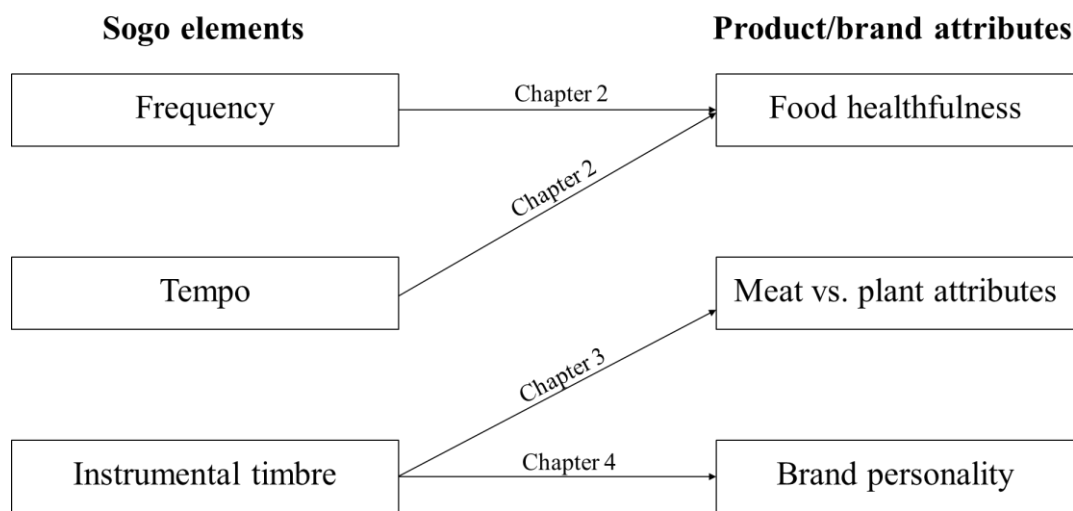


Fig. 1. Research framework.

Table 1*Overview of literature on sonic logos.*

Author	Sogo manipulation	Measurement	Summary of findings
Krishnan, Kellaris, & Aurand (2012)	The number of notes (3, 6 vs. 9)	Willingness to pay	The number of tones in a sogo influences willingness to pay for an advertised product in an inverted U shape (six notes is optimal). This is due to moderate level of processing fluency of the six notes.
Knoeferle, Knoeferle, Velasco, & Spence (2016)	Sogo (congruent with the target, incongruent vs. no-sound)	Use of eye tracking to measure attention (i.e., fixation point), and visual search tasks to measure reaction times of searching	The presence of products' sogo can crossmodally speed up consumer's visual search for and selection of the products, compared to the no-sound and incongruent (i.e., presence of different product's sogo) condition. Also, the semantic congruence between sounds and products leads attention towards the products and modulates the perceptual saliency of the product targets.
Mas (2019)	Intensity (fade up, fade down vs. constant) x pitch (ascending, descending vs. constant) x pace (fast vs. slow)	Emotion, pleasantness and brand personality	Descending sogos are down-to-earth. Slow and faded-up (vs. fast and faded-down) sogos are rated as simpler and more pleasant. Ascending pitch and faded-up (vs. descending pitch and faded-down) sogos are less exciting and less aggressive.
Mas, Bolls, Rodero, Barreda-Ángeles, & Churchill (2021)	Intensity (fade up, fade down vs. constant) x pitch (ascending, descending vs. constant) x pace (fast vs. slow)	Orienting response, emotions and brand personality perception	Sogos with fast (vs. slow) pace increase (vs. decrease) heart rate; and fast sogos with fade up and ascending pitch are judged as more exciting and descending pitch as more pleasant.
Das, Sandhu, & Mondal (2022)	Commercial sogos (survey method)	Brand equity	Sogos positively affect brand equity. Brand awareness contributes to the relationship the most, while brand quality the least.

Author	Sogo manipulation	Measurement	Summary of findings
Melzner & Raghbir (2022)	Timbre (rough vs. smooth sounds)	Brand personality perception	Timbre sound quality (roughness vs. smoothness) influences brand personality (ruggedness vs. sophistication) perception and purchase intention. This is driven by shared abstract meaning between the sounds and brand personalities.
Scott, Sheinin, & Labrecque (2022)	Emotions (happy vs. sad)	Advertisement and brand attitude	A happy (vs. sad) sogo placed in an advertisement produces higher attitudes towards the ad and brand.
Azizi, Karamyar, & Eivazinezhad (2023)	Tempo (slow vs. fast) x phrasing (legato vs. staccato)	Brand attitude	The Nescafe's sogo with staccato (vs. legato) results in positive (vs. negative) brand attitude, regardless of tempo.
Kemp, Kopp, & Bui (2023)	Sogo (present vs. absent)	Negative emotions, trust, competence and empathy of the healthcare provider	The presence of a sogo can relieve negative emotions and enhance trust in the healthcare provider. For consumers who are less engaged in mental health, a sogo also enhances perceived competence and empathy for the provider.
Kemp, Cho, Bui, & Kintzer (2023)	Sogo (present vs. absent)	Positive emotions, brand engagement and brand experience	A sogo embedded in a commercial helps evoke positive emotions, brand engagement, and stimulate brand experiences for consumers who score high in emotion-based decision making.
Puligadda & VanBergen (2023)	Timbre (distinct instruments)	Brand personality perception	The instruments used in sogos influence brand personality (ruggedness vs. sophistication) perception due to conceptual and visceral mechanisms.
This research	Frequency (high vs. low) x tempo (fast vs. slow)	Food healthfulness	The semantic congruence between high- (vs. low-) frequency sogos and health (vs. satiation) can increase purchase intention.

Author	Sogo manipulation	Measurement	Summary of findings
This research	Timbre (masculine vs. feminine musical instruments)	Meat and plant attributes of foods	Sogos played with feminine sound instruments increase the perception of plant appeal due to the shared semantic meaning of gender stereotypes.
	Timbre (masculine vs. feminine musical instruments)	Brand personality and connotative meanings	Sogos created using feminine instruments that connote positive valence are matched on the dimension of sincerity. Those created using masculine instruments that connote potency are matched with ruggedness. Creating sogos with instruments that match a brand's personality positively impacts brand attitude and purchase intention due to perceived congruency.

2.3. Crossmodal correspondences

2.3.1. Definition

In everyday life, we experience objects around us through our senses of sight, hearing, touch, smell and taste. Certain characteristics can only be perceived through specific senses. For example, we can judge the colour or brightness of an object through vision, pitch of a sound through audition, and the weight of an object through dynamic touch. However, in circumstances when a stimulus is presented alone in one sense without being accompanied by other senses (e.g., listening to music which cannot be seen and touched), we are often able to describe the sensory input using attributes typically associated with another sense. For example, we may describe a sound as “bright” even though is a visual characteristic, or a sound as “heavy” even though weight is a tactile characteristic. This suggests that such features are not necessarily restricted to only one sensory modality, but instead can be experienced through different sensory modalities simultaneously (Walker, 2016). As Spence (2011) and Walker (2016) propose, perhaps these features are conceptual in nature, allowing them to be perceived through different senses to which they are directly associated. By this mechanism, sounds can share their perceived brightness with visual stimuli and their perceived weight with tactile stimuli (Walker, 2016).

A basic feature of sound, such as pitch, can guide listeners in interpreting missing information, such as brightness. It is suggested that crossmodal correspondences facilitate this processing of filling in missing information (Spence, 2011; Walker, 2016). Crossmodal correspondence is defined as a tendency for an attribute or a feature in one sensory modality (e.g., audition) to be associated (or matched) with another sensory feature from another modality (e.g., vision) even though the features do not share any obvious commonalities (Parise & Spence, 2013; Spence, 2011). Generally, people can match, either physically presented or imagined,

stimuli that are presented in different sensory modalities (Spence & Parise, 2012). For example, a high-pitched sound may be associated with a small, bright object, while a low-pitched sound may be associated with a large, dark object, even though pitch and visual characteristics like size and brightness are perceived through different senses.

A large body of research has demonstrated that people consistently experience perceptual associations between sensory features (see Knöferle & Spence, 2012; Spence, 2011 for a review). For example, when participants were asked to draw pictures of the music they were listening to, they tended to draw lines and forms in the upper part of the page for higher pitch sounds and thicker lines for louder sounds (Küssner & Leech-Wilkinson, 2014). Higher pitch is also associated with thinness, small size (Evans & Treisman, 2010; Gallace & Spence, 2006), light weight, colour brightness, and angular shape (Marks, 1987), as well as upward position, fruity odours, and sweetness (Deroy, Crisinel, & Spence, 2013). Moreover, loudness is found to be reliably mapped with high contrast images, bright colours (Marks, 1987), and large shapes (Smith & Sera, 1992); timbre and tempo with tastes and temperature (Knöferle & Spence, 2012; Wang & Spence, 2017), to name but a few. The mechanism of crossmodal correspondence has often been investigated using speeded classification and implicit association tests (IAT). These experimental methods are useful for studying crossmodal correspondences because they can reveal automatic associations between features from different sensory modalities that may not be consciously accessible or easily verbalized.

2.3.2. Speeded classification paradigm

The speeded classification paradigm provides evidence that enhances our understanding of crossmodal correspondences. The paradigm posits that congruence between stimuli from different sensory modalities can facilitate faster and more accurate perception compared to

incongruent stimulus pairings (e.g., Bernstein & Edelstein, 1971; Gallace & Spence, 2006; Marks, 2004; Walker & Walker, 2012). In a speeded classification task, participants are required to classify a relevant stimulus from one modality (e.g., a visual image) while ignoring an irrelevant stimulus from another modality (e.g., a sound) presented simultaneously. If the two stimuli are incongruent, selectively attending the relevant stimulus becomes difficult as the irrelevant stimulus may interfere with classification latencies. However, if there is a correspondence between the two stimuli, the congruent pairing facilitates stimulus classification. For instance, Marks (1987) found that a brighter (vs. darker) visual stimulus was classified faster when it was paired with a high- (vs. low-) pitched tone (i.e., congruent) than when it was paired with incongruent tone pitches.

Consistent with one seminal work by Gallace and Spence (2006), the authors had participants judge whether an experimental disk was larger or smaller than a standard disk while simultaneously presenting an irrelevant sound which varied in frequency (i.e., high vs. low). The congruent condition included the presentation of a larger (vs. smaller) disk with a low (vs. higher) frequency sound and the incongruent condition included the opposite pairing. The results revealed that speed latencies were shorter in the congruent condition than the incongruent one. This is also the case even when participants were instructed to ignore the sound. The influence of sound frequency that affects visual judgment indicates the importance of the compatibility between sensory signals on perceptual and judgment tasks.

The facilitating effect of congruent crossmodal pairings in the speeded classification paradigm has been demonstrated extensively across various correspondences. For example, Walker and Walker (2012) investigated the correspondence between brightness and size, where relevant stimuli were visual disks that varied in brightness while the irrelevant stimuli were

response keys that differed in size (smaller or bigger). Participants were instructed to discriminate the brightness of the disk as quickly as possible by pressing the hidden response keys with their left or right hand. The results showed that the participants responded more quickly to brighter (vs. darker) disks when using more the smaller (vs. bigger) response key. This finding confirms the facilitating effect of congruent pairings, where the correspondence between brightness and size led to faster response times when the brighter disk was paired with the small key.

2.3.3. Implicit association test

An alternative approach to investigate the mechanism underlying crossmodal correspondence is through the use of the IAT. The IAT has previously been used to measure the strength of associations between two concepts at an implicit level (Greenwald & Farnham, 2000; Nosek, Greenwald, & Banaji, 2005). The test has successfully demonstrated that the associations between two items from different sensory modalities (e.g., sound and taste, odour and touch) can occur at an implicit level and do not necessarily require explicit cognitive processing (e.g., Demattè, Sanabria, & Spence, 2007; Knöferle & Spence, 2012; Parise & Spence, 2012; Spence & Deroy, 2013). The IAT is a computer-based task that presents participants with words or images related to specific concepts (e.g., gender, race, or brands), and they must sort these stimuli (i.e., targets) into one of two categories (i.e., attributes). The task comprises both compatible and incompatible blocks. In compatible blocks, congruent stimuli (those sharing stronger associations) are mapped onto the same response keys. For instance, small circles and high-pitched tones might share the same response key. In incompatible blocks, incongruent stimuli are mapped onto the same key responses. For example, a large circle and a high-pitched tone might share the same key. Their task is to categorise the stimuli as quickly and accurately as

possible, and their reaction time is recorded. The IAT effect is calculated by the difference in reaction time between the congruent and incongruent trials. Faster reaction times indicate stronger associations between the concepts and attributes.

Using the IAT, Praise and Spence (2012) conducted five experiments to investigate the correspondences between visual stimuli (e.g., that differed in size, shape) and auditory stimuli (e.g., that differed in pitch, or words). In each trial, the visual and auditory stimuli (one stimulus of each at a time) were presented on the screen for just 300 milliseconds (ms) before disappearing. The results across five experiments indicated a notable compatibility effect; that is, more accurate responses were observed in trials where stimuli were expected to be congruent compared to incongruent. More importantly, the authors highlighted that the influence of auditory-visual correspondence was evident (using a bin analysis) even in the fastest participant's responses, which were elicited within 400ms of stimulus onset. Such rapid onset indicated that the crossmodal congruency effect can occur at the implicit (or unconscious) level (Parise & Spence, 2012; Spence & Deroy, 2013). The findings are consistent with a neuroscience study where shape-word correspondences were examined using electroencephalography (EEG) (Kovic, Plunkett, & Westermann, 2010). The study found the compatibility effect within 140-180ms after stimulus onset, as indicated by the latencies of event-related potentials (ERP), reflecting neural activities generated from a related brain area in response to the stimulus. Given that the congruence between sensory modalities can be rapidly processed within milliseconds after stimulus onset, it is evident that crossmodal correspondences can occur at an implicit level before the information is registered at an explicit level, which requires longer latencies (around 600-700ms after the stimuli onset, Calvert, 2015).

2.3.4. Three types of crossmodal correspondence

Structural correspondence. Structural correspondence is thought to occur on a neural basis (Evans & Treisman, 2010; Spence, 2011). Evidence from research on synesthesia, a condition where stimulation in one sensory modality leads to involuntary experiences in another modality, suggests that crossmodal correspondences may arise due to the close proximity of brain regions responsible for processing different senses. For instance, in colour-grapheme synesthesia, where individuals perceive colours when seeing numbers or letters, this phenomenon could be linked to the close proximity of the colour area (V4) and the number-grapheme area in the fusiform gyrus (Ramachandran & Hubbard, 2001). Moreover, damage to the temporal-parietal-occipital (TPO) region, a multisensory processing area, has been observed to cause patients to incorrectly map shapes with corresponding sounds (Ramachandran & Hubbard, 2003). Based on this evidence, it is postulated that the congruency effect between auditory and visual stimuli may be modulated by the TPO region, which enhances the perceptual salience of congruent crossmodal stimuli (Evans & Treisman, 2010). The close proximity of sensory processing areas in the brain could thus facilitate the integration of congruent features across modalities, leading to more efficient processing and faster response times in tasks like speeded classification.

Another example of structural correspondence has been identified in the inferior parietal cortex, which is responsible for the detection of stimulus magnitude (Spence, 2011; Walsh, 2003). This region has been implicated in the mapping between magnitude-based stimuli, such as louder sounds and brighter visual stimuli (Spence, 2011). Such stimuli mapping may be related to the neural connections that process the input from different sensory modalities in similar ways (e.g., the similar rate of neural firing responded to the magnitude of the stimuli, Spence, 2011; Walsh, 2003). Given that the loudness-brightness association was observed even in 3-week-old

infants when linguistic development is not yet matured (Lewkowicz & Turkewitz, 1980), it is possible that such structural correspondence may be innate (Spence, 2011). Taken together, it is suggested that structural correspondence can result from the influence of proximal brain areas, multisensory areas and similar neural coding and can serve as a mechanism for the sensory features that are processed by adjacent brain areas and/or have similarity in neural coding.

Statistical correspondence. The second type of crossmodal correspondence is thought to occur as a result of the brain's adaptive response to regularities in the surrounding environment (Spence, 2011). Spence has posited that the correspondence reflects our internalization of the statistical correlations between different sensory attributes in the natural world. For example, consider the natural co-occurrence of thunder and lightning. The loudness of the thunder and brightness of the lightning are statistically and naturally correlated events. Our brains may internalize this regular pairing of loud sounds with bright visual stimuli, leading to the development of a loudness-brightness association (Spence, 2011).

Statistical correspondence can be effectively explained by the concept of coupling priors in Bayesian integration theory (e.g., Ernst, 2007; Parise & Spence, 2009; see Spence, 2011 for a review). This suggests that the notion of crossmodal correspondence might be based on prior knowledge regarding the co-occurrence of sensory signals. Moreover, repeated exposure to stimuli that co-occur can also impact the intensity of coupling priors and hence determine the strength of the crossmodal associations (e.g., Ernst, 2007; Teramoto, Hidaka, & Sugita, 2010). To illustrate, Ernst (2007) conducted an experiment to train participants on artificial correlations between the brightness of a visual object and the stiffness of a tactile object, which are not naturally correlated, to form coupling priors. As expected, participants learned to automatically associate the two previously unrelated sensory signals after the training.

In the natural world, we are repeatedly exposed to pairs of correlated stimuli over time which can easily reinforce the strength of coupling priors. Thus, our brains may utilize the regularities in nature when judging which sensory features should be combined together (Shepard, 1994; Von Kriegstein & Giraud, 2006). For instance, a sound frequency emitted by an object tends to correlate with its size and shape (Spence & Zampini, 2006). Larger objects typically produce lower frequencies when vocalised (Smith, Patterson, Turner, Kawahara, & Irino, 2005), dropped (Grassi, 2005), or struck (Coward & Stevens, 2004). Concordantly, some animals appear to produce lower frequency sounds to increase their apparent size (Bee, Perrill, & Owen, 2000). This illustrates the numerous statistical correlations that exist among stimuli perceived through auditory, visual, and tactile senses. Such natural correlations help explain the consistent crossmodal associations documented in research, such as pitch-visual size correspondence and pitch-visual elevation correspondences (e.g., Evans & Treisman, 2010; Gallace & Spence, 2006). Accordingly, when preschoolers were asked to indicate which bouncing ball on the screen was making the sounds they were listening to, they were likely to point to a smaller (vs. larger) ball for the higher-frequency sounds (Mondloch & Maurer, 2004). Given that statistical correspondences can be established based on experiences of environmental regularities, it can be considered as a mechanism for associations where certain pairs of stimuli regularly co-occur.

Semantic correspondence. A third explanation for crossmodal correspondence involves linguistic labelling (Walker, 2016), also referred to as semantic correspondence (Spence, 2011). One of the most cited examples is the association between pitch and elevation, where the words "low" and "high" are used across various languages to describe changes in pitch, and vertical elevation (Stumpf, 1883). This linguistic overlap suggests that the mapping between auditory

pitch and visual elevation may arise from the shared use of linguistic terms to describe these distinct sensory features (Spence, 2011). By using the same words (e.g., “high” and “low”) to refer to both pitch and elevation, our language may reinforce the association between these dimensions leading to the development of a crossmodal correspondence. Martino and Marks (1999) proposed the semantic coding hypothesis to explain these associations, suggesting that crossmodal associations can occur once perceptual data has been recoded into an abstract format shared by both linguistic and perceptual systems. Simply put, semantic correspondence emerges after language development once sensory signals can be linguistically described. Moreover, one sensory feature can be described or associated with more than one perceptual continuum (i.e., attribute). For example, higher- (vs. lower-) pitched sounds are often described as sharper, smaller and brighter (Evans & Treisman, 2010; Gallace & Spence, 2006; Martino & Marks, 1999; Spence, 2011; Walker, Walker & Francis, 2012).

Consistent with research illustrated by Walker et al., 2012, semantic correspondences can arise because similar connotative meanings align across different senses (Karwoski, Odbert, & Osgood, 1942). Walker and colleagues (2012) demonstrated that the core set of crossmodal correspondences emerged among three different senses (vision, audition, and touch). In the study, participants were exposed to different stimulus types (i.e., listening to pure tones varying in pitch, touching unseen wooden balls varying in size and viewing circles varying in size, brightness and sharpness) and were then instructed to rate each stimulus as quickly as possible on semantic differential scales. The scale presented a pair of antonyms of connotative meaning such as bright-dark, small-big, fast-slow, light-heavy in weight, high-low in pitch, upward-downward, sharp-blunt.

The results showed that different sensory stimuli were rated in similar patterns across modalities. For example, brighter (vs. darker) visual stimuli were judged to be sharper (vs. blunter) and smaller (vs. bigger), and that similar judgments were assigned to high- (vs. low-) pitched sounds, smaller (vs. larger) tactile and sharper (vs. blunter) visual stimuli. This similar pattern across sensory signals reflects that different sensory modalities can provide corresponding information about a stimulus (Walker et al., 2012), suggesting shared connotative meanings across various dimensions enable us to match or associate stimuli encoded in different senses (Martino & Marks, 1999; Spence, 2011; Walker et al., 2012; Walker, 2016).

The semantic correspondence effect has also been documented in the domain of food research to demonstrate sound-taste associations. For example, Crisinel and Spence (2009; 2010a) showed that high- (vs. low-) pitched sounds are preferentially matched with sweet (vs. bitter) tastes, presumably due to the shared meaning between pitch and taste (Crisinel & Spence, 2009; Crisinel & Spence, 2010a). That is, 'sweetness' and 'high' may similarly connote positive meaning while both low pitch and bitterness signal danger (Crisinel & Spence, 2009; Crisinel & Spence, 2010a). Since the semantic associations were observed using the IAT, it suggests these crossmodal correspondences in food stimuli can occur at an implicit level. While the research used food names as stimuli, subsequent research has been conducted on real food tastes and yields similar associations (Crisinel, Cosser, King, Jones, Petrie, & Spence, 2012). The study revealed that consumers taste a cinder (i.e., honeycomb) toffee as more bitter while listening to a bitter-evoked soundtrack, whereas the same toffee tasted sweeter while listening to a sweet-evoked soundtrack (Crisinel et al., 2012). Given that semantic correspondences are thought to be based on common semantic meanings, this suggests the correspondence effect can occur at the abstract level (e.g., connotative meaning) through the shared meaning between two

concepts/stimuli (Spence, 2011; Walker, 2016). Thus, this mechanism would work best for stimuli with similar semantic meaning/attributes. Relevant to the thesis, we propose this is the most likely mechanism to explain the correspondence between sogos and food attributes.

2.4. Spreading activation theory

To understand further how crossmodal correspondences between stimuli can explain the influence of sogos on consumer responses, the spreading activation theory is introduced (Anderson, 1983; Collins & Loftus, 1975). This theory suggests that semantic memory networks consist of associative concepts (i.e., nodes representing product attributes) that are linked together. When one concept is activated, the activation spreads through the links to all connected concepts. The stronger the link, the faster and greater the activation spreads. Once the activation of a concept exceeds a certain threshold, the activated concept is retrieved and processed. In essence, spreading activation occurs through the processing of concepts that have similar semantic meanings (Hutchison, 2003; Meyer & Schvaneveldt, 1971). To illustrate, a recent study revealed that angular-shaped cakes and cookies are perceived as healthier than their rounded counterparts due to their shared association with the concept of healthfulness (Wang et al., 2022). Angularity has relevant meanings linked to healthfulness (i.e., a utilitarian attribute), while roundedness is associated with unhealthfulness (i.e., a hedonic attribute) (Wang et al., 2022). Thus, the activation of angular (vs. rounded) concepts is transmitted to the concept of healthy (vs. unhealthy) food, forming the association between shapes and healthfulness. As a result, consumers who harbour a healthy (vs. tasty) goal tend to buy more angular (vs. rounded) foods (Wang et al., 2022).

Given these findings, it is plausible to assume that semantic correspondences can genuinely affect consumer responses. We thus assume that, Study 2 for instance, if a sogo element (e.g.,

frequency) that shares semantic meaning/connotation with food attributes (e.g., healthfulness) is activated, the activation would spread to healthy foods as opposed to unhealthy foods; it would then establish the sogo-healthy association in consumers' minds and eventually influence consumer perception and behaviour. Note that assumptions for other associations reported in Chapters 3 and 4 will be discussed within the chapters.

3. Overview of studies

In Chapter 2, Study 1 investigates the association between frequency and tempo with healthy (vs. unhealthy) foods (e.g., salad vs. burgers). Study 2 validates this effect within the same food categories by showing an association between healthier (vs. less healthy) foods (e.g., soy vs. bacon burgers). Study 3 demonstrates that the frequency effect can generalise to the visual modality by demonstrating an association between high- (vs. low-) frequency grating images and healthy (vs. unhealthy) foods. Next, a follow-up study reveals that sogo frequency can also signal how filling the associated food is and influence purchase intention. Specifically, Study 4 shows that food presented with a high-frequency (vs. low-frequency) sogo is perceived as less (vs. more) filling due to the perception of the heaviness of the food. Study 5 demonstrates that when consumers hold a consumption goal of health (vs. satiation), a high-frequency (vs. low-frequency) sogo can enhance purchase intention through perceived congruency.

In Chapter 3, Study 1 provides initial evidence of an association between feminine (vs. masculine) instruments and plant-based (meat-based) meals. Study 2 extends this finding further to illustrate that this association is valid within the same food categories; that is feminine (vs. masculine) instruments are more matched with feminine (masculine) food items in the meat (Study 2a) and plant (Study 2b) categories. Study 3 demonstrates the feminine-plant and masculine-meat associations at an implicit level. Further, Study 4 shows that feminine

instruments can enhance the perception of plant appeal in plant-based meat foods through the mechanism of perceived gender of instrumental sounds, and subsequent brand selection (Study 5).

In Chapter 4, Study 1 explores the associations between feminine (vs. masculine) instruments and brand personality across five dimensions of Aaker's scale (1997). Study 2 explores the association between feminine (vs. masculine) instruments and connotative meanings. Results showed a relationship between feminine instruments and sincerity (Study 1) and positive valence (Study 2). Similarly, the relationship between masculine instruments and ruggedness (Study 1) and potency (Study 2) is observed. The findings indicate that connotative meanings account for the timbre-brand association based on gender stereotypes. Study 3 demonstrates that when songs played with instruments that match a brand's personality, they evoke congruence with brand attributes, which in turn positively impacts brand attitude and purchase intention.

CHAPTER 2

That sounds healthy! Audio and visual frequency differences in brand sound logos modify the perception of food healthfulness

Abstract

Sonic logos (or brand sound signatures), also termed “sogos”, are a marketing communication tool that brands invest in heavily to signify brand or product benefits to consumers in catchy, non-visual ways. Given the considerable utility of brand sogos, it is surprising that to date there has been scant research into the nature of the specific acoustic features that can be modulated to connote certain traits, including in the current paper, to signify the healthfulness of products within the food category. Our findings as described across five studies revealed that sogos created with higher (vs. lower) frequency were indeed significantly matched with healthy food products (vs. less healthy), while the effect of tempo was neutral. Interestingly, this effect generalizes to high- (vs. low-) spatial frequency visual stimuli too. Further, foods presented with sogos created with higher (vs. lower) frequency were also perceived as less (vs. more) satiating due to the perception of food lightness (vs. heaviness). Consequently, amongst participants who regarded health (vs. satiability) as more important, high (vs. low) frequency sogos resulted in higher stated purchase intention. The current study contributes to literature on the crossmodal correspondence between acoustic sound clips and expectations of healthfulness. It also advances theoretical insights into business applications by using optimal sogos that are congruent with visual cues on packaging and consumer motivation to drive healthy consumption behaviour.

Keywords: Crossmodal correspondence; Sonic logos; Food healthfulness; Frequency; Tempo; Sensory branding

1. Introduction

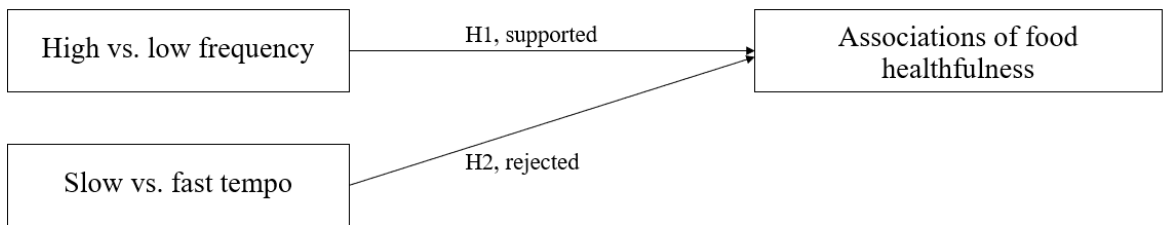
Sensory stimuli (e.g., sounds, colours) play a prominent role in branding. A sonic logo (also termed a sogo) is an integral part of branding and is comprised of a short melody created to support the marketing of a specific brand by some semantic association with the unique selling proposition that the brand offers e.g., McDonald's "I'm loving it" sogo which is crafted in a major key such that it sounds pleasing and playful (Bonde & Hansen, 2013). Compared to other audio assets, sogos tend to be more flexible and adjustable as they can be used across a variety of physical and digital touchpoints to help connect brands to customers at a deep, implicit level in a less cluttered (non-visual) sensory domain (Bonde & Hansen, 2013; Goyal, 2019). These unique properties distinguish sogos from other audible marketing tools, such as background music played in-store or TV advertisements which are not designed necessarily to convey brand identity. Brands thus invest time and financial resources to the creation of these distinctive sound signatures which become a part of their brand identity (e.g., Windows's start-up chime) and consumers quickly learn the association between these short clips and the brands they represent (Goyal, 2019). Importantly, brand managers and agencies need to ensure that sogos are perceived as congruent with the brand and/or product they represent. Recent research suggests that when music is congruent with the associated food/beverage attributes (e.g., 'sweet music' played with the presentation of a sweet meal), participants fixate their eyes on the meal longer, reflecting higher attention, than incongruent combinations (Peng-Li, Byrne, Chan, & Wang, 2020). Congruency between product category and the sound of a brand name can also influence positive responses towards food products including taste expectations and purchase intention (Fenko,

Lotterman, & Galetzka, 2016; Lee & Labroo, 2004; Reber, Schwarz, & Winkielman, 2004). The authors suggest this is because such congruent stimuli enhance the ease of processing, which in turn leads to a more pleasant experience. Thus, achieving this sense of perceptual congruence is important in the context of sogos.

The growth of consumer interest in healthier food choices has urged brands to strive for strategies by which to communicate food healthfulness in competitive markets. While past research on acoustic influences on consumer decision making has mostly focused on how ambient music and background noise influences choice behavior (including the selection of healthy items), similar research on sogos is sparse (e.g., Biswas, Lund, & Szocs, 2019; Mathiesen, Mielby, Byrne, & Wang, 2020). Within the food category, creatively crafted sogos have been used to connote food flavours (e.g., vanilla and citrus) (Bronner, Frieler, Bruhn, Hirt, & Piper, 2012), to create brand recognition (Bonde & Hansen, 2013), and to influence willingness-to-buy the associated product (Krishnan, Kellaris, & Aurand, 2012). Given the considerable utility of brand sogos, it is surprising that to date there has been scant research into the nature of the specific acoustic musical features that can be modulated to connote certain traits (e.g., healthfulness). While previous studies have demonstrated that music can influence consumer decision making processes towards healthy foods through underlying mechanisms of morality cues (Huang & Labroo, 2020), music-evoked emotion and arousal (Motoki, Takahashi, Velasco, & Spence, 2022), and visual attention (Peng-Li, Mathiesen, Chan, Byrne, & Wang, 2021), the current research enriches the literature on acoustic influences on consumer perception and behaviours by systematically evaluating the effect of frequency and tempo present in hypothetical brand sogos on the association with food healthfulness and purchase intention (see Figure 1 for research framework). Frequency and tempo are focal variables because they are

fundamental parameters in music that can connote meaning in a given context (Bonde & Hansen, 2013; Van Leeuwen, 1999). The two parameters are disentangled because they are independent, which means a given musical piece can be played at any combination of frequency and tempo, such as higher frequency and slower tempo, lower frequency and slower tempo, higher frequency and faster tempo and lower frequency and faster tempo. Thus, this study manipulated frequency and tempo accordingly.

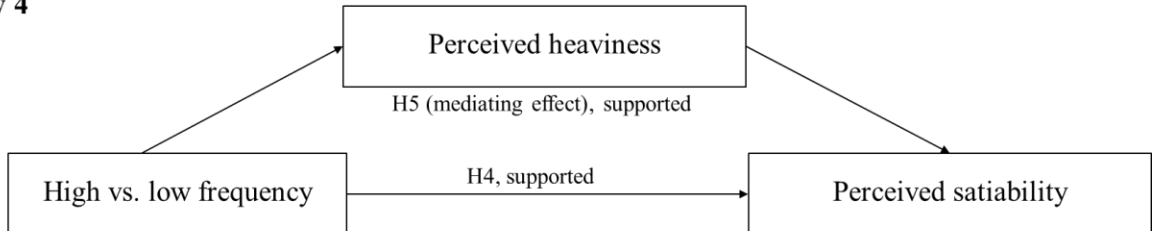
Studies 1 and 2



Study 3



Study 4



Study 5

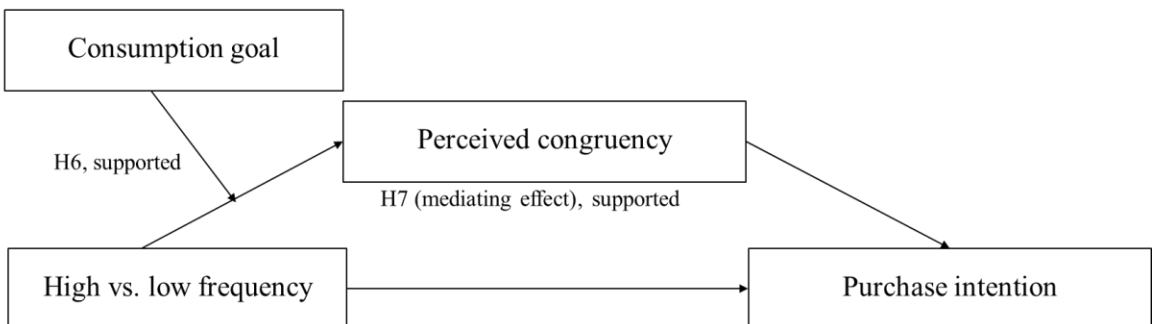


Fig. 1. Research framework.

2. Theoretical background

2.1. Frequency

Frequency refers to the number of repetitions (i.e., cycles) of pressure changes per second, measured in Hertz (Hz) (Wolfe, Kluender, Levi, Bartoshuk, Herz, Klatzky, & Merfeld, 2020). For instance, 1 cycle of pressure change in a second equals 1 Hz, and 500 cycles in a second equals 500 Hz. Frequency is perceived as pitch, whereby a higher-frequency sound is perceived as a high-pitched sound and a lower-frequency sound as a low-pitched sound. For example, a C5 piano note (523.25 Hz) is higher in pitch than a C3 note (130.81 Hz). Frequency is the most critical aspect of sound that makes a commercial sogo unique, as it is more discriminable than other musical features (Bonde & Hansen, 2013). Moreover, the manipulation of frequency is the subject of many studies in the areas of crossmodal correspondence and food research (e.g., Evans & Triesman, 2010; Spence, Reinoso-Carvalho, Velasco, & Wang, 2019; Walker, 2016). However, how the frequency of a sogo can impact perceived food healthfulness remains underexplored.

In the last decade, the association between the frequency of a sound and the attributes of food products (e.g., taste, crispiness, freshness, harshness) has been investigated extensively (e.g., see Spence et al., 2019 for a review). For example, high- (vs. low-) frequency sounds have been reliably mapped with sweet (vs. bitter) tastes (e.g., Reinoso-Carvalho, Wang, De Causmaecker, Steenhaut, Van Ee, & Spence, 2016) and crispiness (Zampini & Spence, 2004). Similarly, alcoholic beverages bearing names with high- (vs. low-) frequency sounds are perceived as harsh (vs. mild) (Pathak, Calvert, & Lim, 2020).

Relevant to the current paper, high- (vs. low-) frequency sounds present in linguistic stimuli (e.g., brand names) are perceived as healthy (vs. unhealthy) (Motoki, Park, Pathak, & Spence, 2021). Similarly, high- (vs. low-) frequency sounds have been shown to be linked with small and light objects (Walker, 2016) and healthy (vs. unhealthy) foods are linked with small and light (Motoki et al., 2021). Background sounds (e.g., music, ambient sounds) can also influence eating behaviour, such that high- (vs. low-) frequency sounds often lead consumers to select small (vs. bigger) portion sizes (Lowe & Haws, 2017; Lowe, Ringler, & Haws, 2018). It has also been shown that consumers make healthier (vs. unhealthy) food choices when ambient sounds are played in high- (vs. low-) frequency (Huang & Labroo, 2020). Another study has identified that high (vs. low) frequency is one of the important determinants in creating a healthy (vs. unhealthy) soundtrack (Peng-Li et al., 2021). This appears to be consistent with a recent study revealing that music genre (e.g., classic and jazz) containing high-frequency components induces consumers to prefer healthy foods in contrast to rock/metal genres (Motoki et al., 2022).

Given this evidence, the concepts of frequency and healthfulness are semantically congruent in terms of perceived weight lightness. If higher frequency implies light weight, and light weight refers to healthier food, then higher frequency should be linked with healthier foods. According to the spreading activation theory, hearing a high-frequency sound could activate the concept of light weight, which then spreads to healthy food that shares the same semantic link. As a result, we predicted that high- (vs. low-) frequency slogans would be more associated with healthier (vs. less healthy) foods.

H1: High- (vs. low-) frequency slogans would be more associated with healthy (vs. unhealthy) foods.

Table 1*The overview of the frequency effects.*

Authors	Research focus	Key findings
Zampini, & Spence (2004)	Examining the effect of biting sounds on the perception of crispiness	Potato chips are rated as crispier and fresher when the frequency of biting sounds increases.
Walker, Walker & Francis (2012)	Examining cross-sensory correspondences between visual, auditory and tactile stimuli	High- (vs. low-) frequency sounds are linked with small and lightweight objects.
Reinoso-Carvalho, Wang, De Causmaecker, Steenhaut, Van Ee, & Spence (2016)	Examining the matching between beer tastes and tone frequency	Bitter (vs. sweeter) beers are associated with the pure tone at a lower (vs. higher) pitch range.
Walker, Scallan, & Francis (2017)	Examining crossmodal mapping between size and weight	Unseen heavier objects are judged to make lower-pitched sounds than objects that are lighter in weight.
Lowe & Haws (2017)	Examining the effect of acoustic pitch on product perception	Products associated with lower pitch in voice or music are perceived as larger through the process of visual imagery.
Lowe, Ringler, & Haws (2018)	Examining the effect of pitch perception on food desirability	Advertisements played with a lower pitch leads consumer to purchase yoghurt in a larger (i.e., more weight) self-serving.
Huang & Labroo (2020)	Examining the effect of background music with high pitch on healthy choice	Listening to high-pitched music can cue morality and lead to a selection of healthier choices.
Pathak, Calvert, & Lim (2020)	Examining the association between brand name and product attributes	Brand names with higher (vs. lower) frequency sounds are perceived as harsh (vs. soft/mild).
Motoki, Park, Pathak, & Spence (2020)	Examining the link between phonemic sounds in brand names and perception of food healthfulness	Brand names containing phonemic sounds with higher (vs. lower) frequency are perceived as healthier.
Peng-Li, Mathiesen, Chan, Byrne, & Wang (2021)	Examining the effect of background music (healthy vs. unhealthy soundtracks) on food choices using an eye tracker	Healthy (vs. unhealthy) soundtracks of high (vs. low) frequency lead to healthier food choices through visual attention.
Motoki, Takahashi, Velasco, & Spence (2022)	Examining the effect of music genre on preferences for healthy vs. indulgent foods	Classic and jazz (vs. rock/metal) music of higher frequency leads consumers to prefer healthy foods.

2.2. Tempo

While the existing literature has mostly emphasized the effect of frequency on consumer expectations, this paper also investigates the effect of tempo, which is another important musical component. Tempo refers to the speed or pace of a given musical piece, measured in beats per minute (bpm) (Van Leeuwen, 1999). To illustrate, a musical piece played at 40 bpm is perceived to be slower than if played at 120 bpm. Tempo is important because beat marking the sound can carry key information in a given context; for example, classical music has used beats to represent movement (Van Leeuwen, 1999). Relevant to this study, past research demonstrated that tempo can also influence food perception (Bronner et al., 2012; Knöferle & Spence, 2012).

While there has been no documented report studying solely the effect of tempo on expectations of food healthfulness, recent research has demonstrated that classical and jazz music containing slow tempo affect selections and preferences of healthy foods (Motoki et al., 2022; Peng-Li et al., 2021). Peng-Li and colleagues (2021) used a combination of auditory features to compose complex soundtracks including ‘healthy’ (e.g., jazz piece, slow tempo, and high-pitched piano) and ‘unhealthy’ (e.g., fast tempo, low-pitched, and dissonant guitar) soundtracks which are associated with healthy and unhealthy eating respectively. The results showed that the healthy soundtrack influenced participants to select healthy (vs. unhealthy) choices of food items relative to the unhealthy soundtrack. In a similar vein, Motoki and colleagues (2022) had participants listen to music with different music genres and indicated their intention to eat different foods comprised of healthy savoury, healthy sweet, unhealthy savoury, and unhealthy sweet foods. The results showed that classical music which was predominantly linked with slow tempo pieces led to more preferences for both healthy savoury and healthy sweet foods compared to rock/metal and hip-hop music. Given the link between slow tempo and

healthy foods, we predicted that hearing sogos with slow (vs. fast) tempo would activate the healthy-related concept, which would in turn be more closely associated with healthier (vs. less healthy) foods.

H2: Slow (vs. fast) sogos are more closely associated with healthy (vs. unhealthy) foods.

2.3. Generalization of the sound frequency effect to the visual one

As mentioned earlier, congruence between sogo design and brand attributes is a successful factor in sonic branding. It thus would be interesting to examine whether the frequency-healthfulness associations found in sogos would be similar to those in visual cues. If this is the case, it would be useful for designing visual cues (e.g., packaging, brand logo) that are consistent with a healthful sogo. Thus, in addition to acoustic frequency, this study also investigated whether the frequency effects observed in the acoustic domain would generalize to the visual modality (specifically, high- versus low-frequency stimuli as widely used in the psychophysics literature; Landy, 2006).

Although acoustic and visual cues are different modalities, they have one characteristic in common – frequency. In the psychophysics literature, while high- (vs. low-) frequency sounds can be heard as high (vs. low) pitched, high (vs. low) spatial frequency visual stimuli are perceived as a set of slimmer (vs. wider) black-white stripes (Kalloniatis & Luu, 2007). By analogy, the graphical representation of sound waves are simple sinusoidal (sine) waveforms. The sine wave represents the area of compression and rarefaction of medium molecules (e.g., air) occurring while the sounds are transmitted. This resembles a visual image known as a sine wave grating (stripes of black and white) where the bands represent the low and high intensity of light and its frequency is also measured in terms of the number of cycles per visual degree (higher cycles indicate higher spatial frequency, see Figure 2). In line with the crossmodal effect,

participants automatically map high- (vs. low-) frequency musical tones with high- (low-) spatial frequency images (Evans & Triesman, 2010). Given this, if the association between sogo frequency and food healthfulness exists, I predicted that the frequency-healthfulness association would be able to generalize to visual frequency as represented by black-white stripes, and high- (vs. low-) spatial frequency images would be associated with healthy (vs. unhealthy) foods.

H3: High- (vs. low-) frequency grating images would be associated with healthy (vs. unhealthy) foods.

The findings might provide some insight as to the characteristics of striped pack designs on healthy foods, e.g., higher frequency gratings may connote healthfulness to a greater extent than low-frequency gratings. As a result, using high- (vs. low-) frequency stripes would be more congruent with high- (vs. low-) frequency sogos than the opposite pairing. However, since the main scope of this research focuses on the effect of sogos, this thesis only provides initial evidence on the association between visual frequency and food healthfulness.

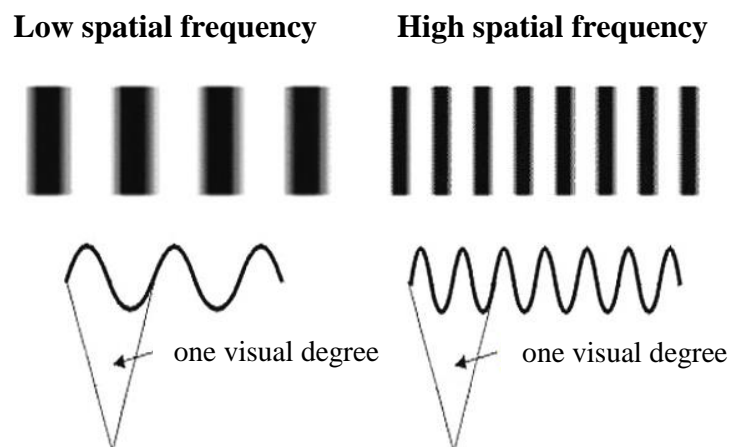


Fig. 2. Sine-wave gratings and measurement of frequency. The frequency of sine-wave gratings is measured in terms of the number of cycles per visual degree. (a) Low spatial frequency (one cycle per degree) (b) High spatial frequency (two cycles per degree) (Kalloniatis & Luu, 2007). Source: <http://webvision.med.utah.edu/>

2.4. Association of sogo frequency and perceived satiability of food

Consumers intuitively associate the weight of food as a determinant of its healthfulness. They believe that foods that are light (vs. heavy) in weight are healthier (Li, Heuvinck, & Pandelaere, 2022) but less filling (Suher, Raghunathan, & Hoyer, 2016). This lay belief is possibly formed based on past experiences and cues from representative healthy vs. unhealthy foods (Suher et al., 2016). That is, lighter and less dense foods (e.g., soup and salad) are often exemplars of healthy foods, whereas heavier or denser foods (e.g., pizza and burgers) often represent unhealthy foods. Relatedly, heavy foods usually refer to those with high calories, fat, carbohydrates and sugar and are linked to fullness and satiation (Chandon, Haws, & Liu, 2022; Yamim, Mai, & Werle, 2020). Drawing upon this evidence, we posit that lighter foods would be considered ‘less filling’ while heavier foods as ‘more filling’.

Moreover, previous research on crossmodal correspondences has demonstrated that sound frequency can be mapped with weight-related attributes across sensory domains (Spence, 2011). Specifically, high-frequency sounds are semantically congruent with concepts of lightness, while low-frequency sounds are with those of heaviness (Walker, Walker, & Francis, 2012). In line with the findings in the current study (Studies 1 and 2), high-frequency sogos correspond to lighter (i.e., healthier) foods, while low-frequency ones correspond to heavier (i.e., less healthy) foods. Together, this implies a linkage between sogo frequency and perceived satiability (which can be derived from heavy vs. lightweight foods). Thus, if a sogo is semantically congruent with a food attribute, hearing the sogo should activate the congruent concept linked with those foods, according to the spreading activation theory (Collins & Loftus, 1975). For example, hearing a high- (vs. low-) frequency sogo belonging to a food brand should

cue consumers to perceive those foods as less (vs. more) satiating as such slogans are typically linked with concepts of lightness (vs. heaviness). Thus, we hypothesised that –

H4: Food that is presented with a high- (vs. low-) frequency slogan would be perceived as less (vs. more) satiable.

H5: The relationship would be mediated by the perceived heaviness of the food.

2.5. The effect of frequency-food congruency on purchase intention

According to the congruence theory (Eklund & Helmefalk, 2022; Osgood, Suci, & Tannenbaum, 1957), sensory and semantic cues are interrelated in products/brands and are the foundation for congruence. Sensory and semantic cues play an important role in various marketing contexts and are sometimes referred to as brand attributes (Knöferle, Woods, Käppler, & Spence, 2015). Research has demonstrated the interlinkages between sensory cues and semantic associations related to those cues (e.g., a high-frequency sound can connote the symbolic meaning of smallness) (Spence, 2011). Eklund & Helmefalk (2022) further proposed that semantic properties of (sensory) cues are nodes that are interconnected in a vast semantic network of concept nodes. The strength of the connections between nodes determine the congruency effects. As a result, semantic congruence (or incongruence) results in positive or negative effects which are continuously formed in memory across time and space. Relevant to the current study, the congruence between cues (e.g., sensory cues and product attributes) is beneficial for positive behavioural responses (e.g., purchase intention) (Gvili, Levy, & Zwilling, 2018).

Similarly, research on consumer behaviour has demonstrated that the congruency between brand elements and product attributes brings about favourable consumer evaluation and

purchase behaviour (e.g., Luffarelli, Stamatogiannakis, & Yang, 2019; Wang, Zhang, & Jiang, 2022). For instance, a sogo with a rough (vs. smooth) sound that is presented with a congruent angular (vs. rounded) visual logo could effectively communicate a rugged (vs. sophisticated) brand personality, while the incongruent combination would diminish this effect (Melzner & Raghurir, 2022). Moreover, consumers exhibited positive affective responses towards an advert for a cosmetic surgery service when the musical soundtrack was played on a piano (vs. a church organ) due to the perceived congruency between the musical instrument and product (Oakes & North, 2006). Also, a recent study showed that the congruence between food taste (i.e., sweetness) and brand personality (i.e., sincerity) leads to a positive brand attitude and an increase in the actual sales volume (Motoki, Nakahara, & Velasco, 2023). Based on these findings, we assume that presenting a sogo with a frequency level that matches the food attribute would be perceived as congruent and enhance the purchase intention of the associated food.

We therefore hypothesized that if a high- (vs. low-) frequency sogo is semantically congruent with the perception of less (vs. greater) satiability, the presentation of a food attribute that is congruent with a sogo's frequency (e.g., high frequency, lightness and health; low frequency, heaviness and satiety) would enhance purchase intention of the associated foods. In this study, food attributes were manipulated as consumption goals (i.e., healthy vs. high satiety/filling foods) as consumers' decision-making relies on these goals (Wang et al., 2022; Yamim et al., 2020). For instance, consumers' preference for high-calorie foods is attenuated when a healthy consumption goal is active (Yamim et al., 2020). Drawing upon this, we assume that when consumers regard health (vs. satiety) as important, they tend to purchase healthy (vs. filling) foods. Thus, if participants perceive a high- (vs. low-) frequency sogo to be congruent with health (vs. satiety) goals, this congruency should result in a higher purchase intention.

However, if they perceive them as incongruent, this effect would be diminished (i.e., lower purchase intention). Thus, we predicted that 1) when consumers are motivated to buy food that brings them health benefits (vs. satiety), they would be more likely to purchase food that is advertised with a high- (vs. low-) frequency sogo, and 2) these relationships are mediated by perceived congruency. Formally stated,

H6: A high- (vs. low-) frequency sogo would result in purchase intention for consumers with a health (vs. satiety) goal.

H7: The relationship would be mediated by perceived congruency between the goals and sogos.

3. Sogo development

The sogos used in this study were created and manipulated using the Audacity software (<https://www.audacityteam.org/>). The sogos comprised of novel short melodies without the inclusion of a human voice to rule out the confounding effect of spoken words. The melodies for the sogos were generated using the Random Music Generator online software (<https://random-music-generators.herokuapp.com/melody>) and comprised of major notes ranging from C4 to B4 (261.63 - 493.88 Hz), moderate tempo (95 bpm), and a constant rhythm at the eighth note (1/2 beat). The frequency and tempo of each melody was then manipulated. The frequency of melody was shifted by an octave (12 semitones) to create four melodies differing in the frequency range: very low frequency (65.41 - 123.47 Hz), low frequency (130.81 - 146.94 Hz), moderate frequency (261.63 - 493.88 Hz), and high frequency (523.25 – 987.77 Hz). For the tempo manipulation, the tempo of the melody was adjusted to slow tempo (70 bpm), moderate tempo (95 bpm), and fast tempo (145 bpm) (MasterClass, 2020). Once the sogos were created, they were adjusted to be approximately 9 seconds in length with normalized loudness at -20 dB RMS

(a sample of sogos is available at <https://soundcloud.com/musicclipss/10-c4tob4-95bpm?si=efc3093eee83449399e7cd575625965c>).

A pretest was conducted to ensure that the pleasantness of tunes used as sogos¹ in the main studies were controlled. 56 participants (31 males and 25 females) between the ages of 24 to 69 years ($M = 38.46$ years, $SD = 11.61$) were recruited. Using G*Power 3.1.9 (Faul, Erdfelder, Lang, & Buchner, 2007), the sample size had 95% power to detect a medium-sized effect (0.25) in the repeated measure ANOVA. Participants took part in a 4 (frequency: very low, low, moderate, and high) x 3 (tempo: slow, moderate, vs. fast) within-participants pre-test where they rated the pleasantness of sogos on an 11-point Likert scale (from 1 = not pleasing at all to 11 = extremely pleasing). Participants also reported their proficiency in musical training (from 1 = not at all trained to 11 = very well trained), and musical knowledge (from 1 = not at all good to 11 = very good).

Participants rated sogos with very low and moderate frequencies to be significantly different in terms of their pleasantness appeal and thereby these logos were discarded. No difference was found in the pleasantness appeal of sogos created in low and high frequencies and low and fast tempos (frequency: $F(1,55) = 1.78$, $p = .19$; tempo: $F(1,55) = .30$, $p = .60$), thereby these logos were retained for the subsequent studies (see Table 1 for the stimulus development). No effect of the level of musical training nor of the musical knowledge was noted.

¹ Sogos are referred to tunes (series of musical notes) in this study, the terms ‘tunes’ and ‘sogos’ will be used interchangeably.

Table 1*Overview of stimulus development.*

Study	Stimulus development	Results of pretest
1 - 3	<p>Four sogos comprised of major notes in nine seconds duration were manipulated by frequency and tempo.</p> <ul style="list-style-type: none"> - Sogos with a low frequency included notes ranging from C3 to B3 (130.81 - 146.94 Hz). - Sogos with a high frequency included notes ranging from C5 to B5 (523.25 – 987.77 Hz). - Sogos with slow tempo were played at 70 beat per minute (bpm). - Sogos with fast tempo were played at 145 bpm. 	<p>The sogos were not different in terms of their pleasantness appeal.</p> <ul style="list-style-type: none"> - Frequency: $F(1,55) = 1.78, p = .19$ - Tempo: $F(1,55) = .30, p = .60$
1	<p>Food images were selected from the standardized food images of the CROCUFID database and F4H Image Collection.</p> <ul style="list-style-type: none"> - Healthy foods: Green salad, fruit salad, and tomato and cucumber salad. - Unhealthy foods: Cheeseburger, French fries, and chocolate cookies. 	N/A
2	<p>Food images were selected from resources online with the control for tone and colour.</p> <ul style="list-style-type: none"> - Burger: Soy vs. bacon burger. - Salad: Salad vs. salad with fries. 	<p>The healthier options were perceived as healthier than the less healthy counterparts.</p> <p>$M_{soy} = 62.17, SD = 22.80; M_{bacon} = 14.36, SD = 15.02; t(57) = 13.03, p < .001, d = 1.71$</p> <p>$M_{salad} = 89.90, SD = 11.49; M_{salad\ with\ fries} = 41.64, SD = 25.90; t(57) = 14.04, p < .001, d = 1.84$</p>
3	<p>The visual stimuli were black and white grating images. The grating had bars oriented at 0°, 45°, 90°, and 135°. The spatial frequencies were manipulated at high (12 cycles/degree) and low (4 cycles/degree) frequency.</p>	<p>The associations between high- (vs. low-) frequency sogos and high- (vs. low-) frequency grating images were observed.</p>

Study	Stimulus development	Results of pretest
		$M_{high-freq} = 75.86\%$, $SD = 29.97$, $M_{low-freq} = 50.86\%$, $SD = 33.10$, $n = 58$; $z = 3.09$, $p = .002$, $r = .29$.
4 and 5	A melodic note consisted of five notes with a wave-like pattern were created. High- and low-frequency sogos were three octave differences and were two seconds in length.	N/A

4. Method and overview of studies

Five studies were conducted. Participants were presented with hypothetical sogos (Studies 1, 2, 4, and 5) or visual cues (study 3) followed by images of food products and then asked to select the food that they felt best suited for. Each sogo was automatically played one at a time. All studies were programmed on the Qualtrics online survey platform (<https://www.qualtrics.com>). Participants were native English speakers residing in the USA and recruited from Amazon Mechanical Turk (Studies 1-3) and Connect platform of Cloudresearch (Studies 4 and 5). They were invited to take part in only one of the studies in the present research and were compensated for their time and effort. They were first asked to provide consent and demographical information and then took part in a few practice trials before proceeding to the main task.

Based on data from previous research on sound symbolism (e.g., Pathak & Motoki, 2022; Pathak, Motoki, Techawachirakul, & Calvert, 2022) examining the associations between sounds and product attributes, the effect sizes ranging approximately from 0.20 to 0.60 were reported, which are considered to be small to medium using Cohen (1988)'s criteria. Thus, the sample sizes were estimated to detect medium-sized effects throughout the thesis. Priori power analyses were conducted using G*Power 3.1.9 (Faul et al., 2007) to estimate sample size for Studies 1-3.

In Studies 1 and 2, given $\alpha = .05$, power = .95, the sample size ($n \approx 60$) had power to detect a medium-sized effect (0.25) in the repeated measure (RM) ANOVA with one group and two measurements. In study 3, with a significance criteria at $\alpha = .05$, power = .95 and two-sided effect, the sample size ($n \approx 60$) had power to detect a medium-sized effect (0.5) in the Wilcoxon signed-rank test. Moreover, given $\alpha = .05$ and power = .90, a sample size of $n \approx 100$ was estimated to detect an indirect effect of 0.35 in a within-subject mediation analysis (Study 4) and $n \approx 200$ to detect an indirect effect of 0.23 in a moderated mediation analysis using a percentile bootstrap confidence interval (Study 5) (Montoya, 2023). The research was approved by the ethics committee of a large northern university in the UK.

5. Study 1: Associations between food categories

The purpose of this study was to examine the association between sogo frequency, tempo and food healthfulness. The associations were tested between healthy and unhealthy categories of foods.

5.1. Participants

60 participants (39 males and 21 females) between the ages of 22 and 63 years ($M = 36.67$ years, $SD = 8.96$) took part in the study.

5.2. Stimuli

Sogos selected in the pretest were used as the auditory stimuli. Visual stimuli were selected from the standardized food images of the CROCUFID database (Toet et al., 2019) and F4H Image Collection (Charbonnier, van Meer, van der Laan, Viergever, & Smeets, 2016) to control the colour tones within each food category. The images comprised of three healthy foods (green salad, fruit salad, and tomato and cucumber salad) and three unhealthy foods

(cheeseburger, French fries, and chocolate cookies) (Bucher, Müller, & Siegrist, 2015; Plasek, Lakner, & Temesi, 2020) (see Appendix A for food images used in this study).

5.3. Design and procedure

A 2 (frequency: high vs. low) x 2 (tempo: slow vs. fast) within-participants design was conducted. Participants were informed that a food company has a range of new products and wanted to select slogans that can convey the healthfulness of its food products. Participants listened to four slogans (one at a time) and then select one of the two foods (healthy vs. unhealthy) that they felt best matched the slogan. 12 pairs of the food choices was randomized and the position (i.e., left vs. right) was counterbalanced within-participant. The experiment lasted for approximately 8 minutes. The healthy choice was coded as 1 and unhealthy choice as 0. We then summed up all the choices for each participant to create a healthy-choice index, as a dependent variable, ranging from 0 – 3 (Huang & Labroo, 2020). The higher index was interpreted as the greater association with healthy choices. To rule out the role of familiarity, participants also rated the familiarity of slogans after the experiment (from 1 = not at all familiar to 11 = very familiar).

5.4. Results and discussion

Data were analysed using SPSS 22.0 for Windows (IBM SPSS Inc., Chicago, IL, USA). Although the raw data of the healthy-choice index were binary choices, the scored index generated from a forced-choice task could be treated as continuous data as indicated in previous research (e.g., Huang & Labroo, 2020 (Study 3); Huang, Dong, & Labroo, 2018 (Study 2); Pathak, Calvert, & Motoki, 2020 (Studies 1 and 3); Semin, & Palma, 2014 (Studies 3 and 4)). An RM ANCOVA was performed to test the effect of frequency and tempo on healthy choice selection with familiarity as a covariate. The results revealed the main effect of frequency, supporting H1 ($M_{\text{high}} = 2.22$, $SD = .81$, $M_{\text{low}} = 1.47$, $SD = .98$; $F(1,58) = 13.45$, $p = .001$, $\eta_p^2 =$

.19) while the main effect of tempo was not significant, rejecting H2 ($M_{\text{slow}} = 1.98$, $SD = .77$, $M_{\text{fast}} = 3.40$, $SD = .85$; $F(1,58) = 2.58$, $p = .11$). The interaction effect was not significant ($F(1,58) = .72$, $p = .40$)² (see Figure 3). The effect of familiarity was not found ($F(1,58) = 1.07$, $p = .31$). That is, participants expected the sogos with high (vs. low) frequency to be more associated with healthy (vs. unhealthy) foods, whereas the association of healthy foods was not different between the two tempos.

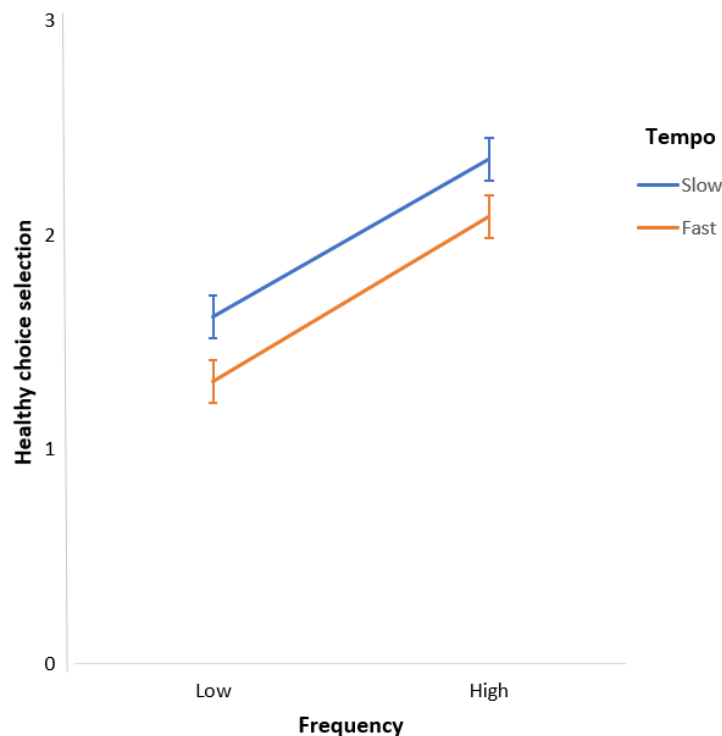


Fig. 3. The interaction effect of frequency and tempo on healthy choice selection (Study 1).

² We also performed the Wilcoxon signed-rank test to determine whether participants differ in matching food images with low vs. high frequency and slow vs. fast tempos. As the Shapiro-Wilk Normality test revealed that the null hypotheses of normal population distributions were rejected at $p < .05$, non-parametric statistical methods were used. In this analysis, the healthy-choice index ranged from 0 to 6. The results revealed that participants selected more healthy choices as matching with sogos with a high (vs. low) frequency ($M_{\text{high}} = 4.43$, $SD = 1.63$, $M_{\text{low}} = 2.93$, $SD = 1.93$; $z = 3.64$, $p < .001$, $r = .33$), supporting H1. However, the selection of healthy choices did not differ between slow and fast tempo, rejecting H2 ($M_{\text{slow}} = 3.97$, $SD = 1.55$, $M_{\text{fast}} = 3.40$, $SD = 1.67$; $z = 1.91$, $p = 0.056$, $r = .17$). The results confirmed the associations between high (vs. low) frequency and healthy (unhealthy) foods, while the tempo-healthy association was not found.

6. Study 2: Associations within food categories

While Study 1 provided evidence for an association between sogos with healthy vs. unhealthy categories of foods, it is plausible that the category of food (e.g., salad vs. burger) possibly influenced the results. We, therefore, wanted to extend these findings to a similar food category by varying the healthfulness appeal (e.g., by ingredients), such as soy burgers which are perceived as healthier than beef burgers (Motoki et al., 2021). Thus, Study 2 was conducted to test whether the association between sogos and healthfulness extends to foods *within* the same food category (e.g., healthy burger vs. unhealthy burger or healthy vs. unhealthy salad). If this is the case, the significant association between high (vs. low) frequency and slow (vs. fast) tempo with healthy (vs. less healthy) foods should be observed. As the different colour tones between food categories in Study 1 might have affected the results, in Study 2, colour tones between food choices were matched.

6.1. Participants

59 participants (28 males and 31 females) between the ages of 20 to 68 years ($M = 41.17$ years, $SD = 11.37$) took part in the study.

6.2. Stimuli

Sogos selected in the pretest were used again here as the auditory stimuli. Visual stimuli were selected from freely available resources online. The images comprised of two variations of burger (soy burger vs. bacon burger) and two variations of salad bowl (spring salad vs. spring salad with fries). For all images, special care was taken to ascertain similar backgrounds, viewpoints, and colour tones to minimize any confounds between the images. To create the unhealthy version of a salad, images of fries were superimposed on the salad image to create an

unhealthy version (since fries are perceived as healthier; Bucher et al., 2015). All images were presented at a resolution of 300 x 300 px (see Appendix A for food images used in this study).

A pretest was conducted to verify the perceived healthfulness of the selected images. 58 participants (23 males, 33 females, and 2 with unspecified gender) between the ages of 26 to 70 years ($M = 44.33$ years, $SD = 12.15$) rated the images on perceived healthfulness on a visual analog scale (VAS) from 0 (not at all healthy) to 100 (very healthy). As expected, an independent samples t -test, using SPSS 22.0 for Windows (IBM SPSS Inc., Chicago, IL, USA) revealed that soy burger and spring salad were perceived as healthier than spring salad with fries and bacon burger (soy burger: $M = 62.17$, $SD = 22.80$; bacon burger: $M = 14.36$, $SD = 15.02$; $t(57) = 13.03$, $p < .001$, $d = 1.71$; spring salad: $M = 89.90$, $SD = 11.49$; spring salad with fries: $M = 41.64$, $SD = 25.90$; $t(57) = 14.04$, $p < .001$, $d = 1.84$).

6.3. Design and procedure

A 2 (frequency: high vs. low) x 2 (tempo: slow vs. fast) within-participants design similar to Study 1 was conducted. Participants were presented with a pair of healthier and less healthy foods (i.e., soy burger vs. bacon burger, spring salad vs. spring salad with fries) and were asked to select the food that they felt best matched the sogo, in total of eight trials. The healthier choice was coded as 1 and less healthy choice as 0 and we then summed up all the choices for each participant to create a healthy-choice index, as a dependent variable, ranging from 0 – 2 (Huang & Labroo, 2020). Subsequently, the data were analysed as described above in Study 1.

6.4. Results and discussion

An RM ANOVA was conducted to test the effect of frequency and tempo on healthy choice selection. The results revealed the main effect of frequency, supporting H1 ($M_{\text{high}} = 1.40$,

$SD = .58, M_{\text{low}} = 0.94, SD = .61; F(1,58) = 18.31, p < .001, \eta_p^2 = .24$) while the main effect of tempo was not significant, rejecting H2 ($M_{\text{slow}} = 1.15, SD = .65, M_{\text{fast}} = 1.19, SD = .65; F(1,58) = .08, p = .79$). The interaction effect was not significant ($F(1,58) = 1.22, p = .27$)³ (see Figure 4). That is, sogos with high (vs. low) frequency were associated with healthier (vs. less healthy) whereas the associations were not different between slow and fast tempo.

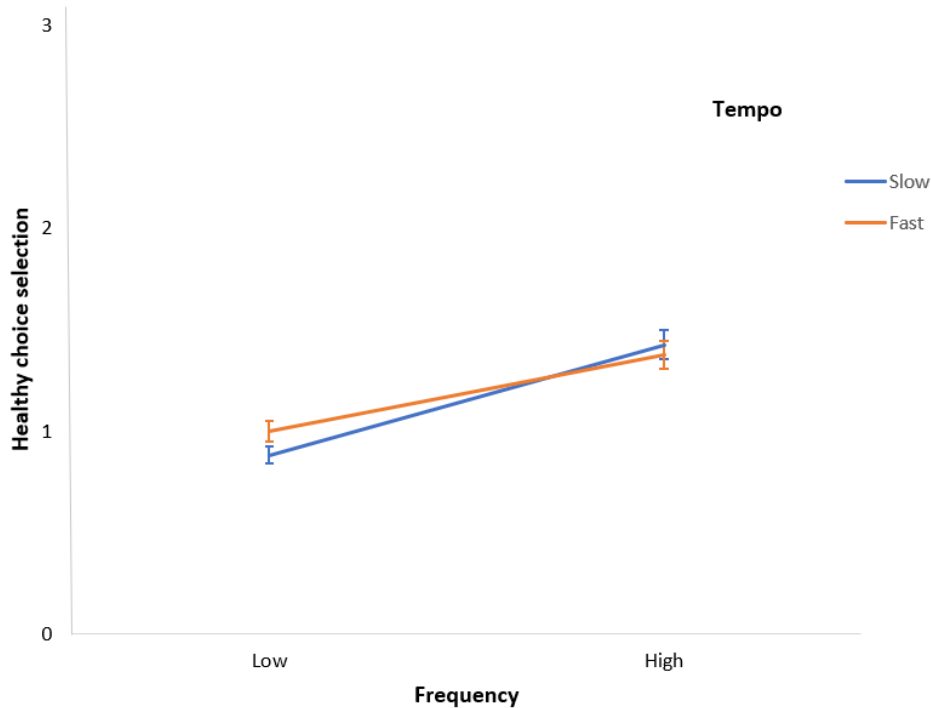


Fig. 4. The interaction effect of frequency and tempo on healthy choice selection (Study 2).

Data was also analyzed separately for each type of food (i.e., burger and salad). Two binary logistic models using generalized linear model were carried out for each food type.

³ The Wilcoxon signed-rank test was also performed to compare the healthier choice selections (the index ranged from 0 – 4) between sogos with low vs. high frequency and slow vs. fast tempos. The results revealed that participants expected the sogos with a high (vs. low) frequency to be more associated with the healthy (vs. less healthy) foods, supporting H1 ($M_{\text{high}} = 2.80, SD = 1.16, M_{\text{low}} = 1.88, SD = 1.25; z = 3.73, p < .001, r = .34$); no effect of the tempo was observed, rejecting H2 (tempo: $M_{\text{slow}} = 2.31, SD = 1.30, M_{\text{fast}} = 2.37, SD = 1.29; z = .43, p = .67$). The findings supported the association between frequency and food healthfulness.

Frequency and tempo were the independent variables and healthy choice selection (0 = unhealthy choice and 1 = healthy choice) was the dependent variable. For burger, the results revealed that the model explains a significant amount of the variation in whether the healthy choice is selected or not (Likelihood $\chi^2(3) = 14.82, n = 236^4, p = .002$). However, frequency (low vs. high), tempo (slow vs. fast) and the interaction of frequency and tempo did not make a contribution to the amount of variation in the healthy choice selection (Frequency: Wald $\chi^2(1) = 2.75, p = .10$; Tempo: Wald $\chi^2(1) = 1.91, p = .17$; Frequency x Tempo: Wald $\chi^2(1) = 1.61, p = .21$). For salad, the results revealed that the model explains a significant amount of the variation in whether the healthy choice is selected or not (Likelihood $\chi^2(3) = 14.50, n = 236, p = .002$). Specifically, frequency (low vs. high) makes a contribution to the amount of variation in the healthy choice selection (Wald $\chi^2(1) = 6.03, p = .01$) but tempo (slow vs. fast) and the interaction term did not (Tempo: Wald $\chi^2(1) = .66, p = .42$; Frequency x Tempo: Wald $\chi^2(1) = 0, p = .99$). The odds of healthy choice selection are 0.38 (95% CI .17 to .82) times higher in high compared to low frequency. The findings indicated that high-frequency sogos were associated with healthier choice within a food category specifically salad.

7. Study 3: Associations between visual frequency and food healthfulness

Considering our findings on the correspondence between high-frequency sogos and food healthfulness, we hypothesized that if the crossmodal association between high-frequency sounds and healthfulness holds true, this association should also be observed in the presence of high-frequency images. We, therefore, used sine-wave grating images (visual) as proxies for the

⁴ 4 conditions x 59 participants = 236.

acoustic stimuli in Studies 1 and 2 and hypothesized that high- (vs. low-) spatial frequency grating images would be associated with healthy (vs. unhealthy) foods.

7.1. Participants

58 participants (32 males and 26 females) between the ages of 23 to 77 years ($M = 44.10$ years, $SD = 13.76$) took part in the study. Data of one participant who spent over 10 minutes to complete the task was excluded.

7.2. Stimuli

The visual stimuli were black and white sine-wave gratings created using PsychoPy 2 (Peirce et al., 2019). The grating had bars oriented at 0° , 45° , 90° , and 135° , moderate contrast of 1, and resolution of 280×280 px. The spatial frequencies were manipulated at high (12 cycles/degree) and low (4 cycles/degree) frequency (see Appendix A for the gratings and food images used in this study). Food images comprised of healthy foods (salad, fruit salad, salad with shrimps, and tuna salad) and unhealthy foods (French fries, cheeseburger, brownies and donuts) and were selected from the F4H Image Collection (Charbonnier et al., 2016). Food images were presented at a resolution of 350×240 px and were randomly paired and counterbalanced (i.e., left vs. right position) for each participant.

A pre-test was conducted to verify the association of high- (vs. low-) frequency sogos and high- (vs. low-) frequency grating images. 60 participants (33 males, 26 females, and 1 with unspecified gender) between 23 – 75 years old ($M = 41.53$ years, $SD = 12.95$) were instructed to select a grating image that they felt best matched the sogo. Data of two participants who spent over 10 minutes to complete the task were excluded. As predicted, the Wilcoxon signed-rank test, using SPSS 22.0 for Windows (IBM SPSS Inc., Chicago, IL, USA), revealed that high- (vs.

low-) frequency images were associated with high- (vs. low-) frequency grating images ($M_{high-freq} = 75.86\%$ ⁵, $SD = 29.97$, $M_{low-freq} = 50.86\%$, $SD = 33.10$; $z = 3.09$, $p = .002$, $r = .29$).

7.3. Design and procedure

The study utilized a one-way, two-level (high- vs. low-frequency gratings) within-participant design. Similar to study 1, participants were presented a grating image and a pair of food images and were instructed to select the food that they felt best matched the grating image (a total of eight trials). The healthier choice was coded as 1 and less healthy choice as 0, summing score (ranging from 0-4) across all the choices for each participant, and then converted to a percentage to create a healthy-choice index.

7.4. Results and discussion

Data were analysed using SPSS 22.0 for Windows (IBM SPSS Inc., Chicago, IL, USA). As the Shapiro-Wilk Normality test revealed that the null hypotheses of normal population distributions were rejected at $p < .05$, non-parametric statistical methods were used for subsequent data analysis.

The Wilcoxon signed-rank test was performed to determine whether participants differ in matching food images with low and high frequency. Specifically, the percentage of healthy food selection was compared between images with low- vs. high-spatial frequency. As predicted, the results revealed that participants expected high- (vs. low-) frequency grating images to be associated with healthy (vs. unhealthy) foods, supporting H3 ($M_{high-freq} = 35.09\%$, $SD = 32.68$, $M_{low-freq} = 24.12\%$, $SD = 30.24$; $z = 2.13$, $p = 0.03$; $r = 0.20$) (see Figure 5). The results confirm the

⁵ M is the averaged proportion of trials that participants selected high over low-frequency grating images

generalization of the acoustic frequency effect to visual cues and association with food healthfulness.

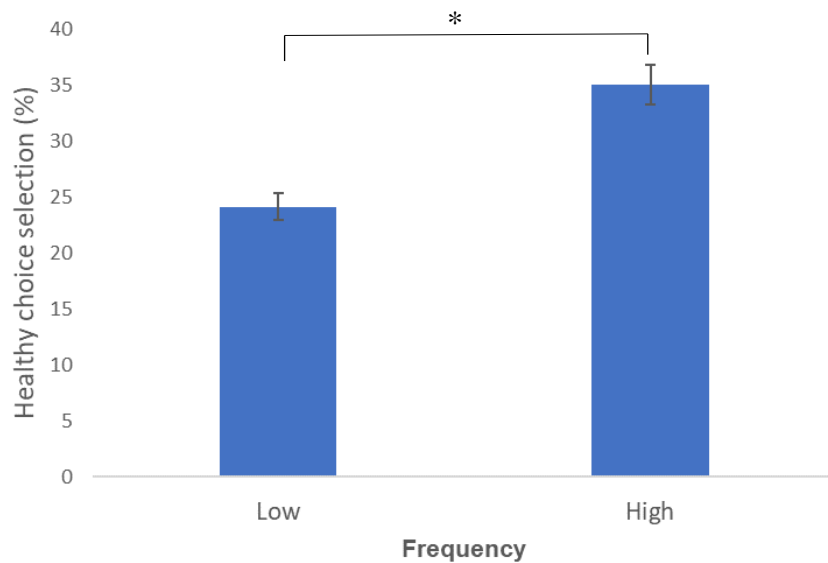


Fig. 5. Percentage of healthy food selection as a function of the visual frequency. $*p = .03$.

The significance of this intriguing finding is to highlight the vital role of frequency per se, regardless of sensory modality, in connoting healthfulness in food products. Given that the stripes of high-frequency gratings are apparently smaller than those of low-frequency counterparts, it would be possible that the semantic meaning of smallness accounts for the association between grating images and food healthfulness in a similar way as it does in sonic logos. The findings add to crossmodal correspondence and sensory marketing literature by demonstrating that the semantic correspondence of smallness between frequency and food stimuli may drive consumers to associate high-frequency cues with food healthfulness, which will be discussed in detail in the next section (see Visual frequency-healthfulness association). Besides, the implication of this novel finding also contributes to practitioners in marketing in terms of novel sensory branding strategies for healthy food products (e.g., the use of high-

frequency sogos and incorporating high-frequency stripes in visual logos and packaging design), which will be further discussed in Theoretical and managerial contributions.

8. Study 4: Associations between sogo frequency and perceived satiability

So far, convergent evidence of the frequency effect on perceived healthfulness through the semantic correspondence has been provided. Given that healthfulness is related to satiability (i.e., healthy food is lighter in weight and less filling; unhealthy foods, heavier and more filling), Study 4 aimed to examine the association between the sogo frequency and perceived satiability, and whether this relationship is mediated by the perceived heaviness of the food.

8.1. Participants

111 participants from the Connect platform of Cloudresearch, USA took part in this study. Data of five participants were discarded: Two provided the same answer for all the questions and three spent > 3 SD of the average completion time. The data from 106 participants were further analysed (*Male* = 41, *Female* = 65; Age range = 18-73 years, $M = 41.69$, $SD = 12.27$).

8.2. Sogo development

Two new sogos with the same melodies were created. The melody resembled the characteristics of commercial sogos, which consisted of five notes with a wave-like pattern (Anzenbacher, 2016; SoundOut, 2021). The sogos were manipulated into high and low frequency with 3 octaves difference using *FL Studio 20* with *Morphine* plugin. Using *Audacity*, the sogos were amplified to 3.5 dB to control for amplitude differences arising from frequency differences and then normalized to -15 LUFS (i.e., the standard perceived loudness). The sogos used in this study are available at <https://on.soundcloud.com/6bkB6>.

8.3. Design and procedure

A one-factor (high vs. low frequency) within-participants design was used. Participants were told to imagine that they were looking for something to eat at a grocery store and saw a company representative offering free trials of newly launched crackers advertised with a jingle. Then, they listened to one sogo at a time and were instructed to rate the perceived amount of sugar, fat, carbohydrates, and calories of the advertised crackers on a VAS scale, perceived heaviness (0 = very low, 100 = very high) and how filling they thought the crackers would be (perception of satiability: 0 = not at all filling, 100 = very filling; Yamim et al., 2020). The presentation of sogos and questions was counterbalanced between participants. In the end, participants rated the perceived frequency of the sonic logo (0 = very low, 100 = very high), hunger level (0 = not hungry at all, 100 = very hungry), and time since last food intake (0 = an hour ago, 1 = two hours ago, 2 = three hours ago, 3 = four hours ago, 4 = above four hours). The dependent variable was the perceived satiability and the mediator was the perceived heaviness.

8.4. Results and discussion

Manipulation check. A paired *t*-test revealed that the high- (vs. low-) frequency sogo was perceived as higher ($t(105) = 26.86, p < .001, d = 4.16; M_{high} = 77.67, SD = 14.08, M_{low} = 22.71, SD = 12.29$).

Perceived satiability. A repeated ANOVA was used where the frequency was the independent variable (IV), perceived satiability was the dependent variable (DV), and level of hunger and time since the last food intake were the covariates. The results revealed that the cracker advertised with high-frequency sogo was rated as significantly lower in the perceived satiability ($F(1,103) = 26.28, p < .001, \eta_p^2 = .20; M_{high} = 33.93, SD = 18.84, M_{low} = 56.86, SD =$

21.92). The level of hunger and the time since the last food intake did not affect the results ($ps > .41$).

Perceived heaviness. We averaged the rating of sugar, fat, carbohydrates, and calorie amount as an index of perceived heaviness ($\alpha = .85$) (Oakes, 2006; Wedderburn, 1999). A repeated ANOVA was then used where the frequency was the independent variable, the perceived heaviness was the dependent variable, and the level of hunger and time since last food intake were the covariates. The results revealed that participants perceived the crackers as less heavy while listening to a high-frequency sogo than a low-frequency one ($F(1,103) = 16.70, p < .001, \eta_p^2 = .14; M_{high} = 43.48, SD = 19.17, M_{low} = 55.95, SD = 17.01$). The level of hunger and time since last food intake did not affect the results ($ps > .10$).

Mediation analysis. A mediation analysis (MEMORE macro, Model 1, Montoya, 2022) was conducted, where the frequency was the IV, perceived satiability was the DV, and perceived heaviness was the mediator, to investigate how the perceived heaviness of food mediated the relationship between frequency and perceived satiability. The indirect effect of perceived heaviness was estimated using 95% percentile bootstrap intervals with 5000 bootstrap samples. The results showed that the direct effect of the frequency on the perceived satiability was significant, supporting H4 ($b = -12.20, SE = 2.27, t(103) = -5.36, p < .001$) (see Figure 6). The indirect effect of frequency on perceived satiability through perceived heaviness was significant ($b = -10.73, SE = 2.29, 95\% CI [-15.35, -6.46]$), supporting H5. Specifically, the crackers advertised with high-frequency sogo were perceived as less heavy ($b = -12.47, SE = 2.05, t(105) = -6.09, p < .001$), and the perceived heaviness was positively related to the perceived satiability ($b = .86, SE = .09, t(103) = 9.17, p < .001$). This indicates that the perceived heaviness mediates the relationship between the sogo frequency and perceived satiability.

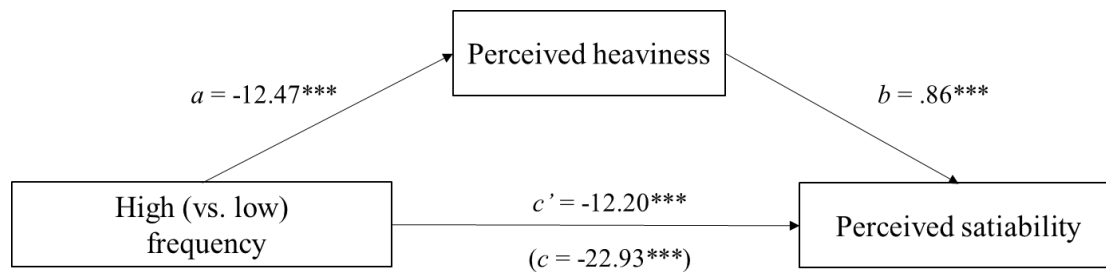


Fig. 6. The figure illustrates the mediating effect of perceived heaviness of food on the relationship between frequency and perceived satiability in Study 4. *** $p < .001$.

This study revealed the effect of sogo frequency on the perceived satiability of food while ruling out the effect of consumers' level of hunger and the time since their last food intake. Specifically, consumers perceived a food product advertised with a high-frequency sogo as less heavy, leading to a perception of lesser satiety (or less satiability) of the advertised food. In contrast, a food product that was advertised with a low-frequency sogo was judged as heavier, leading to a perception of higher satiety (or greater satiability). Next, we investigated how sogo frequency can drive purchase intention in consumers holding different consumption goals (health vs. satiation).

9. Study 5: The effect of sogo frequency on purchase intention

This study aimed to demonstrate the effect of sogo frequency on purchase intention. To achieve this, consumption goals were manipulated into two levels: health (i.e., less filling) and satiation (i.e., more filling). The key attributes of the health condition consisted of healthy, light, health benefits, whereas those of the satiation condition consisted of filling, heavy, satiation. As aforementioned, given that congruence can evoke a positive response (Eklund & Helme Falk, 2022), it is plausible to predict that sogos signalling healthfulness (i.e., high frequency) would

enhance purchase intention when the healthy goal is activated, and those signalling satiety would do so for the satiation goal. The relationship would be driven by perceived congruency between the goals and sogos.

9.1. Participants

205 participants were recruited from the Connect platform of Cloudresearch, USA to take part in this study. Data from three participants who provided the same answers for all the questions were discarded (*Male* = 106, *Female* = 96; Age range = 22-77 years, *M* = 41.05, *SD* = 11.74).

9.2. Design and procedure

A 2 (goal: health vs. satiation) x 2 (frequency: high vs. low) mixed design was used where the consumption goal was the between-participant factor and the frequency was the within-participant factor. Sogos were developed using the same procedure as described in Study 4. Participants were randomly assigned to one of the two scenarios.

In the health condition, “*Your friend attaches great importance to foods that are healthy and normally chooses food that is light and brings health benefits.*”

In the satiation condition, “*Your friend attaches great importance to foods that are filling and normally chooses food that is heavy and brings satiation.*”

In each condition, they were instructed to imagine that they were buying food for their friend online and saw food brands advertised with two different sogos (high vs. low frequency). Then, they rated their purchase intention (how likely they would buy the food advertised with the sogo; 0 = not buy it at all, 100 = definitely buy it) and perceived congruency between the sogos and advertised food on an 8-point graphical scale (1 = far apart, 8 = complete overlap) (Bergami

& Bagozzi, 2000; Motoki et al., 2023). In the end, they indicated the perceived frequency of sogos (0 = very low, 100 = very high) and their friend's food preference (0 = very unhealthy, 100 = very healthy food) as a manipulation check question. The dependent variable was the purchase intention and the mediator was the perceived congruency.

9.3. Results and discussion

Manipulation check. An independent t -test revealed that participants in the health (vs. satiation) condition perceived that their friend prefers healthy (unhealthy) food ($t(182.98) = 20.19, p < .001$, Hedge's $g^6 = 2.87$; $M_{health} = 88.70, SD = 17.55, N = 103, M_{satiation} = 30.13, SD = 23.06, N = 99$). A paired t -test revealed that the high-frequency sogo was perceived as higher than the low frequency ($t(201) = 22.79, p < .001, d = 2.61$; $M_{high} = 75.93, SD = 16.64, M_{low} = 25.13, SD = 21.94$).

Purchase intention. We performed a mixed ANOVA to test the effect of frequency and consumption goal on purchase intention. The results revealed that there were no main effects of frequency and consumption goal on purchase intention (Frequency: $F(1,200) = .24, p = .62$; Goal: $F(1,200) = .08, p = .78$). However, a significant interaction effect of frequency and goal was observed ($F(1,200) = 124.27, p < .001, \eta_p^2 = .38$) (see Figure 7). Specifically, in the health condition, participants had a higher intention to buy food advertised with a high (vs. low) frequency sogo ($t(102) = 7.92, p < .001, d = 1.03$; $M_{high} = 61.20, SD = 23.11, M_{low} = 36.99, SD = 23.91$). In the satiation condition, participants had a higher intention to buy food advertised with a low- (vs. high-) frequency sogo ($t(98) = 7.85, p < .001, d = 1.04$; $M_{high} = 35.14, SD = 27.09, M_{low} = 61.60, SD = 23.86$).

⁶ Due to the difference in sample sizes

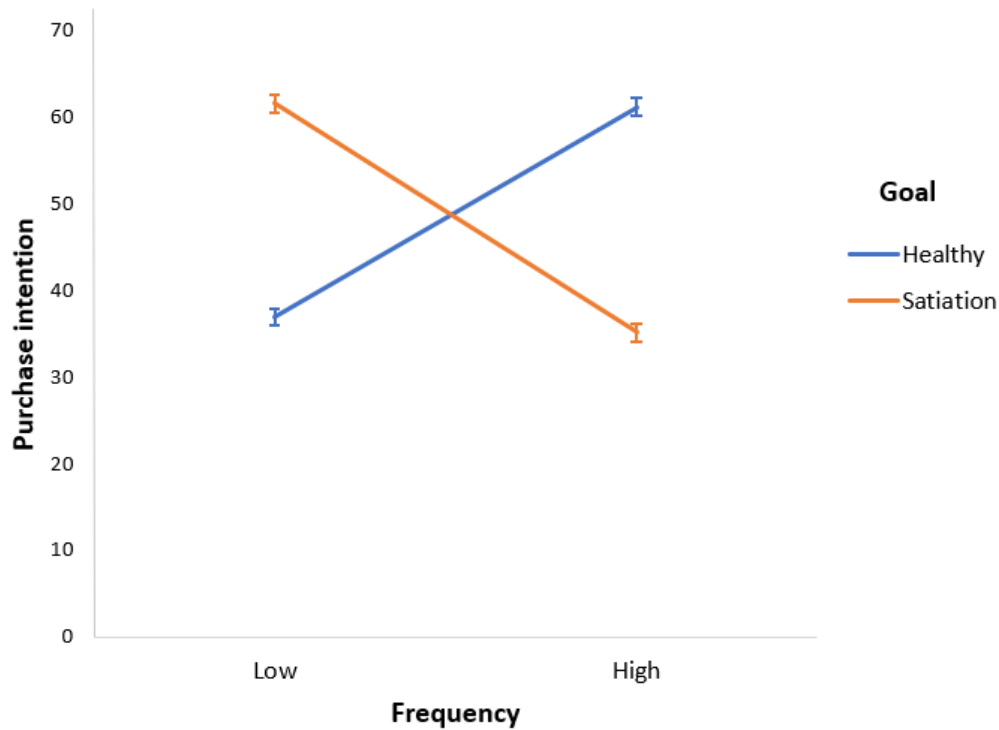


Fig. 7. The interaction effect of frequency and consumption goal on purchase intention.

Perceived congruency. We conducted a mixed ANOVA to test the effect of frequency and consumption goal on perceived congruency. The results showed that there was no main effect of frequency ($F(1,200) = 2.42, p = .12$), while a significant main effect of consumption goal was found ($F(1,200) = 14.48, p < .001, \eta_p^2 = .07$). Further, a significant interaction effect of frequency and goal was observed ($F(1,200) = 165.82, p < .001, \eta_p^2 = .45$) (see Figure 8). Specifically, in the health condition, the high-frequency sogo was perceived as significantly more congruent than the low-frequency counterpart ($t(102) = 8.94, p < .001, d = 1.19; M_{high} = 4.66, SD = 1.80, M_{low} = 2.59, SD = 1.68$). In the satiation condition, the low-frequency sogo was perceived as significantly more congruent than the high-frequency one ($t(98) = 9.27, p < .001, d = 1.38; M_{high} = 3.00, SD = 1.95, M_{low} = 5.63, SD = 1.85$).

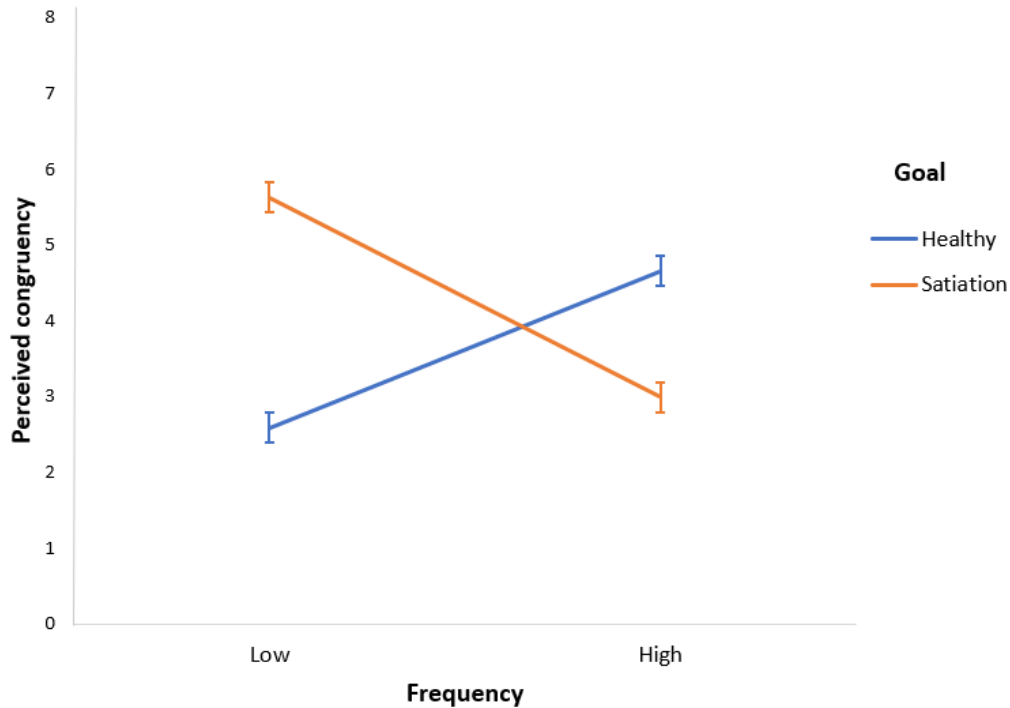


Fig. 8. The interaction effect of frequency and consumption goal on perceived congruency.

Moderated mediation analysis. A moderated mediation analysis (MEMORE macro, Model 15, Montoya, 2022) was conducted where the frequency was used as the IV (0 = high, 1 = low), consumption goal as the moderator (0 = health, 1 = satiation), perceived congruency as the mediator, and purchase intention as the DV. The results revealed a significant index of moderated mediation = -39.06, $SE = 4.15$, 95% CI [-47.41, -30.87] with 5000 bootstrapped samples (see Figure 9). Specifically, there is a significant moderation effect of the consumption goal on the relationship between frequency and purchase intention through perceived congruency ($b = -4.70$, $SE = .37$, $t(200) = -12.88$, $p < .001$, 95% CI [-5.43, -3.98]), supporting H6 and H7. Perceived congruency has a significant effect on purchase intention ($b = 8.30$, $SE = .55$, $t(199) = 15.05$, $p < .001$, 95% CI [7.21, 9.39]). However, the direct effect of frequency on purchase intention was not significant ($b = 1.35$, $SE = 1.91$, $t(199) = .71$, $p = .48$, 95% CI [-2.42, 5.13]).

Additionally, there were significant indirect effects on health ($b = 17.17$, $SE = 2.36$, 95% CI [12.68, 21.89]) and satiation consumption goals ($b = -21.89$, $SE = 2.78$, 95% CI [-27.60, -16.57]). This suggests that consumption goal moderated the indirect effect of frequency on purchase intention through the perceived congruency.

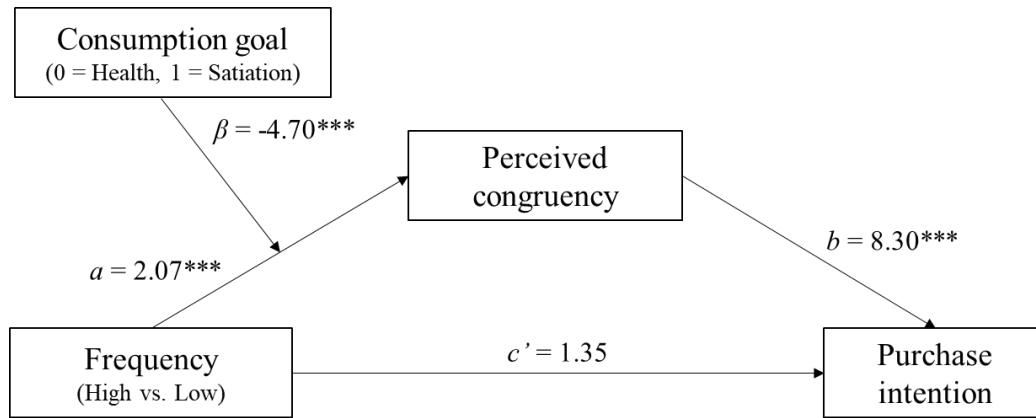


Fig. 9. The figure illustrates the indirect effect of frequency on purchase intention through perceived congruency moderated by consumption goal. *** $p < .001$.

This study revealed that the congruency between sogo frequency and consumption goal can influence purchase intention of the associated products and perceived congruence acts as a mechanism underlying this effect. In other words, sogos played at the frequency level that aligns with a consumer goal can drive buying behaviour. Specifically, when participants regarded health (vs. satiation) as important, a sogo with high (vs. low) frequency was perceived as congruent, and subsequently, such perception resulted in a higher purchase intention.

10. General discussion

The primary purpose of the study was to examine whether sogos composed with high (vs. low) frequency and with slow (vs. fast) tempo would be expected to be associated with healthy (vs. unhealthy) foods and influence subsequent purchase intention by systematically

manipulating the sound frequency and tempo. The findings partially support the hypotheses. That is, the robust effect of the high- (vs. low-) frequency sogos on the perception of food healthfulness was observed, while the effect of slow (vs. fast) tempo was not significant (Studies 1 and 2). The current study thus provides initial evidence of the generalization of the frequency effect in the visual domain whereby high-frequency grating images are also more associated with healthy foods (Study 3). Further, this study suggests that consumers perceived food products advertised with a high-frequency sogo as lighter and less filling, whereas low-frequency sogos led to the perception of foods that are heavier and more filling (Study 4). Subsequently, a high-frequency sogo enhanced purchase intention for health-related foods amongst consumers concerned with their health benefits; a low-frequency one increased purchase intention for satiability-related foods in consumers who are more concerned with satiety. These effects were shown to be due to the semantic congruence between sogos and food type (Study 5).

10.1. Sound frequency-healthfulness association

Our findings are in line with previous research suggesting a linkage between high-frequency sounds and healthy food products (Motoki et al., 2021; Motoki et al., 2022; Peng-Li et al., 2021). For example, Peng-Li et al., 2021 demonstrated that listening to a ‘healthy’ (vs. ‘unhealthy’) soundtrack comprised of high (low) frequency, slow (fast) tempo, and other features guided participants’ attention towards healthier foods, and lead to healthier food choice selections. Our findings further support the observation that frequency itself can potentially connote the attribute of healthfulness. Specifically, Study 1 demonstrated this phenomenon using two broad types of food categories (healthy vs. unhealthy foods) and the results revealed that sogos with high (vs. low) frequency and slow (vs. fast) tempo were expected to be more closely

associated with healthy (vs. unhealthy) food products. In Study 2, we extended these findings using foods within the same category (healthy vs. less healthy burgers, healthy vs. less healthy salads) and only the effect of frequency was detected. Given this, the association between frequency and healthy foods can generalize from healthy vs. unhealthy food categories to varying healthfulness appeal within a food category. In other words, sogos with high (vs. low) frequency are associated with healthy (vs. less healthier) foods, irrespective of the food category.

However, recent studies have revealed a boundary condition between tastes/flavors in the frequency effect and showed that listening to music genres comprised of higher frequencies (e.g., classic and jazz) evoked positive valence which in turn appears to increase preferences for sweet and healthier savoury foods compared to rock/metal music (Motoki et al., 2022). Furthermore, Motoki and colleagues (2021) demonstrated that hypothetical brand names containing higher (vs. lower) frequency sounds were rated to be more appropriate for healthy savoury foods while there was no significant difference in the sweet food category. It should be noted that food stimuli used in this study contained savoury and sweet foods in both healthy and unhealthy food categories which is not the case in our current study. This issue will be discussed in a later section.

In this study, the automatic association between high-frequency stimuli and food healthfulness can possibly be explained by the shared semantic association between the features of frequency and food stimuli. We assume that high-frequency sogos and healthfulness are preferably matched because both stimuli signify smallness and lightness, while low frequency and less healthful indicators are preferably associated because both features connote largeness and heaviness (e.g., Lowe & Haws, 2017; Motoki et al., 2021). Thus, hearing a high-frequency sogo (or seeing a high-frequency grating image) stimulates the healthy-related concepts which

are semantically linked with healthy foods. As a consequence, a high-frequency sogo is perceived as associated with healthy foods, while a low-frequency counterpart is with unhealthy foods.

Additionally, we also provided evidence that sogos used here are matched in terms of tune pleasantness (in the process of fictitious sogo development), and the covariate effect of tune familiarity was not observed (Study 1); hence, it is less likely that our findings will be explained by tune pleasantness and familiarity.

10.2. Sound tempo-healthfulness associations

Although there has been evidence that music consisting of slow tempo increased choice selection and preferences towards healthy food items (Motoki et al., 2022; Peng-Li et al., 2021), no significant difference between the matching of healthy foods with slow versus fast tempo sogos was observed here. It is possible that our sogo stimuli were less complex than music stimuli used in the prior studies. Moreover, when the tempo is manipulated solely, its effect on consumer responses might differ from when it is mixed with other musical attributes. Perhaps the other auditory parameters (e.g., high/low frequency) might override the tempo effect on healthy food preferences in the previous studies using music with greater compositional complexity (Motoki et al., 2022; Peng-Li et al., 2021). Furthermore, considering the tempo itself, previous research has demonstrated that tones with increasing tempo led to increasing movement speed (Küssner et al., 2014). Much in line with research on food-related behaviours, participants chewed more rapidly when high (vs. low/no) tempo music was played (Roballey et al., 1985). Participants exhibited longer (vs shorter) eating times when music was played at a slower (vs faster) tempo (Mathiesen et al., 2020). Given this, it is plausible to suggest that tempo is more related to consumption rate (see Spence et al., 2019 for a review) rather than food perception and

this might explain why solely varying tempo (while other parameters remain constant) does not differently influence association with healthy vs unhealthy foods.

10.3. Visual frequency-healthfulness associations

While the previous literature has provided evidence of the crossmodal correspondence between high- (vs. low-) frequency musical tones with high- (vs. low-) spatial frequency images (Evans & Triesman, 2010), our findings extend this correspondence effect to high frequency-healthfulness association in both auditory and visual stimuli. Specifically, in Study 3, we extended the frequency-healthy association to visual stimuli and the results confirmed that similar to high-frequency sounds, high- (vs. low-) frequency images are similarly matched with healthy (vs. unhealthy) foods. Given that grating images with high spatial frequency correspond to smaller stripes and finer detail, whereas low spatial frequencies represent larger stripes and encode coarseness (Bar, 2004), it is possible that the high- (vs. low-) frequency gratings connote the trait of healthfulness through the shared semantic meaning in a similar way to auditory stimuli. Collectively, high- (vs. low-) frequency stimuli, both auditory and visual are crossmodally correspondent with healthy (vs. less healthy) attributes in food products.

10.4. The congruency effect on purchase intention

Given that a high- (vs. low-) frequency sogo is matched with healthier (vs. less healthy) foods (Studies 1 and 2), and healthier (vs. less healthy) food is perceived as less (vs. more) filling, this study further demonstrates that a high- (vs. low-) frequency sogo is perceived as less satiating since it is associated with lightness in weight. When food is advertised using sogo frequencies that match consumers' consumption goal, it can induce consumers' purchase intention. Specifically, when consumers have a healthy (vs. satiation) goal, they are more likely

to buy food advertised with a high- (vs. low-) frequency sogo. These findings demonstrate the vital role of congruency between sensory and semantic cues.

According to the congruence theory (Eklund & Helmfalk, 2022), the strong connection between nodes (i.e., semantic and sensory cues) determine the congruency effects. Therefore, hearing a high-frequency sogo that can connote healthfulness attributes (e.g., healthy, lightness, and less filling) activates the healthy-related node (e.g., healthy and less filling) and subsequently enhances the positive effect on consumers' purchase intention towards healthy foods. Similarly, hearing a low-frequency sogo that connotes satiability attributes (e.g., more filling) activates the satiability-related node, and thus influences consumers to select a satiable choice. The findings support previous research showing the positive effect of congruence between sensory cues and product attributes on purchase intention (Gvili et al., 2018). For instance, the congruence between sweetness of food and brand personality of sincerity induced a favourable brand attitude and increased actual sale volume of ice-creams (Motoki et al., 2023).

11. Theoretical and managerial contributions

By linking frequency to healthfulness, this paper offers four specific contributions. First, the current study adds evidence to the extant literature on sound-healthfulness associations by providing evidence that sogos can shape the perception of healthy food amongst consumers by manipulation of stimulus frequency. Moreover, these findings illustrate that the sound frequency effect generalizes to visual stimuli by showing that high- (vs. low-) frequency images are also associated with healthfulness. The discovery of the frequency effect is intriguing since it paves avenues for future research in other modalities, such as touch. Extant research has demonstrated that packaging texture influence consumer perception of food tastes and satisfaction (Ferreira, 2019). Further, research in psychophysics suggested that the roughness of the product surface is

related tactile feedback from the vibration of the fingertips touching the packaging surface (Bensmaïa & Hollins, 2003). Given that, we propose that our findings pave the way to investigate the association between packaging texture and food healthfulness. For instance, whether packaging with finer rough texture (i.e., higher vibration frequency) may be more associated with healthfulness than coarse texture (i.e., lower vibration frequency) awaits future investigation.

Second, the study adds to the literature on multisensory and food marketing by demonstrating the effect of sogo in signaling food satiability. While extant literature has extensively revealed that multiple brand attributes (e.g., packaging, brand names, health claim, food shape) can influence the perception of food healthfulness (e.g., Chan & Zhang, 2022; Wang et al., 2022; Yamim et al., 2020), this current study suggests that sogo frequency also plays a vital role in healthy consumption. Our findings provide initial evidence that a short melodic tune (i.e., sogo) created in a low frequency can alter a consumer's perceived satiability of food (while ruling out the level of hunger and time since the last food intake). Moreover, this highlights the crucial role of the shared semantic association between the frequency of sounds and food satiability in modulating consumer perception. Specifically, variation in the frequency of sogos can connote the satiability and healthfulness of foods through the shared meaning of heaviness/lightness and can influence consumers' purchase intention providing the sogo matches semantically consumers' consumption goal (health vs. satiety).

Third, the findings provide a managerial contribution to brand managers and their agencies who are seeking a novel sensory branding strategy for healthy food products. Specifically, we have advanced the application to the marketing of cross-modal correspondences such that high-frequency sogos (and potentially slow tempo) can enhance the healthy appeal of

foods. Moreover, the effectiveness of sogos can be enhanced by congruent packaging or visual logos using high-frequency images (e.g., differing design of stripes or bars) to lead consumers into making healthier choices without having to evaluate complex information often contained in the nutritional labels. Thus, incorporating the healthy sound logos and high-frequency visual cues in food brands could boost healthy food choices at an implicit level.

Finally, our research provides insight to brand managers creating brand elements that are matched with the brand's unique selling points and at the same time can also promote healthy eating habits. Our findings reveal that a sogo with a high frequency is an appropriate choice for brands that aim to promote the health appeal of their food products. On the other hand, a low-frequency sogo can signal satiety and thus represent a useful cue for teenagers/athletes seeking high energy/ carbohydrate foods. For example, food containing high levels of "good fat" (e.g., unsaturated fats and complex carbohydrates) can use low-frequency sogos to induce higher perceived satiety. This could help boost healthy eating habits amongst consumers by satiating their hunger using both sogos (semantically) and food (physiologically).

12. Limitations and future research directions

Firstly, although the findings imply how the inclusion of high-frequency components in sogos could signify the healthfulness of food products, future research could further investigate whether and to what extent the effect generalizes to actual sogos which involves more compositional complexity (e.g., instrumental timbre, intensity fade up/down, pitch ascending/descending) (e.g., Mas, Bolls, Rodero, Barreda-Ángeles, & Churchill, 2021). The fictitious sogos used in the current study (which comprise sound clips modified in terms of their frequency and tempo) were created with less complexity in order to control for potential confounds associated with naturalistic stimuli in the first instance. Future research could thus

investigate the effect of sogos crafted with more complex parameters to gain further insights as to how combinations of music parameters can convey desired product attributes (including beyond the trait of healthfulness). Moreover, as the sogos used in this paper were manipulated in an experimental setting, adopting actual sogos would perhaps increase the ecological validity of the findings.

Secondly, although high frequency is found to be associated with healthfulness, it is also linked with sweetness (e.g., Knöferle & Spence, 2012). Given that sounds differently influence the perception of sweet and savory foods (Motoki et al., 2021, 2022), it is interesting that somewhat differential results were obtained here. In studies 1 and 3 we included both savoury and sweet foods in both the healthy and unhealthy categories. Thus, it should be noted that our finding of high frequency-healthfulness association might be partially influenced by the inclusion of sweet foods in the healthy category, and the low frequency-unhealthfulness association might be also affected by the inclusion of savoury foods in the unhealthy category. In addition, in Study 2 all food stimuli were savoury; hence, the frequency effect found here might be partly affected by the saltiness of the foods. However, it is important to note that since the sounds used in previous research were composed with more complex features than the current study, the music genre (with compositional complexity), instead of frequency solely, may serve as a determinant for taste and healthfulness evaluations (Motoki et al., 2022). Nonetheless, before firm conclusions can be drawn, further investigations are required. For example, subsequent research should consider examining whether the frequency solely affects evaluations of food healthfulness combined with different tastes.

Thirdly, an intriguing clue to the biological basis of this effect comes from research showing how noises alter the taste perception of food being consumed (Yan & Dando, 2015).

The authors explain that while the chorda tympani nerve carries taste information from the anterior portion of the tongue to the brain, it crosses the tympanic membrane of the middle ear. Loud noises temporarily disturb the transition of taste signals while they are crossing through the middle ear such that sweet taste signals become weakened and umami tastes become strengthened, leading to the altered perception of food tastes (Yan & Dando, 2015). Based on this observation, an interesting topic for future research would be to investigate the precise neural mechanisms underlying the association between frequency and perceptions of healthfulness. Given that they are possibly linked by some shared semantic association, the study of the neural correlates of semantic associations and conceptual similarity, in regions such as the anterior temporal lobe (Jackson, Hoffman, Pobric, & Lambon Ralph, 2015) would possibly help us gain more insight into how acoustic stimuli are crossmodally associated with such abstract concept as healthfulness in the brain.

Fourthly, although at this point, we have introduced the new finding of visual frequency-healthfulness association, further research is needed to investigate whether adding a design of a high-frequency grating image would enhance (i.e., the additive effect) the appeal of the healthfulness of a product. Further, our preliminary findings have yet to illuminate the boundary conditions under which these audio-visual frequency-healthfulness effects occur. Thus, additional research is needed to investigate the moderating role of health concern/motivation on the implicit association between sogos and perceived healthfulness. Further, the current paper used only the piano to create sogos, future research could explore the role of timbre or other musical instruments on the perception of food healthfulness.

Moreover, although the results are meaningful and insightful, one may be concerned that it ignores another possible factor of perceived food healthfulness that could be evoked by the

frequency effect. For example, high frequency may induce a sense of healthy in consumers' minds which in turn leads them to higher intention to purchase healthy foods, and low frequency leads to lower perceived healthfulness and subsequent lower purchase intention. Given that this study primarily examined the effect of semantic correspondence between two stimuli, we did not incorporate the participants' experiences evoked by the sogos into the current investigation. Instead, we aimed to demonstrate the perceived congruence as an underlying mechanism behind our results. That is, we aimed to demonstrate that the congruence of sogo and product attributes can induce purchase intention, while the incongruence would diminish the intention. However, it is interesting to investigate the perceived healthfulness as another underlying mechanism of the effect of frequency on purchase intention. Whether and how the increase of perceived food healthfulness could attribute to the purchase intention requires future investigation.

Lastly, our study demonstrates the effect of sogos on the expected/perceived satiability of food. Future research could explore the role of sogos in altering actual behaviour. Specifically, how can sogos affect consumer behaviour to ensure moderate food consumption? Previous research has demonstrated that musical elements (e.g., tempo) serve as a contextual cue to modulate eating behaviour (Mathiesen et al., 2020). For example, consumers spend a longer time eating while slow (vs. fast) and legato music is being played in the background (Mathiesen et al., 2020). Since low-frequency sogos can connote food heaviness, hearing such music could possibly induce consumers to order lesser or smaller food portions. This could be a possible avenue for future research.

CHAPTER 3

Sonic branding of meat- and plant-based foods: The role of timbre

Abstract

Despite the wide body of literature available on the sound symbolism of food, the role of timbre in influencing food perception remains underexplored. Given the shared gender stereotypes between timbre (musical instruments) and foods, this research examined the relationship between masculine/feminine instruments and meat/plant attributes across four studies. We identified the masculine timbre-meat and feminine timbre-plant associations (Study 1), which hold even within the same food category (Study 2a and 2b). Interestingly, the feminine timbre-plant associations (vs. masculine) were found to be stronger at the implicit level (Study 3). Study 4 demonstrated that sogos created in feminine instruments activate the feminine concepts linked to plant appeal and results in enhancing these regardless of consumers' perceived pleasantness of the sogos. Moreover, the feminine sogos were perceived as more suitable for female than male consumers when advertised with plant-based meats (Study 5). These insights suggest novel sonic branding strategies for brand managers, and advertisers in the plant-based (meat-alternative) food industry.

Keywords: Musical instruments; Timbre; Meat-based food; Plant-based food; Gender associations; Sonic logo

1. Introduction

“Brands are investing in sound like never before” (McCullough, 2021) and sonic branding is now a well-established branding strategy. A sonic logo or a brand’s sound signature (e.g., ta-dum of Netflix) is a brief melodic sound customised to represent a brand’s identity (Bonde & Hansen, 2013). Cook (1998) pointed out that a distinctive melody of one or two notes is sufficient to sync social and cultural values with a product. Given that, sonic logos (sogos) are capable of brand signalling in a way other audio assets (e.g., in-store music) cannot. Sogos help brands stay connected with consumers even when the brands are not visible (Bonde & Hansen, 2013); resonate with the brand personality and thus improve brand recognition (Bonde & Hansen, 2013; Mas, Bolls, Rodero, Barreda-Ángeles, & Churchill, 2021). Evidently, the number of brands using sonic identity has increased by 22% in the last year (McCullough, 2021; SoundOut, May 2021) and almost all leading brands (e.g., McDonald’s, Coca-Cola, Oreo) in the Food and Beverage (F&B) sector now use sonic logos (SoundOut, May 2021).

Despite this, how firms can use sogos to connote product attributes associated with the nature of the food (i.e., meat or plant; the latter is collectively used here to refer to fruits, vegetables, legumes, and mushrooms) is yet unclear. This issue is gaining importance as there is a global trend to embrace more plant-based food products (Vegan Society, 2021) and with this trend, firms need to identify attributes (e.g., sogos) which can enhance inherent food attributes. Another research gap lies in the demonstration of sogos that can influence the perception of meat or plant-based attributes of foods. This is surprising as extant literature in sound symbolism has demonstrated that the manipulation of musical parameters (e.g., frequency, loudness, timbre, melodic consonance, legato articulation, and mode) can alter sensory perceptions (e.g., tastes, flavours, aroma, texture, creaminess, crispiness, healthfulness, and temperature to name but few)

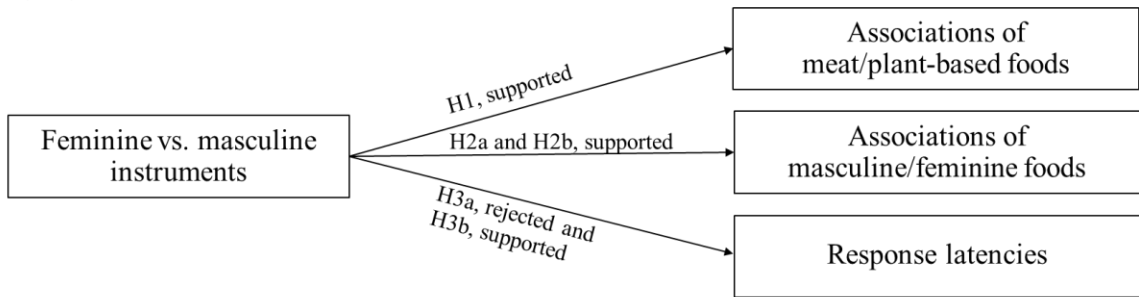
of a variety of foods and beverages (e.g., ice-cream, cinder toffee, coffee, beer, wine, chips, apple, chocolate) (e.g., Crisinel, Cosser, King, Jones, Petrie, & Spence, 2012; Crisinel & Spence, 2010b; Demattè et al., 2014; Kantono et al., 2019; Knöferle & Spence, 2012; Reinoso Carvalho et al., 2016; Spence & Wang, 2015; Techawachirakul, Pathak, & Calvert, 2022; Wang & Spence, 2017; Zampini & Spence, 2004; see Spence, 2015; Spence, Reinoso-Carvalho, Velasco, & Wang, 2019 for a review). However, there remains little understanding of how timbre can affect the perception of foods, especially the nature of foods (i.e., meats vs. plant), leaving a notable gap in this research stream.

In addressing these research gaps, the purpose of the current study is to scrutinize the association between timbre (i.e., different musical instrumental sounds) present in sogos with the meat/plant attributes of foods and examine whether sogos created using putative feminine vs. masculine instruments can alter consumers' perception related to the composition of foods (i.e., their meat vs. plant nature). Given that musical instruments and foods share similar gender stereotypes, we assume that instruments perceived as masculine (vs. feminine) would be associated more with similarly stereotyped foods. We test this framework mainly by manipulating the instrument type (masculine vs. feminine) as the independent variable and perception of food type (meat- vs. plant-based food products) as the dependent variable (see Figure 1 for research framework). Our findings demonstrate that sogos created with masculine instruments are associated more with meat-based food products and those with feminine instruments with plant-based foods. Moreover, this research shows that feminine attributes present in sogos can enhance the perception of plant appeal.

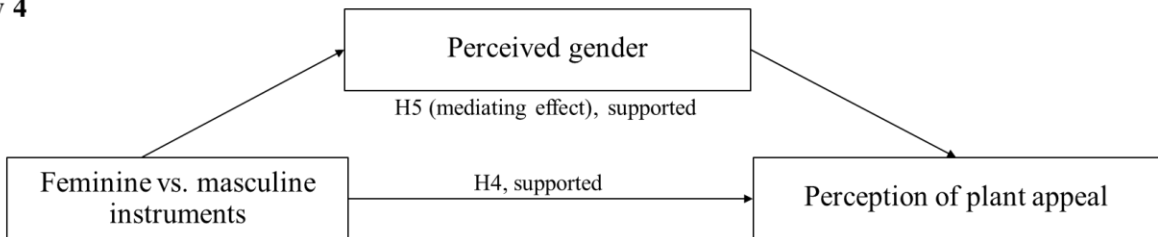
This research makes several contributions to literature and practice. Firstly, we advance the literature on sound symbolism by demonstrating that timbre is associated with meat/plant

attributes of foods due to their shared semantic association with gender. Secondly, we add to the research on multisensory marketing by demonstrating that feminine-sounding instruments can enhance the perception of foods as plant-based. Lastly, we provide insight for practitioners in selecting brand attributes (e.g., slogans) that can promote the nature of food type (i.e., plant vs. meat).

Studies 1, 2a, 2b and 3



Study 4



Study 5



Fig. 1. Research framework.

2. Theoretical background

2.1. Branding for meat-based and plant-based foods

Prior research has found that the language used to describe products can enhance food appeal in meat- and plant-based food categories (Papies, Johannes, Daneva, Semyte, &

Kauhanen, 2020). For example, products described as ‘plant-based’ are perceived as healthier and more eco-friendly than those described as ‘meat alternatives’ (Sucapane, Roux, & Sobol, 2021). Relatedly, although sustainability and healthfulness are different terms, consumers typically perceive sustainable plant-based food products as healthy due to the well-established halo effect (Schiano, Harwood, Gerard, & Drake, 2020).

Given the plant-healthy correlation, the effect of sensory cues on the perception of healthy foods has also been widely documented. In terms of visual cues, green (vs. red) packaging is more strongly associated with (healthier) plant- (vs. meat-) related products (Sucapane et al., 2021) and slim-shaped packaging increases the health appeal of a product compared to wide-shaped packaging (van Ooijen, Franssen, Verlegh, & Smit, 2017). Similarly, images of slimmer (vs. wider) striped bars are matched with healthier (vs. less healthy) foods (Techawachirakul et al., 2022). Moreover, visual cues indicating high (vs. low) placement (i.e., upward vs. downward camera angle) of a food product leads consumers to judge a product as healthier (Wang & Basso, 2021).

Concerning auditory cues, a recent study showed that classical music (vs. Jazz, Hip-hop, Rock/Heavy Metal) evokes positive valence and subsequently increases preferences for healthy savoury and sweet foods (Motoki, Takahashi, Velasco, & Spence, 2022). This finding may be attributed to the high frequency of sounds that shape consumer preferences and prompt them to select healthier meal options (Huang & Labroo, 2021; Motoki et al., 2022). This argument is consistent with other research supporting that high-frequency sogos are semantically congruent with the concept of healthy foods (Techawachirakul et al., 2022). These authors revealed that low-pitched sogos are matched with an unhealthy burger (i.e., bacon burger) and high-pitched

sogos with a healthy salad bowl. However, this research stream has not yet examined the association between musical timbre with meat vs. plant attributes of food products.

2.2. Timbre and crossmodal associations

Timbre, often described as the colour of sound (Handel, 1993), is a complex sound attribute that encompasses both objective and subjective elements (McAdams & Giordano, 2008; Siedenburg, Saitis, & McAdams, 2019).

2.2.1. Timbre as an objective element

From the perspective of the objective component, timbre involves a set of harmonics and computational modelling. First, on a physical basis, timbre arises from the complex waveform of a sound, called an audio spectrum, that is composed of a combination of harmonics (see Figure 2) (Goldstein, 2010; Wolfe, Kluender, Levi, Bartoshuk, Herz, Klatzky, & Merfeld, 2020). Harmonics are essential elements giving a timbre characteristic to each sound. The bottom panel of Figure 2 illustrates the spectral shape of a piano sound of the middle C note. Each vertical line represents a harmonic. The place of the line represents its frequency, and the height of it represents amplitude. A harmonic is thus an interplay between frequency and amplitude. The first harmonic (i.e., the most left vertical line) is the lowest frequency component of the sound. All the other harmonics are multiples of the fundamental; that is, the second, third, fourth harmonics (and so on) have higher frequencies along the y-axis. Thus, timbre is not just loudness, pitch (Bregman, 1990), and duration but the combination of them (McAdams & Giordano, 2008; Siedenburg et al., 2019). Further, each instrumental sound (see Figure 2) has its own set of harmonics, resulting in a unique spectral shape, which contributes to the quality of the sound. Their different qualities (i.e., timbre) allow us to distinguish the sound of a saxophone, trombone, and piano.

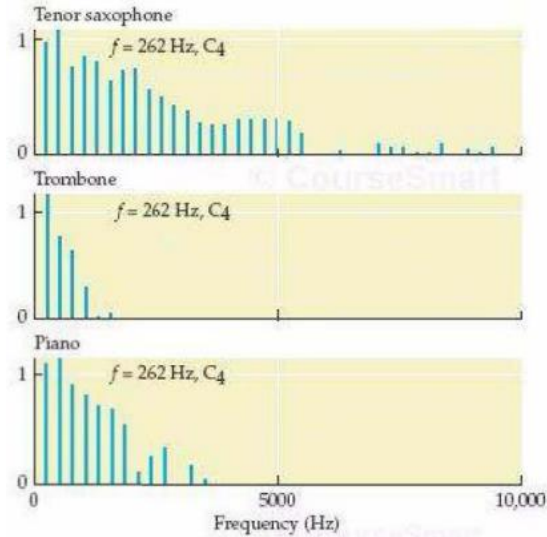


Fig. 2. The spectra of middle C (262 Hz) played by a tenor saxophone, trombone, and piano (Wolfe, Kluender, Levi, Bartoshuk, Herz, Klatzky, & Merfeld, 2020).

In addition to instrumental sounds, consider the sounds in our surrounding environments, such as breaking glass, human speech, and city traffic. These sounds are perceived differently to our ears because they vary in timbre. Interestingly, timbre has a dual nature (Siedenburg & McAdams, 2017). On one hand, two sounds can be distinguished from each other based on their sound quality, even without knowing their meaning or source. On the other hand, because timbre involves a unique set of auditory attributes, it helps listeners identify the origin or source of the sound (Siedenburg & McAdams, 2017). As a result, timbre helps listeners determine whether two sounds with similar pitch and amplitude are dissimilar (American National Standard Institute, 1973; Goldstein, 2010; Wolfe et al., 2020). This allows us to distinguish the sound of a piano from a trombone, even when they are playing the same note (i.e., the same frequency) at the same pitch (Helmholtz, 1877) (see Figure 2 for comparison of the spectral shapes differed in saxophone, trombone and piano).

In addition to harmonic components, timbre is also influenced by the shape and materials of instruments which contribute to differences in tone or resonance (i.e., natural vibration frequencies). For instance, a violin's timbre produces a richer sound than a viola because it contains more overtones (Oakes & North, 2006). Moreover, playing technique also influences instrumental timbre, such as bowing technique for string instruments (e.g., a violin) and emboucher technique for wind instruments. Even when the same instrument is played using different techniques (e.g., different strikes on the same piano key), the differences in timbre might be quite subtle. This highlights the complexity of timbre, which can vary on different scales of details; whether it is due to different playing techniques on the same instrument or entirely different instruments (Siedenburg & McAdams, 2017).

Thus it is apparent that timbre is not only determined by the harmonic components (i.e., the spectral shape), but is also influenced by the shape and material of the musical instruments as well as how they are played. As a result, timbre is often equated to the musical instrument being played (i.e., instrumental timbre) as we can observe in the extant consumer behaviour literature (e.g., Oakes & North, 2006; Sunaga, Meng, & Zhuang, 2020).

In addition, timbre also contains quantifiable characteristics that are often used in computational modelling. In computational models, timbre is typically represented by a set of acoustic features that capture the unique characteristics of a sound's spectrum (i.e., the interaction of frequency and amplitude) and temporal envelope (i.e., changes in the frequency and amplitude of sound that individuals perceive over time) (Siedenburg et al., 2019). These features often include fundamental aspects like the spectral centroid, which relates to the brightness of a sound (Grey & Gordon, 1978); and attack and decay time, all of which describe how a sound starts and ends (Patil, Pressnitzer, Shamma, & Elhilali, 2012). These features are

fundamental in the analysis and synthesis of sound, providing a computational model for understanding and manipulating timbre in various audio applications; for instance, a computational framework to understand the similarity between timbre and colour based on structural analogies between the two perceptual domains of hearing and vision (Mannone & Arias-Valero, 2022). The goal of computational timbre modelling is to create a mathematical representation that can mimic the human perception of timbre, and which can then be used in various applications such as retrieval of music information, digital sound synthesis, and enhancing the quality of sound in cochlear implants (Siedenburg et al., 2019). Moreover, advanced models may also incorporate machine learning techniques to learn and predict timbre from large datasets of sound samples (Mannone & Arias-Valero, 2022). Since a computational model is beyond the scope of the thesis, the definition of the timbre in the thesis is not computationally defined.

2.2.2. Timbre as a subjective element

From a subjective perspective, timbre not only exists in melodies but also in the listener's mind (Siedenburg et al., 2019). Saitis and Weinzierl (2019) (p.119) defined timbre as “a set of verbally defined perceptual attributes that represent the dimensions of a semantic timbre space.” This can be illustrated by the wide variety of words people use to describe timbre (McAdams & Giordano, 2008; Siedenburg et al., 2019). For example, simple tones (i.e., the sounds of a single frequency) are described as “free from roughness”, “pleasant”, “having a very soft sound” and “dull” when played in low frequencies, while piano tones are often described as “splendid and rich” (Helmholtz, 1877). Rough, soft, dull and rich are exemplars of verbal attributes that are shared by composers, musicians, scientists, sound engineers and even nonmusicians (Siedenburg et al., 2019). These metaphorical descriptors play a significant role in how we conceptualize

timbre as a perceptual attribute (Siedenburg et al., 2019). While it is possible to recognize, compare, or imagine timbres without necessarily verbalizing them, the descriptors are crucial for communicating the subtle acoustic properties to others (Siedenburg et al., 2019). These descriptors draw upon a range of shared human experiences, which can be sensory attributes from different modalities (e.g., sweet, bright, warm) or onomatopoeic attributes (e.g., shrill, buzzing) or abstract (e.g., rich, harsh), allowing for a deeper understanding and communication of timbre variations (Saitis & Weinzierl, 2019; Wallmark, 2014). That is, the language used to describe timbre can reveal insights into how it is perceived and understood.

Semantic rating and factor analysis approaches are useful and frequently applied to understand the dimensionality of different timbres (Saitis & Weinzierl, 2019; Von Bismarck, 1974; Zacharakis, Pasiadis, & Reiss, 2014). The timbral semantics are often reported between two and four dimensions (e.g., Edwards, 1978; Von Bismarck, 1974; Zacharakis et al., 2014), but can be up to 20 (Reymore, 2022). For example, Von Bismarck (1974) used the spectral shape and the semantic differential approach (i.e., verbally anchored scales of two antonym adjectives) in musicians and nonmusicians and four dimensions of timbre emerged, which are dull-sharp, compact-scattered, full-empty, and colourful-colourless. Nevertheless, Moravec and Štěpánek (2003) revealed another four dimensions that are commonly mentioned by music professionals and non-music professionals, which are sharp, gloomy, soft, and clear. Edwards (1978) analysed the verbal data describing trombone sound quality from over 300 trombonists and proposed two dimensions of timbre: dull-clear, round-square, and small–wide.

Moreover, Zacharakis et al. (2014) had Greek and English participants describe the tones of 23 musical instruments using the given 30 adjectives. The results revealed three salient semantic dimensions: luminance (i.e., brightness or sharpness), texture (i.e., roughness or

harshness) and mass (i.e., fullness or richness) (Zacharakis et al., 2014), which are correlated with physical properties: the duration of the initial attack, the midpoint of spectral energy distribution, and the variability or irregularity in the spectrum, respectively (Zacharakis, Pastiadis, & Reiss, 2015). The research indicated the correlations between physical properties and semantic dimensions of timbre and these dimensions are somewhat consistent across languages (Zacharakis et al., 2014). Further, a recent study by Reymore (2022) arrived at a 20-dimensional model of timbre qualia (i.e., subjective experiences of perceiving timbre, Saitis & Weinzierl, 2019). The authors had musician participants imagine the sounds of 34 musical instruments common in Western orchestras and wind ensembles and then rate their auditory image one at a time. The results of factor analysis yielded 20 dimensions of timbre (termed as Timbre Trait profiles); for instance, rumbling/low, soft/singing, watery/fluid, nasal/reedy.

2.2.3. Timbre and crossmodal correspondence

Given that timbre is commonly perceived and described using non-auditory sensory attributes, it implies a role for semantic processing in crossmodal mapping between sensory experiences encoded in different modalities (Saitis & Weinzierl, 2019; Simner, Cuskley, & Kirby, 2010). That is, somehow timbre semantics can be viewed through the lens of crossmodal correspondences. Several multisensory studies have now provided evidence that different musical instrumental sounds can play a crucial role in shaping sensory experiences in all five senses (e.g., taste, flavour, aroma, colour, shape, roughness) (e.g., Adeli, Rouat, & Molotchnikoff, 2014; Bronner et al., 2012; Crisinel & Spence, 2010b; Guest, Catmur, Lloyd, & Spence, 2002). For example, participants matched musical notes played on a piano with sweet tastes and fruity aromas (e.g., raspberry, blackberry, and apricot), and those played on brass instruments with bitter and sour tastes, as well as musky, smoky, and woody aromas (see Spence

et al., 2019 for a review). In terms of aesthetic packaging, piano sounds (i.e., soft timbres) have been shown to be associated with cool colours (e.g., blue, green) and rounded shapes. In contrast, cymbal sounds (harsh timbres) are matched with warm colours (e.g., red, yellow) and angular shapes (Adeli et al., 2014). Moreover, instrumental timbre has also been shown to shape consumer choices. For example, when music with Spanish (vs. Italian) instruments was played in a university canteen in North America, students and faculty selected a Spanish meal (i.e., seafood paella) over an Italian meal (i.e., chicken parmesan) (Zellner, Geller, Lyons, Pyper, & Riaz, 2017).

In summary, timbre is both a physical property of sound (related to its harmonics and the instruments creating the sounds) and perceptual experience (i.e., sound semantics) of the listeners. Relevant to the thesis, timbre has been shown to be a decisive element in slogans that facilitates brand recognition and without it, one would find it challenging to recognise melodies (Bonde & Hansen, 2013). Based on prior data mapping instrumental sounds, it is plausible to propose some crossmodal correspondence between instrumental sounds and meat/plant food attributes. In this thesis, timbre is therefore objectively defined as the type of musical instrument from which sounds are generated (i.e., feminine vs. masculine instruments) as reported in previous consumer research (e.g., Oakes & North, 2006; Sunaga, Meng, & Zhuang, 2020).

One may be concerned about whether timbre is a social construct. It is important to note that associations between sound qualities and gender are culturally and subjectively constructed. While some people may describe certain timbres as "masculine" or "feminine" based on personal or cultural associations (e.g., Reymore & Huron, 2020; Stronsick et al., 2017), there is no inherent gender identity in timbre itself. Timbre is a multidimensional perceptual attribute that encompasses a wide range of qualities beyond simplistic gender binaries. In this sense, a

“feminine/masculine timbre” could describe a sound that is perceived as having qualities associated with femininity/masculinity (Pernet & Belin, 2012; Reymore & Huron, 2020; Stronsick et al., 2017). For example, Pernet and Belin (2012) used mathematical modelling to probe gender categorization of male/female voices and instruments (i.e., clarinet and oboe, respectively). The results showed that the categorization performance can be based on the timbral sounds alone. That said, the idea of a gender-related timbre is also a social construct because the perception of the sound can be based on societal norms and stereotypes about gender (as discussed in the next section). For example, certain musical instruments might be described as having a feminine timbre because they are often played by feminine performers and have softer, lighter, or more delicate—qualities that are similar to the female voice (Reymore & Huron, 2020; Stronsick et al., 2017) and can be linked with feminine traits (e.g., Langford & Mackinnon, 2000; Klink, 2000). Given this, the term “masculine/feminine timbre” can be understood as either a timbre or a social construct.

2.3. Cognitive schemas of gender-stereotyped instruments

A large body of research has shown that musical instruments can be categorized into masculine and feminine subtypes based on the repeated co-occurrence of certain instruments with musicians of specific gender (e.g., Cramer, Million, & Perreault, 2002). The gender associations of instruments are possibly formed after observing that certain musical instruments are typically selected by male or female musicians. For example, brass (e.g., tuba) is mostly played by male musicians, while high woodwinds (e.g., flute) by females (Cramer et al., 2002). Consistent with another study linking gender roles to musical activities, boys commonly selected the tuba, trombone, bass, guitar, and percussion as their primary performing instruments whereas girls typically selected the flute, oboe, and bassoon (Harrison & O’Neill, 2003). In fact, the

association of musical instruments with gender stereotypes forms early in life and persists in adulthood (Abeles, 2009; Wrape, Dittloff, & Callahan, 2016). Given this evidence, it suggests that people develop cognitive schemas for instruments marked as masculine (vs. feminine) via the process of learned association. Therefore, based on the prevailing gender stereotypes, we classified brass (e.g., saxophone, trumpet, trombone, tuba) as masculine instruments whereas high woodwinds (e.g., flute, oboe, clarinet) and violin as feminine ones (Abeles, 2009; Elliot & Yoder-White, 1997; Eros, 2008; Hallam, Rogers, & Creech, 2008; McLeod, 2009; Stronsick, Tuft, Incera, & McLennan, 2017). It is important to note that although we categorized instrument type as masculine and feminine, we refer only to the sounds of those instruments as masculine and feminine (not masculine or feminine musical instruments per se).

2.4. Gender stereotypes of food

Similar to musical instruments, certain foods are typically considered masculine vs. feminine (Gal & Wilkie, 2010; Mooney & Lorenz, 1997; see Rodrigues, Gómez-Corona, & Valentin, 2020 for a review; Rozin, Hormes, Faith, & Wansink, 2012). Specifically, extensive research now suggests that meat is considered masculine, whereas vegetables, fruits, and dairy products as feminine in many countries (Jensen & Holm, 1999; Love & Sulikowski, 2018; Rozin et al., 2012; Ruby, 2012; Vartanian, Herman, & Polivy, 2007). For example, US and Turkish consumers commonly consider steak, hot dogs, and chicken wings as masculine, and salads, pasta, and ice cream as feminine (Ekebas-Turedi, Cilingir Uk, Basfirinci, & Pinar, 2021).

Gender stereotyping of foods possibly arises from gender role stereotypes (Rodrigues et al., 2020), specifically the ancient hunting/gathering roles of men and women in early history. The structuralist metaphor "wild male = weapons, hunting and killing" and "wild female = agriculture and fertility" is widely stated across cultures (LaFontaine, 1978; MacCormack, 1980).

Historically, meat as a product of hunting was seen as a value meal and a limited resource. Successful hunters also gained privileged access to meat to symbolize higher social status and simultaneously reinforced their physical strength (Boesch, 1994; Gurven & Hill, 2009; Stanford, 1999). On the contrary, traditional female roles required less strength and therefore vegetables and fruits (as products of agriculture and gathering), and milk and eggs (as symbolic of female fertility), were considered the most feminine food products (Heisley, 1990). Apparently, meat was not only food for men, but a socially constructed symbol of virility, higher status/power, and masculinity (Kildal & Syse, 2017; Rothgerber, 2013), whereas vegetables/fruits were regarded as symbols of femininity (Kildal & Syse, 2017; Rodrigues et al., 2020; Rothgerber, 2013).

Besides gender roles, evidence from the cognitive perspective suggests that the masculine-meat association is established at the implicit level of cognitive processing. For example, participants respond more quickly when meat-related words are paired with strength-related attributes (e.g., virile, strong, powerful), which are related to maleness, than when paired with weakness-related attributes (e.g., diseased, weak, sick) (Love & Sulikowski, 2018). Similarly, the reaction time for meats (e.g., beef, pork) paired with masculinity (e.g., male names such as John, Robert) is faster than with femininity (e.g., Joan, Claire) (Kimura et al., 2009; Rozin et al., 2012).

It is noteworthy that despite the progress of gender equity in societies, the notion of food-gender association persists and plays a crucial role in signalling one's social identity through food choices (Rodrigues et al., 2020). According to social identity theory, individuals conform to group stereotypes to increase a sense of belonging and to differentiate themselves from those outside the group (Tajfel, 1981). Recent research suggests that individuals following vegan diets were judged as more feminine (or unmanly) than those following omnivorous meals (Rozin et

al., 2012; Thomas, 2016). Given that taking meat off the plate possibly leads to a more feminine association and decreased masculinity (Kildal & Syse, 2017; Rodrigues et al., 2020), men tend to avoid foods considered feminine (e.g., vegetarian, Rothgerber, 2013) due to the conflict with their social identity (Judge & Wilson, 2019; MacInnis & Hodson, 2017). Echoing prior research, males (vs. females) tend to have a more negative evaluation of foods linked with a dissociative (e.g., femininity) reference group (e.g., a steak labelled as a lady's cut) than a food labelled as non-gendered (White & Dahl, 2006). Taking these findings, we refer to masculine foods as meat-based food products and feminine foods as plant-based food products.

3. Method and overview of studies

According to the theory of spreading activation in semantic memory networks (Collins & Loftus, 1975), semantic concepts (nodes) are linked together bi-directionally in the large memory network. When one concept is activated or processed, it will stimulate a related concept within the network, and hence spread the activation to other corresponding concepts within the memory network. Given that the concepts of musical instruments and foods are semantically congruent in terms of gender ascriptions, hearing an instrumental sound could stimulate a gender-related concept, and then the activation spreads out to food that shares the same gender link. Therefore, we proposed that type of musical instrument (masculine vs. feminine) would be associated with the perception of food attributes (meat-based vs. plant-based) and conducted four studies to test this main hypothesis. The hypotheses for each study would be provided in corresponding studies.

Study 1 sought to provide evidence that sogs with masculine (vs. feminine) sounding instruments are expected to be associated with meat-based (vs. plant-based) foods. In Study 2, we extended the timbre-food associations *within* the same food category to validate the role of shared semantic associations between instrument-type and food-type. Study 3 tested the strength

of the association between timbre and perceived food attributes at an implicit level by using a semantic priming paradigm. Study 4 aimed to demonstrate that the use of musical instruments can influence consumers' perception of plant attributes of an otherwise gender-ambiguous food and the perceived gender of the instrumental sounds underlies this influence. Study 5 aimed to show that the use of instruments that are congruent with consumers' gender can result in choice selection.

3.1. Participants

Participants were recruited from the USA using the subject pool of Amazon Mechanical Turk (Studies 1-4) Connect platform of Cloudresearch (Study 5). They were invited to take part in only one of the studies and were paid for their time and effort. Participants were required to indicate their consent at the beginning of the experiment. As indicated in previous research (e.g., Pathak & Motoki, 2022; Pathak, Motoki, Techawachirakul, & Calvert, 2022), the effect size of the associations between sound and product attributes ranges approximately from 0.20 to 0.60, which is considered to be small to medium using Cohen (1988)'s criteria. Thus, the sample sizes were estimated to detect medium-sized effects in this study. The sample size ($N \approx 60$ for each study) was calculated using G*Power 3.1.9 (Faul, Erdfelder, Lang, & Buchner, 2007) given power = .90, $\alpha = .05$ and two-sided effect to detect a medium-sized effect (0.5 and 0.24) in Wilcoxon signed-rank tests (Studies 1, 2a and 2b) and repeated measures (RM) ANOVA (Study 3). In Study 4, given power = .90, $\alpha = .05$ in within-subject mediation analysis, a sample size of $n \approx 100$ was estimated (Montoya, 2023). In Study 5, given power = .95, $\alpha = .05$, two tails, the sample size ($N \approx 60$) was estimated using G*power 3.1.9 (Faul et al., 2007) to detect a medium-sized effect (0.5) in a paired-sample *t*-test.

All the studies were designed on Qualtrics online survey platform except Study 3 which was designed on the Inquisit 6 platform of Millisecond.com. The analyses were performed using IBM SPSS version 22.0 for Windows.

3.2. Sound stimuli

Fictitious sogos (Studies 1, 2, 4 and 5) and 800 ms musical notes (Study 3) were used as auditory stimuli and were created using *Noteflight* (an online music composing application, www.noteflight.com) and *FL Studio* (a music production software) (see Table 1 for overview of stimulus development). The timbre of the stimuli was manipulated at two levels (masculine vs. feminine musical instruments). The research was approved by the ethics committee of a large northern university in the UK.

Table 1

Overview of stimulus development.

Study	Stimulus development	Results of pretest
1,2	<p>12 sogos comprised of C4 to B4 notes, 90 bpm and 6 seconds duration were manipulated by instruments.</p> <ul style="list-style-type: none"> - Masculine instruments: Alto saxophone, trombone, trumpet, tuba. - Feminine instruments: Clarinet, flute, oboe, violin. - Neutral instruments (fillers): Bassoon, guitar, piano, xylophone. 	<p>The instruments were classified following previous literature (Abeles, 2009; Elliot & Yoder-White, 1997; Eros, 2008; Hallam, Rogers, & Creech, 2008; McLeod, 2009).</p>
1	<p>24 food items were presented in text.</p> <ul style="list-style-type: none"> - Meat-based foods: Steak, beef sandwich, hamburger, grilled pork, meatball spaghetti, beef stew, bacon pizza, corned beef. - Plant-based foods: Salad, vegetable sandwich, mushroom burger, grilled corn, tomato spaghetti, lentil stew, tomato pizza, baked beans. 	<p>The food items were classified following previous literature (Ekebas-Turedi et al., 2021; Gal & Wilkie, 2010; Jensen & Holm, 1999; Kimura et al., 2009; Lipschitz, 2009; Rozin et al., 2012).</p>

Study	Stimulus development	Results of pretest
2a	<p>- Fillers: Mango juice, apple juice, chocolate cookies, butter cookies, cupcake, muffin, cinnamon rolls, cinnamon donuts.</p> <p>16 animal-based foods presented in text were manipulated based on gender stereotypes.</p> <p>- Masculine items: Sausage, beef, bacon, salami, pork, bologna, ham, turkey.</p> <p>- Feminine items: Fish, butter, clam, lamb, egg, milk, cream, yoghurt.</p>	<p>The foods were rated as masculine at $ps < .001$ and feminine at $ps < .01$.</p>
2b	<p>16 plant-based foods presented in text were manipulated based on gender stereotypes.</p> <p>- Masculine items: Potato, onion, corn, mushroom, broccoli, green bean, bell pepper, asparagus.</p> <p>- Feminine items: Tomato, lettuce, grape, cantaloupe, plum, strawberry, cherry, peach.</p>	<p>The foods were rated as masculine at $ps < .05$ and feminine at $ps < .01$.</p>
3	<p>Eight C4 quarter notes of 800 milliseconds were manipulated by instruments.</p> <p>- Masculine instruments: Alto saxophone, trombone, trumpet, tuba.</p> <p>- Feminine instruments: Clarinet, flute, oboe, violin.</p>	<p>The instruments were classified following previous literature (Abeles, 2009; Elliot & Yoder-White, 1997; Eros, 2008; Hallam, Rogers, & Creech, 2008; McLeod, 2009).</p>
3	<p>16 food words.</p> <p>- Non-vegetarian food words: sausage, beef, bacon, salami, pork, ham, bologna, and turkey.</p> <p>- Vegetarian food words: peach, cherry, strawberry, plum, cantaloupe, grape, lettuce, and tomato</p>	<p>The food items were taken from Study 2.</p>
4	<p>Two melodic notes consisted of five notes with a wave-like pattern were created. One is played by a masculine instrument (i.e., tuba) and the other by a feminine instrument (i.e., flute).</p>	<p>The two melodies did not differ in the likeability ($t(49) = .14, p = .89$), pleasantness ($t(49) = .48, p = .63$), and familiarity ($t(49) = .82, p = .41$).</p>

Study	Stimulus development	Results of pretest
4	Two images of burgers that were neutral in meat and plant appeals.	The burgers did not differ in the neutral attribute ($t(49) = .04, p = .96, M_{burger1} = 47.90, SD = 32.07; M_{burger2} = 48.06, SD = 29.13$).
5	Two melodic notes consisted of five notes with a wave-like pattern were created. One is played by a masculine instrument (i.e., tuba) and the other by a feminine instrument (i.e., flute).	The two melodies did not differ in the pleasantness ($t(49) = .86, p = .39$), likability ($t(49) = .23, p = .82$), and familiarity ($t(49) = .13, p = .89$).

4. Study 1: Associations between instrument and food type

The purpose of this study was to examine the association between instrument type and food type at the explicit level. Given the shared traits of masculinity with masculine instruments and meat and femininity with feminine instruments and fruits/vegetables, we predicted that:

H1: Sogos with masculine (vs. feminine) instruments¹ would be associated more with meat- (plant-) based foods.

4.1. Participants

A total of 60 participants took part in this study. The data of three participants who provided the same answers for all the questions were excluded (*Males* = 34, *Females* = 22, gender unspecified = 1; $M_{age} = 43.86$ years, $SD = 13.66$, age range = 24 -70 years; omnivore = 51, vegetarian = 6).

4.2. Sogo stimuli

¹ It is important to note that throughout this article we refer masculine and feminine instruments as instruments whose sounds are perceived as masculine and feminine respectively.

Twelve sogos were used in the study. Four sogos each were created with masculine (alto saxophone, trombone, trumpet, and tuba) and feminine instruments (clarinet, flute, oboe, and violin), and four sogos used as fillers were created with non-gender stereotyped instruments (bassoon, guitar, piano, xylophone) (Elliot & Yoder-White, 1997; Eros, 2008; Stronsick et al., 2017; Wrape et al., 2016) (see Table 2). Sogos with instrumental sounds of bassoon, clarinet, oboe, piano, trumpet, trombone, and violin were created using *Noteflight*. The others were generated using *FL Studio* (*Saxophia* plugin for alto saxophone, *Morphine* plugin for flute, and *Sonatina Orchestra* for tuba and xylophone). The sogos were composed of a series of melodic notes taken from a published study (Techawachirakul et al., 2022) (C4 to B4 notes; frequency range 261.63 – 493.88 Hz; played at a moderate tempo of 90 beats per minute [bpm]: 6 seconds in duration). The loudness of sogos was normalized to -20 dB RMS using the *Audacity* software (<https://www.audacityteam.org/>). A sample of sogos can be found online at <https://soundcloud.com/musicclipss/sets/timbre>.

Table 2

The list of instrumental timbre used in Studies 1 and 2.

Musical instruments		
Masculine	Feminine	Neutral (Fillers)
Alto saxophone	Clarinet	Bassoon
Trombone	Flute	Guitar
Trumpet	Oboe	Piano
Tuba	Violin	Xylophone

Note. The instruments were classified following previous literature (Abeles, 2009; Elliot & Yoder-White, 1997; Eros, 2008; Hallam, Rogers, & Creech, 2008; McLeod, 2009).

4.3. Food stimuli

Twelve pairs of food items were selected and presented as text stimuli. Eight pairs of food items consisted of meat-based versus plant-based (i.e., fruits, vegetables, legumes) meals (see Table 3) (Ekebas-Turedi et al., 2021; Gal & Wilkie, 2010; Jensen & Holm, 1999; Kimura et al., 2009; Lipschitz, 2009; Rozin et al., 2012) and matched in gender-associated meal types (e.g., hamburger and pizza are perceived as masculine, whereas spaghetti is perceived as feminine; Ekebas-Turedi et al., 2021) and perceived healthfulness (e.g., a sandwich is considered healthier than hamburger; Mooney & Amico, 2000). Another four pairs of food items acted as fillers and consisted of beverages and desserts with no prior known gender associations.

Table 3

The list of food items used in Study 1.

Food items	
Meat-based	Plant-based
Steak	Salad
Beef sandwich	Vegetable sandwich
Ham burger	Mushroom burger
Grilled pork	Grilled corn
Meatball spaghetti	Tomato spaghetti
Beef stew	Lentil stew
Bacon pizza	Tomato pizza
Corned beef	Baked beans

4.4. Design and procedure

The experiment used a one-way within-participant design in which musical instruments were manipulated at two levels (masculine vs. feminine). Participants were told that a food company wanted to select different slogans for products that are equally tasty, healthy, and

attractive. Participants were then instructed to listen to a fictitious sogo and select the food items (using a forced choice task) that they felt it was best suited for each trial. Each sogo was played automatically, one at a time and was followed by the presentation of food items (randomized). There were 12 trials in total, lasting for approximately four minutes. The target trials comprised eight sogos where gender-associated musical instruments were randomly paired with eight gender-associated food pair choices (one food item each was randomly selected from the meat- and plant-based food pool). The filler trials consisted of four sogos created with gender-neutral instruments and paired with four gender-neutral food choices. The food pairs were displayed in a random order (left vs. right) and were counterbalanced within-participant.

4.5. Results and discussion

Meat-based choices were coded as 1 and plant-based choices as 0, summing scores (ranging from 0 – 4) across masculine instrument conditions and feminine instrument conditions for each participant. These were then converted to percentages to create two meat-choice indices (one for each instrument type). A Wilcoxon signed-rank test was then used to compare the indices between masculine versus feminine instrument conditions. The results revealed that participants expected the sogos created using masculine (vs. feminine) instruments to be associated with meat-based (vs. plant-based) foods ($M_{\text{masc timbre}} = 61.40\%^2$, $SD = 20.63$; $M_{\text{fem timbre}} = 37.71\%$; $SD = 27.60$; $z = 4.19$, $p < .001$, $r = .39$) (see Table 4 and Figure 3), supporting H1³.

² M is the averaged proportion of trials that participants selected for meat-based over plant-based foods.

³ We also performed a mixed ANOVA to test the interaction effect of type of instrument and participants' gender on the meat choice selection (ranging from 0-4), which was treated as continuous data (Huang & Labroo, 2020; Huang, Dong, & Labroo, 2018; Pathak, Calvert, & Motoki, 2020; Semin, & Palma, 2014). Data of one participant who did not indicate their gender were removed, hence $n = 56$. The results revealed that the main effect of type of instrument was significant ($F(1,54) = 26.02$, $p < .001$, $\eta_p^2 = .33$) while the main effect of gender was not found ($F(1,54) = 2.37$, $p = .13$). The interaction of type of instrument and gender was not significant ($F(1,54) = 1.41$, $p = .24$). This

Data were also separately analysed for each type of instrument (i.e., masculine and feminine). For each instrument type, two choice indices (meat and plant) were created following the method mentioned above. Then, two Wilcoxon signed-rank tests (one for each instrument type) were used to compare the meat-choice versus plant-choice indices. The results revealed that participants expected sogos played in masculine instruments to be associated more with meat-based than plant-based foods ($M_{meat} = 61.40\%$, $M_{plant} = 38.60\%$, $SD = 20.63$; $z = 3.67$, $p < .001$, $r = .34$), and those played in feminine instruments which were associated more with plant-based than meat-based foods ($M_{meat} = 37.71\%$, $M_{veg} = 68.28\%$, $SD = 27.60$; $z = 3.01$, $p = .003$, $r = .28$) (see Table B.1 in Appendix B for analyses by instruments).

Consistent with our prediction, the results showed that sogos created with masculine instruments were expected to be associated with meat-based foods and those with feminine instruments with plant-based foods. These findings provide initial evidence of the association between instrumental timbre and food attributes. Study 2 aimed to further examine whether this

indicated that participants' gender has no effect on the association between type of instrument and meat/plant attributes.

Table 4*Summary of effects of instrumental timbre (masculine vs. feminine) on food perception.*

Study	<i>n</i>	Dependent variable	Mediator	Masculine instruments	Feminine instruments	<i>p</i>	
				<i>M(SD)</i>	<i>M(SD)</i>		
1	57	% selecting meat-based diets		61.40% (20.63)	37.71% (27.60)	< .001	
2a	59	% selecting masculine animal-based foods		65.79% (25.28)	35.96% (25.00)	< .001	
2b	60	% selecting masculine plant-based foods		66.25% (24.28)	38.33% (24.12)	< .001	
3	62	Response latencies to non-vegetarian words (milliseconds)		593.41 (70.81)	599.09 (73.51)	.104	
		Response latencies to vegetarian words (milliseconds)		605.83 (71.46)	596.76 (74.58)	.038	
				Effect of IV on mediator (<i>a</i>)	Effect of mediator (<i>b</i>)	Indirect effect (<i>ab</i>)	95% CI
				<i>b (SE)</i>	<i>b (SE)</i>	<i>b (SE)</i>	
4	98	Perception of plant appeal	Perceived gender	42.91 (3.76)***	.40 (.13)**	17.35 (5.61)	[6.53, 28.39]

*** $p < .001$, ** $p < .01$.

association holds within the same food-category type (animal-based foods and plant-based foods).

5. Study 2: Associations within food categories

Study 1 demonstrated the association of sogos created with masculine (vs. feminine) instruments with meat-based (vs. plant-based) foods. It is likely that the results might have been affected by the choice of food category itself (e.g., it is likely that prior timbre-food associations exist for certain foods and consumers associate meat- vs. plant-based foods with a certain type of music). We thus conducted Study 2 to extend these findings to within the same food category, having a varying degree of perceived masculinity and femininity (e.g., within meats, beef is perceived as more masculine than fish; Rozin et al., 2012, and within plants, potato is considered as more masculine than peach; Heisley, 1990). If our hypothesis holds, a similar timbre-food association could be extended to within-one food category itself. Consequently, we selected two food categories, animal-based (Study 2a) and plant-based products (Study 2b), with varying masculinity and femininity appeals within. The experimental design and procedure were similar to that used in Study 1. We hypothesized that:

H2a: Sogos with masculine (vs. feminine) instruments would be associated more with masculine (vs. feminine) animal-based foods.

H2b: Sogos with masculine (vs. feminine) instruments would be associated more with masculine (vs. feminine) plant-based foods.

5.1. Study 2a (Animal-based foods)

5.1.1. Participants and procedure

A total of 59 participants took part; data of two participants were excluded⁴ (*Males* = 29, *Females* = 26, gender unspecified = 2; $M_{age} = 41.23$ years, $SD = 12.03$, age range = 22 -73 years; Omnivore = 49, Vegetarian = 8). Animal-based food items were selected from a pretest and used as stimuli (see Appendix C for the pretest). The procedure was similar to Study 1.

5.1.2. Results

Following the method in Study 1, masculine food choices were coded as 1 and feminine food choices as 0, scores were summed (ranging from 0 – 4) across masculine instrument conditions and feminine instrument conditions for each participant, then converted to percentages to create two masculine-choice indices (one for each instrument type). A Wilcoxon signed-rank test was then used to compare the indices between masculine versus feminine instrument conditions. The results revealed that participants expected the sogos with masculine (vs. feminine) timbre to be associated more with masculine (vs. feminine) animal-based foods ($M_{masc\ timbre} = 65.79\%$ ⁵, $SD = 25.28$; $M_{fem\ timbre} = 35.96\%$; $SD = 25$; $z = 5.32$, $p < .001$, $r = .50$) (see Figure 3), supporting H2a⁶. The results were not affected by consumption preference (i.e., omnivore or vegetarian eating habits)⁷.

⁴ One participant completed the study in more than 12 minutes (whereas the average completion time is around 4 minutes ($SD = 2$) and the other participants provided the same response to all the questions.

⁵ M is the averaged proportion of trials that participants selected masculine over feminine food choices.

⁶ We additionally performed a mixed ANOVA to test the interaction effect of type of instrument and participants' gender on the masculine choice selection (ranging from 0-4), which was treated as continuous data (Huang & Labroo, 2020; Huang, Dong, & Labroo, 2018; Pathak, Calvert, & Motoki, 2020; Semin, & Palma, 2014). Data of two participants who did not indicate their gender were removed, hence $n = 55$. The results revealed that the main effect of type of instrument was significant ($F(1,53) = 50.70$, $p < .001$, $\eta_p^2 = .49$) while the main effect of gender was not found ($F(1,53) = .47$, $p = .50$). The interaction of type of instrument and gender was not significant ($F(1,53) = .53$, $p = .47$). This indicated that participants' gender has no effect on the association between type of instrument and masculine/feminine attributes of the foods.

⁷ Though the sample size of vegetarians was inadequate, a repeated measures ANOVA was carried out with consumption preference as a covariate. No effect of consumption preference was observed ($F(1,55) = 2.18$, $p = .15$).

We also analysed the responses in each instrument type (i.e., masculine and feminine) separately. Similar to the method in Study 1, two choice indices (masculine and feminine) were created for each instrument type. Then, two Wilcoxon signed-rank tests (one for each instrument type) were used to compare the masculine-choice versus feminine-choice indices. The results demonstrated that participants expected sogos created with masculine timbre to be more associated with masculine (than feminine) animal-based foods ($M_{\text{masc foods}} = 65.79\%$, $M_{\text{fem foods}} = 34.21\%$, $SD = 25.28$; $z = 3.98$, $p < .001$, $r = .37$), and those with feminine timbre to be more associated with feminine (than masculine) animal-based foods ($M_{\text{masc foods}} = 35.96\%$, $M_{\text{fem foods}} = 64.04\%$, $SD = 25$; $z = 3.64$, $p < .001$, $r = .34$) (see Table B.2 in Appendix B for analyses by instruments).

5.2. Study 2b (Plant-based foods)

5.2.1. Participants and procedure

A total of 60 participants completed the study ($Males = 35$, $Females = 25$; $M_{\text{age}} = 41.98$ yrs., $SD = 13.25$, age range = 22 -77 yrs.; non-vegetarian = 56, vegetarian = 4). Plant-based items were selected from a pretest and used as stimuli (see Appendix C for the pretest).

5.2.2. Results and discussion

The method outlined in Study 2a was used to create the indices (one for each instrument type) and compare them between masculine versus feminine instrument conditions. A Wilcoxon signed-rank test revealed that participants expected the sogos played in masculine (vs. feminine) musical instruments to be associated more with masculine (vs. feminine) plant-based foods ($M_{\text{masc timbre}} = 66.25\%$ ⁸, $SD = 24.28$; $M_{\text{fem timbre}} = 38.33\%$; $SD = 24.12$; $z = 4.73$, $p < .001$, $r = .43$)

⁸ M is the averaged proportion of trials that where participants selected masculine over feminine food choices.

(see Figure 3), supporting H2b⁹. The results were not affected by consumption preference (i.e., omnivore or vegetarian eating habits)¹⁰.

We also analysed the responses to each instrument type (i.e., masculine and feminine) separately using the method mentioned in Study 2a. The results showed that participants expected sogos with masculine timbre to be more associated with masculine (than feminine) plant-based foods ($M_{\text{masc foods}} = 66.25\%$, $M_{\text{fem foods}} = 33.75\%$, $SD = 24.28$; $z = 4.27$, $p < .001$, $r = .39$), and feminine instruments to be more associated with feminine (than masculine) plant-based foods ($M_{\text{masc foods}} = 38.33\%$, $M_{\text{fem foods}} = 61.67\%$, $SD = 24.12$; $z = 3.43$, $p = 0.001$, $r = .31$) (see Table B.3 in Appendix B for analyses by instruments).

While Study 1 demonstrates the association of instrumental timbre and food types (meat-based and plant-based), Study 2 further validates this association within the same food categories. Specifically, masculine (vs. feminine) instrumental timbres were matched with foods rated higher in masculinity (femininity) in both animal-based and plant-based products.

⁹ We additionally conducted a mixed ANOVA to examine the interaction effect of type of instrument and participants' gender on the masculine choice selection (ranging from 0-4), which was treated as continuous data (Huang & Labroo, 2020; Huang, Dong, & Labroo, 2018; Pathak, Calvert, & Motoki, 2020; Semin, & Palma, 2014). The results revealed that the main effect of type of instrument was significant ($F(1,58) = 41.66$, $p < .001$, $\eta_p^2 = .42$) while the main effect of gender was not found ($F(1,58) = .09$, $p = .76$). The interaction of type of instrument and gender was not significant ($F(1,58) = 1.84$, $p = .18$). This indicated that participants' gender has no effect on the association between type of instrument and masculine/feminine attributes of the foods.

¹⁰ Though the sample size for vegetarians was inadequate for the analysis, a repeated measures ANOVA was carried out with consumption preference as a covariate. No effect of consumption preference was observed ($F(1,58) = .90$, $p = .35$).

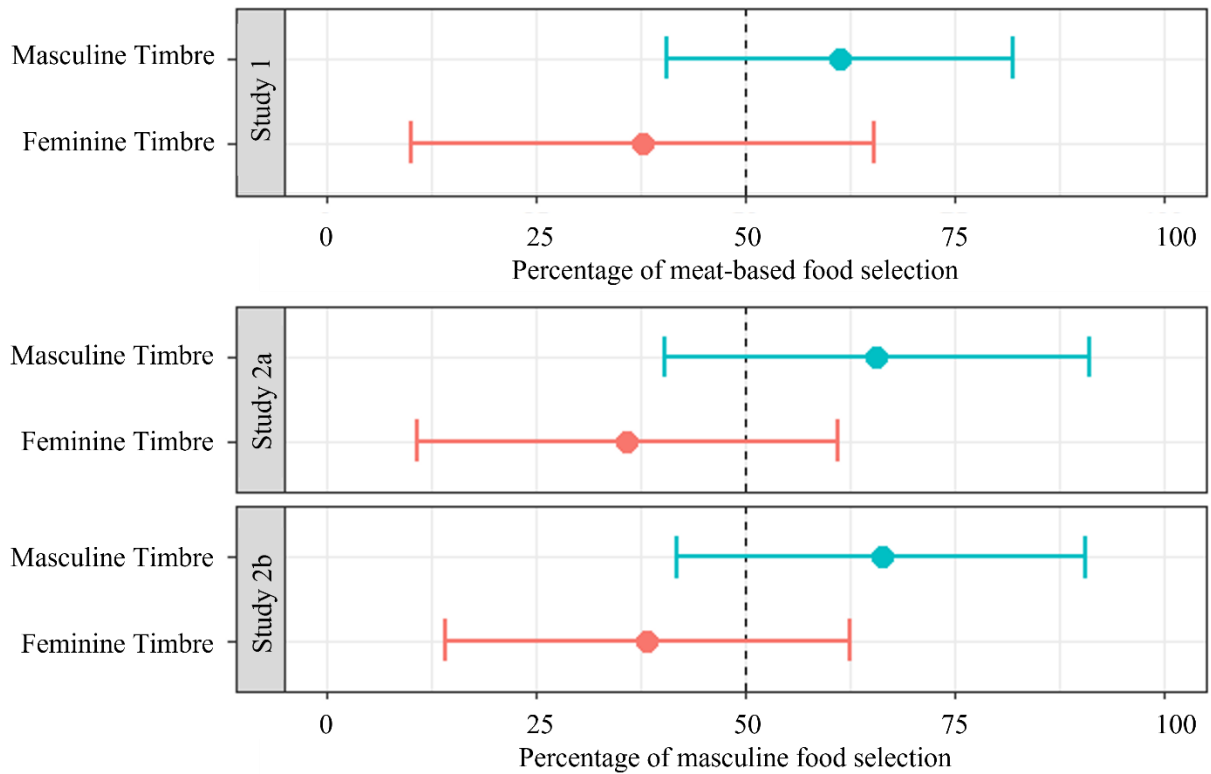


Fig. 3. An illustration of the results of food selection in each timbre type in Studies 1, 2a, and 2b. The percentage of meat-based (Study 1) and masculine (Studies 2a and 2b) food selection is shown on a 100-point scale. Dots represent the averaged percentage of food selections and the error bars indicate the standard deviation. Significant differences in matching meat-based foods with masculine timbres and plant-based foods with feminine timbres were observed in Study 1 ($p < .001$). Significant differences in matching masculine foods with masculine timbres and feminine foods with feminine timbres were observed in Studies 2a and 2b ($ps < .001$).

6. Study 3: Associations at the implicit level

We have so far provided converging evidence for the proposition that sogos created with masculine (vs. feminine) instruments are expected to be associated with foods connoting masculinity (femininity) at an explicit level of consciousness (i.e., response to the survey/questions). Study 3 tested this association at the implicit level of processing using a semantic priming task. Such a measure focuses on the automatic activation of an evaluation (e.g., pleasant or awful) associated with a prime (e.g., flower vs. insects) (Fazio & Olson, 2003). It

potentially explores the semantic associative network between schemas of musical instruments and food items occurring at an implicit level. Many marketing scholars have applied this technique to examine the unconscious processing of products and their associated attributes (Pathak, Calvert, & Lim, 2020). The task involves judging the connotation of the target. If the target words and the prime are semantically congruent, a faster latency response to the congruent conditions (vs. the incongruent ones) is observed. Therefore, we posited that if musical instruments can convey the masculinity and femininity of food products as observed in Studies 1 and 2, then it is likely that the same instrumental notes will be implicitly perceived as more congruent with one trait than the other. Hence, we hypothesized that:

H3a: Response latencies for non-vegetarian food items would be faster when preceded by masculine (vs. feminine) sound notes.

H3b: Response latencies for vegetarian food items would be faster when preceded by feminine (vs. masculine) sound notes.

6.1. Participants and stimuli

A total of 62 participants completed the study (*Males* = 34, *Females* = 28, M_{age} = 48.81 years, SD = 12.57, age range = 26 -76 years). The musical notes were composed with a C4 quarter note (frequency 261.63 Hz; tempo at 80 bpm) of 800 ms, including a 75 ms fadeout (Lahdelma, Armitage, & Eerola, 2022). To ensure the natural and realistic instrumental timbre, *Noteflight* was used to create the sound of clarinet, oboe, trumpet, and violin, and *FL Studio* was used to generate the sound of alto saxophone and tuba (*DSK Brass* plugin), flute (*Morphine* plugin), and trombone (*Sonatina Orchestra* plugin). All stimuli were normalised to -15 LUFS (i.e., the standard perceived loudness) using *Audacity* (<https://www.audacityteam.org/>), then

amplified to 3.5 dB to control for amplitude difference arising due to timbre dissimilarity and to enhance the loudness (a sample of stimuli are available online at <https://soundcloud.com/musicclipss/sets/timbre-traits-c4-note>). A total of eight musical notes (masculine vs. feminine instrument) were used as primes (masculine instrumental sounds: alto saxophone, trombone, trumpet, and tuba; feminine instrumental sounds: clarinet, flute, oboe, and violin). A total of 16 food words (taken from Study 2) were selected as targets (Non-vegetarian food words: sausage, beef, bacon, salami, pork, ham, bologna, and turkey; Vegetarian food words: peach, cherry, strawberry, plum, cantaloupe, grape, lettuce, and tomato).

6.2. Design and procedure

A 2 (instruments: masculine vs. feminine) x 2 (target words: non-vegetarian vs. vegetarian foods) repeated-measures experimental design was used (see Figure 4) (e.g., Lahdelma et al., 2022). The task involved categorizing the presented words in respective categories (non-vegetarian vs. vegetarian) by pressing the E and I keys on the computer keyboard. The key mapping (i.e., E = non-vegetarian and I = vegetarian) was continuously displayed on top of the screen and was counterbalanced between participants. Participants were presented with a series of words comprising food items. Each word presentation was preceded by a musical note of 800ms (see the section above). If a participant pressed a wrong key, an error message (a red cross) appeared on the screen which provided a cue to give a correct response. A few instructions were given aurally to ensure compliance with the speaker/headphone requirement in the study. Participants were asked to be as fast and accurate as possible and were familiarised with the task in a practice block of 10 practice trials. The main task comprised one block of 128 trials (8 musical notes x 16 types of foods). Each trial comprised a fixation cross that appeared for 500 ms, followed by a musical note (800 ms). At 200 ms after the onset of the

musical note, the target word (non-vegetarian vs. vegetarian food items) was displayed and remained in the centre of the screen for 2000 ms during which participants can make a response (Figure 4; see Lahdelma et al., 2022 for a similar approach and experimental design using musical notes).



Fig. 4. The procedure of semantic priming used in Study 3.

6.3. Results and discussion

The response latencies were analysed using a linear mixed-effects model, with *lme4* package (Bates, Maechler, Bolker, & Walker, 2015) contained in the statistical software package *R*. We had fixed effects for instrument type (masculine vs. feminine), food type (non-vegetarian vs. vegetarian foods) and their interaction, and included a random intercept for participants. All response latencies between 250 ms and within 2 SD were log-transformed¹¹ and analysed ($M_{correct\ response} = 95.8\%$, $SD = 3.76$) (Hermans, De Houwer, & Eelen, 2001; Lahdelma et al., 2022).

¹¹ The analysis of latencies without log transformation using linear mixed-effects model was also performed. Similar to the results of log-transformed latencies, there were no main effects of the instrument type ($F(1,7774) = 0.24$, $p = .63$) and the food type ($F(1,7774) = 2.15$, $p = .14$); however, the interaction effect of the instrument and food type was observed ($F(1,7776.9) = 5.38$, $p = .02$). Moreover, the AIC of the model with log transformation was lower (-16153.64) than the model without log transformation (99475.5). Thus, the latencies were transformed and reported.

The results revealed that there were no significant main effects of instrument type ($F(1,7774) = .59, p = .44$) or food type ($F(1,7774) = 2.84, p = .09$). However, the interaction between instrument type and food type was found to be significant, $F(1,7776.3) = 6.59, p = .01$ revealing a congruency effect of the instrument type on the faster detection of the type of food words. Post-hoc tests confirmed that the reaction times to words related to vegetarian food were significantly faster when the words were preceded by musical notes from feminine instruments ($M = 596.76$ ms, $SD = 74.58$), than when preceded by musical notes from masculine instruments ($M = 605.38$ ms, $SD = 71.46$; $b = -8.63, SE = 4.35, t(7775) = 1.99, p = .047$) (see Figure 5), supporting H3b. Similarly, reaction times to words related to non-vegetarian foods were faster when the words were preceded by musical notes from masculine instruments ($M = 593.41$ ms, $SD = 70.81$), than when preceded by musical notes from feminine instruments, though not significantly ($M = 599.09$ ms, $SD = 73.51$; $b = 5.65, SE = 4.35, t(7776) = 1.30, p = .20$), rejecting H3a.

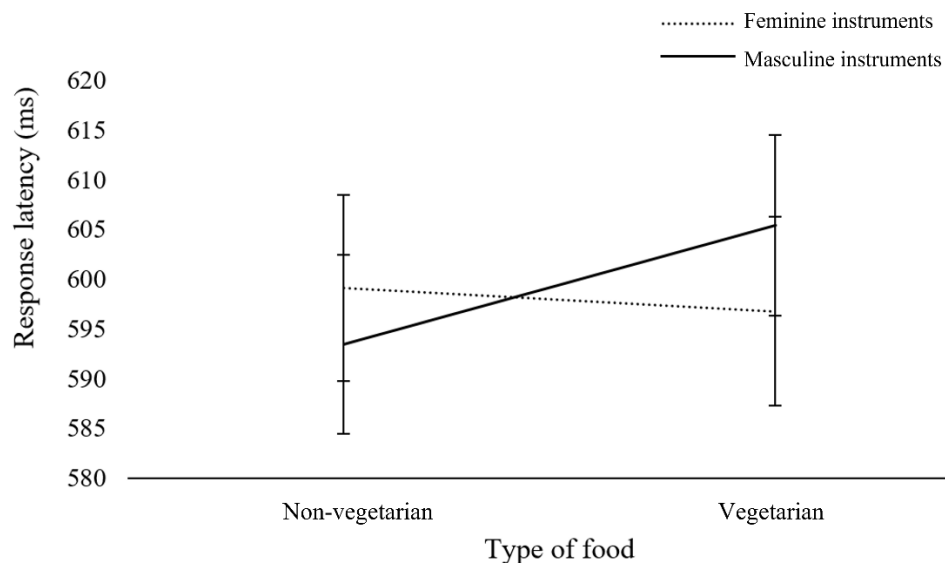


Fig. 5. Response latencies of Study 3 and the interaction of the musical instrument type and the type of word. Error bars represent the SE of means.

Study 3 confirmed the implicit semantic association between instrument type and food type. Specifically, participants responded more quickly to plant-based food items when they were primed with feminine instrumental notes than when primed with masculine instrumental notes. While the differential reaction times toward meat-based food items (faster responses to masculine food items when primed with masculine instruments) trended in the same direction, this did not meet statistical significance.

7. Study 4: Feminine instruments and perception of plant appeal

Given that the association between feminine instruments and plant-based foods are stronger than those between masculine instruments and meat-based foods, we thus focused on the relationship between feminine instruments and the perception of plant-based attributes (also called plant appeal in the current paper) only and did not test the relationship between masculine instruments and perception of meat appeal. Specifically, we compared the perception of plant appeal between masculine and feminine instruments. Whether masculine instruments could increase the appeal of meat was not investigated in this study. We conducted this study to test whether feminine instruments can induce/enhance the perception of plant appeal in otherwise ambiguous foods and whether perceived gender of these cues drives the effect. We hypothesized that:

H4: Sogos created with feminine instruments would enhance the perception of plant appeal in ambiguous foods.

H5: Perceived gender of instrumental sounds would mediate the influence of feminine instruments on the perception of plant appeal.

7.1. Participants

One hundred participants were recruited for this study; data of two participants who spent more time ($> 2SD$ from the average completion time) and provided the same response to all the questions were discarded ($Males = 45$, $Females = 52$, gender unspecified = 1; $M_{age} = 39.90$ years, $SD = 12.55$, age range = 22 - 66 years).

7.2. Sogo stimuli

In this study, new sogos were created for two reasons. Firstly, to increase generalizability, we used notes different from those used in earlier studies to create the sogos. Secondly, to enhance the ecological validity of this study, we created melodies with characteristics similar to those used in commercial sogos, which consisted of five notes with a wave-like pattern (Anzenbacher, 2016; SoundOut, 2021). Two sogos were selected after a pre-test (see Appendix D) to ensure that likability, pleasantness, and familiarity of the sogos were controlled (one created with a tuba and another with a flute with 130 bpm using the tools and procedure described in Study 3; samples of the sogos are available online at https://soundcloud.com/musicclipss/sets/s5a_timbre).

7.3. Procedure

We used a within-subject design in which we manipulated instrument type into two levels (masculine vs. feminine). Sogos created with tuba and flute were used as masculine and feminine stimuli (see Table B.1 – B.3 in Appendix B).

Participants were informed that a food company wants to select food adverts where sogos and foods are matched perfectly. Each trial started with one of the sogos being played for a few seconds, followed by the image of a burger to ensure that participants listened to the whole sogo tune. The image stimuli comprised images of burgers that were neutral in meat and plant-related

attributes/appearance (i.e., ambiguous in food composition [meat vs. plant]). The images were selected after a pretest to ensure that the appearance of the images was matched (see Appendix E).

Next, participants evaluated food attributes using a VAS scale on the perception of plant appeal (what type of burger they think it is; 0 = Definitely meat, 100 = Definitely vegetable). Later, participants also rated how masculine or feminine the sogos were (0 = Very masculine, 100 = Very feminine) and how pleasant the sogos were (0 = Not pleasant at all, 100 = Very pleasant). The anchors of the rating scales were counterbalanced between participants.

7.4. Results

Manipulation checks for the perceived gender of the instrumental sounds. A paired-sample *t*-test showed that the sogo created with the flute was perceived as feminine ($M_{flute} = 78.26, SD = 16.34$) and the sogo created with tuba as masculine ($M_{tuba} = 35.35, SD = 30.87; t(97) = 11.42, p < .001, d = 1.15$).

Perception of plant appeal. An RM ANOVA was performed, with instrument type as the IV, food perception as the DV, and controlled for the pleasantness of the instrumental sounds ($p > .14$). The results revealed that the burger image when presented with flute sogo was rated as a vegetable burger ($M_{flute} = 59.64, SD = 29.97$) more than when presented with tuba sogo ($M_{tuba} = 38.45, SD = 31.34; F(1,95) = 10.89, p = .001, \eta_p^2 = .10$), supporting H4.

Mediation. We performed a mediation analysis (MEMORE macro, Model 1; Montoya & Hayes, 2017), with instrument type as the IV, perception of plant appeal as the DV, and perceived gender of the instrumental sounds as the mediator, to investigate how the perceived gender mediates the relationship between the instrument type and perception of plant appeal. The

indirect effect of the perceived gender was estimated using 95% percentile bootstrap intervals with 5000 bootstrap samples. The results showed that the direct effect of the instrument type on the perception of plant appeal was not significant ($b = 2.27$, $SE = 6.04$, $t(96) = .38$, $p = .71$). In support of H5, indirect effect of the instrument type on the perception of plant appeal through perceived gender of the instrumental sounds was significant ($b = 18.92$, $SE = 4.82$, 95% CI [9.82, 28.97]). Specifically, the flute was rated as more feminine ($b = 42.91$, $SE = 3.76$, $t(97) = 11.42$, $p < .001$) and the perceived femininity was positively related to the perception of plant appeal ($b = .44$, $SE = .11$, $t(96) = 4.14$, $p < .001$) (see Figure 6). This indicated that the feminine attribute of the instrumental sounds fully mediated the relationship between the instrument type and perception of plant appeal.

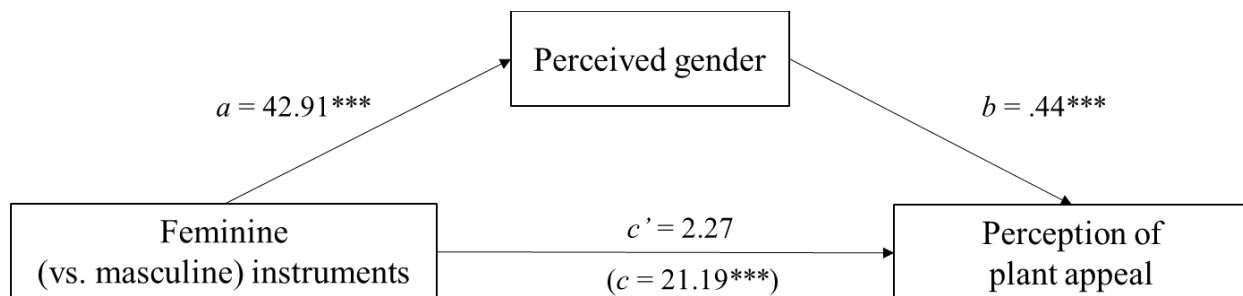


Fig. 6. The figures illustrate the mediating effect of perceived gender on the relationship between instrument type (masculine vs. feminine) and perception of plant appeal in Study 4. *** $p < .05$.

7.5. Discussion

In this study, we demonstrated that sogos created with feminine (vs. masculine) instruments were perceived as more feminine, leading to the perception of ‘plant appeal’ in ambiguous foods. There was no influence of the pleasantness of sounds.

Considering that brand names could signal feminine attributes (Pogacar Angle, Lowrey, Shrum, & Kardes, 2021), we conducted follow-up studies on brand names to demonstrate that the feminine effect on food evaluation could generalize to another brand element (e.g., brand name, see Appendices F and G). The results showed the association between feminine brand names and plant-based meals (Appendix F) and a feminine brand name could enhance the perception of plant appeal in food (Appendix G).

8. Study 5: Choice selection

We have so far demonstrated that feminine instruments can enhance the perception of plant appeal in plant-based meat products through the perceived femininity of instrumental sounds. This study aimed to further examine how the effect of instrumental type might influence choice of an ambiguous food (i.e., plant-based meat foods) for male versus female consumers.

Extant literature indicates that gender norms play a significant role in shaping consumers' food consumption (Gal & Wilkie, 2010; Rodrigues et al., 2020). Social identity theory proposes that individuals conform to group stereotypes to enhance their sense of belonging and distinguish themselves from those outside the group (Tajfel, 1981). Studies demonstrate that adhering to gender expectations leads to rewards (e.g., Wood et al., 1997), while failure to do so often leads to adverse psychological outcomes due to social prejudice against the norm violation (Herek, 2000; Major & O'Brien, 2005). As a result, the selection of foods conforming to consumers' gender norms is an option to reinforce their identity; for instance, females tend to select food menus containing feminine features (e.g., Nature Salad) against masculine features (e.g., Western Salad) than males (Gal & Wilkie, 2010). Similarly, men tend to avoid vegetarian/vegan foods (i.e., feminine foods) as vegan men are viewed as unmanly, especially in the eyes of other men (Brookes & Chałupnik, 2022; Judge & Wilson, 2019; MacInnis & Hodson, 2017). Taken

together, it is plausible to assume that gender-congruent choices possibly persist even in a condition where the food attribute is ambiguous (i.e., plant-based meat alternatives) by relying on gender-associated instrumental sounds (Stronsick et al., 2017). Given the robust association between sogos with feminine instruments and plant attributes (which is associated with femininity) (Studies 1, 3 and 4), this study primarily focused on the effect of feminine sogos on female consumers and predicted that ambiguous foods advertised with feminine sogos would be more often selected by female than male consumers. If feminine instrumental sounds are perceived as feminine, consumers who want to purchase a plant-based meat product for their female (vs. male) friend should be more likely to select a brand advertised with a feminine (vs. masculine) brand sogo. Formally stated,

H6: Participants would select a brand that uses a sogo created in a feminine instrument for their female (vs. male) friend.

8.1. Participants

70 participants were recruited from the Connect platform; data of five participants were excluded (two participants took more than 3SD above the average completion time; one provided the same answers, and the other two failed the attention check). Data from 65 participants were further analysed (*Males* = 32, *Females* = 33: $M_{age} = 36.90$ years, $SD = 12.13$, age range = 20 - 69 years).

8.2. Design and procedure

A one-way within-participant design was used where friend's gender was manipulated at two levels (male vs. female). Participants were instructed to imagine that they were buying a plant-based burger online for their *female [male]* friend and heard two different brand's sogos.

Then, they indicated which brand they wanted to select for their friend. Brand choices were presented on a VAS scale in which the values are invisible to them (0 = Brand A, 100 = Brand B) and counterbalanced between participants. Brand A was represented by a sogo played with a flute and Brand B by a sogo played with a tuba (samples of sogos are available at <https://on.soundcloud.com/hz7ym>). The sogo melodies differed between instruments to induce variability but they were matched on pleasantness, familiarity, and likability (Techawachirakul, Pathak, Motoki, & Calvert, 2023a).

Next, they rated how masculine or feminine the sogos were (0 = Very masculine, 100 = Very feminine) and how familiar were they with plant-based meat products (0 = Not familiar at all, 100 = Definitely familiar). To ensure that all the participants were attentive, they were asked to indicate whether they heard a given brands' sogo and the musical instrument used in the study (0 = No, 1 = Yes). Participants who failed these questions were excluded from the analysis.

8.3. Results and discussions

Manipulation check. A paired *t*-test revealed that participants rated sogo created in a flute ($M = 75.43, SD = 16.10$) as more feminine than by a tuba ($M = 20.35, SD = 15.11; t(64) = 15.52, p < .001, d = 3.53$).

Brand selection. Since the brand choices were presented on a semantic differential scale, the higher (vs. lower) rating represented a higher tendency to select a sogo with a tuba (vs. flute). A paired *t*-test was performed to compare the selection of brands for female versus male friends, whereby friend's gender was the IV and brand selection was the DV. The results revealed that a

sogo created in a flute were selected for a female friend ($M = 19.57$, $SD = 25.44$) a male friend significantly ($M = 58.11$, $SD = 34.61$; $t(64) = 7.34$, $p < .001$, $d = 1.27$)¹², supporting H6¹³.

9. Discussion

Despite the vast literature on correspondences between music and food attributes, scant research has examined the association between musical timbre (masculine vs. feminine) and the nature of food products (e.g., meat vs. plant). The current study provides the first evidence of the masculine timbre-meat and feminine timbre-plant association, and manipulation of instruments can induce a perception of desirable food attributes. We demonstrate that sogos with masculine instruments are more associated with meat-based foods, and feminine ones with plant-based foods (Study 1). This association holds even within the same food category. Specifically, sogos created in masculine (vs. feminine) instruments are expected to match with masculine (feminine) animal-based foods (Study 2a) and plant-based foods (Study 2b). However, the association between feminine instruments and plant items is stronger than between masculine instruments and meat items at the implicit level (Study 3). Accordingly, playing a sogo created with a feminine instrument (flute) helps enhance the plant appeal of the advertised foods due to the perceived femininity of the instrumental sound (Study 4).

9.1. 'Masculine timbre-meat' and 'feminine timbre-plant' correspondences in sogos

¹² A repeated-measure ANCOVA was performed to test whether familiarity with plant-based meat products would affect brand selection. Friend's gender was the IV, brand selection was the DV and product familiarity was the covariate. The results revealed that participants' brand selection was not affected by product familiarity (Brand selection: $F(1,63) = 7.28$, $p = .009$, $\eta_p^2 = .10$; Product familiarity: $F(1,63) = .21$, $p = .65$).

¹³ A mixed ANOVA was additionally carried out the test whether participants' gender would affect the choice selection. Friend's and participants' gender were the IV and brand selection was the DV. The results revealed that choice selection was not affected by participants' gender ($F(1,63) = .08$, $p = .78$) and the interaction of friend's and participants' gender ($F(1,63) = .01$, $p = .93$). This indicated that the ambiguous food that was advertised with a feminine instrument was selected by female consumers more than male consumers.

Although extant literature has noted that low-pitched sogos are matched with a bacon burger (less healthy) whereas high-pitched sogos with a spring salad (healthier), it is noteworthy that this association was investigated under the concept of healthfulness, and not as meat/plant attributes (Techawachirakul et al., 2022). Our findings identify a direct association between masculine timbre-meat and feminine timbre-plant. We first demonstrate this phenomenon using the same meal (e.g., sandwich) with different ingredients (e.g., beef vs. vegetable) and the results showed that masculine instruments are matched more with meat-based meals, and feminine instruments with plant-based counterparts.

However, one may argue that this effect may be attributed to the food category itself. To support our argument, prior research proposed that meats and plants vary in gender association (Heisley, 1990). This notion is observed in our pretests. For example, for meats, we find that beef and pork are more masculine than fish and clam. This gender association may be developed due to the traditional men and women roles, whereby men hunted large animals and women gathered smaller animals (Bird, 1999). For plants, we found that peaches and strawberries are more feminine than potatoes and corn. This association is possibly based on their tastes and physical traits such as texture, shape, and size (Heisley, 1990). Specifically, masculinity within fruits and vegetables is thought of as hard, rough, long, large, dry, and grown in the dirt, whereas femininity is determined as soft, round, small, juicy, and sweet (Heisley, 1990). We thus extended our findings using foods within the same category and the results revealed that masculine (vs. feminine) instruments were associated more with masculine (feminine) foods regardless of the food category.

Drawing upon the convincing evidence, the shared semantic association between the features of timbre and food products can account for the timbre-food correspondence. We

propose that sogos played by brass instruments and meat-based products are preferably mapped because both features connote masculinity, whereas those played by high woodwinds are preferably matched with plant-based products because they both connote femininity. Consequently, hearing a sogo played by a brass instrument (vs. flute, for instance) stimulates a masculine (feminine) concept, and activation then spreads to a meat (plant) item, consistent with the theory of spreading activation (Collins & Loftus, 1975).

To support this argument, we designed a semantic priming task to test the strength of semantic association. The findings concur with our earlier observations, showing the timbre-food association at the implicit level. Nevertheless, it is somewhat surprising that the feminine timbre-plant association is stronger than the masculine-meat association, which implies that the latter association may be derived less from the shared trait of masculinity.

One possible explanation of the weak masculine-meat link relates to gender congruency consumption. Research suggests that men have a stronger desire (than women) to choose foods congruent with their gender identity, and women appear to be less concerned about food-gender congruency (Gal & Wilkie, 2010; Ye, Bose, & Pelton, 2017). Therefore, while men are less likely to accept vegetarian diets than women, women hold a favourable view towards meat in addition to vegetarian diets (Judge & Wilson, 2019; Love & Sulikowski, 2018; Rosenfeld & Tomiyama, 2021; Rothgerber, 2013). To some extent, meat thus is possibly viewed as a common food for both genders rather than being restricted to only masculine diets, which in turn weakens the connection with masculinity.

9.2. Femininity promotes plant appeal

Our findings further revealed that a sogo created in a feminine instrument can influence consumers' perceived plant appeal of food regardless of sogo pleasantness. The results are in accordance with prior literature which indicates crossmodal influences of music on the sensory experiences of foods (Spence, 2020; Spence & Wang, 2015). Our studies demonstrate that when the meat/plant properties are visually ambiguous, participants judge the burger as a vegetable in a significantly more intense way when the burger is presented with the feminine (vs. masculine) sogo. This phenomenon is mediated by the perceived femininity of the instrumental sound.

This finding could be attributed to the crossmodal priming effect (Spence, 2012) where the exposure to a stimulus in one sensory modality may prime expectations that crossmodally correspond with it, which in turn affects the sensory perception towards another stimulus that is presented later (Spence, 2012; Deliza & MacFie, 1996). In our case, sogos created using a flute (perceived as feminine) could have induced expectations (or primed 'vegetable') in consumers' minds, and subsequently influenced the perceived plant appeal. This account is also in line with the existing evidence, for example, changing frequencies of music can modulate the taste perception of actual food items (cinder toffee) as the music frequencies share correspondences with the toffee (Crisinel et al., 2012). Given the results reinforce this perception pattern, the present research highlights the role of femininity in promoting plant appeal using popular communication tools such as sogos.

9.3. Choice selection

Our study also demonstrated that when participants were motivated to select a plant-based meat product advertised with different sogos, they tended to select the brand with feminine (vs. masculine) sogos for a female (vs. male) friend. The findings were consistent with previous research indicated that food consumption is affected by gender norms whereby consumers tend

to select the foods that conform to gender norms to affirm their gender identity (Gal & Wilkie, 2010; Rodrigues et al., 2020). That is, males tend to avoid foods that contain feminine features while females tend to select foods that contains more feminine than masculine features (Brookes & Chałupnik, 2022; Gal & Wilkie, 2010; Judge & Wilson, 2019; MacInnis & Hodson, 2017). Our study supported extant literature by showing that when ambiguous food (i.e., plant-based meats), which is gender neutral, was presented with femine features (i.e., a sogo played by a flute), it was more often selected for female consumers. Similarly, when the food was presented with masculine features (i.e., a sogo played by a tuba), it was deemed as more suitable for male consumers. The findings demonstrated that the congruence of sogo-gender would facilitate the choice selection.

10. Research contributions

10.1. Theoretical contributions

The contribution of this research to the current literature is twofold. First, these findings advance the literature on sound symbolism by demonstrating a direct association between instrumental timbres (masculine vs. feminine) and food types (meat- vs. plant-based foods). The literature regarding sound-food correspondence has predominantly focused on aspects such as tastes, flavours, and healthfulness (see Spence et al., 2019 for a review). For example, music with high-pitched sounds is linked with healthy foods (Motoki et al., 2022; Techawachirakul et al., 2022). Although to some extent healthy foods refer to vegetables and fruits, our understanding of how sounds and music directly associate with the natural composition of foods (e.g., meat and plants) is sparse. Our findings enrich this research stream by presenting a novel perspective of masculine timbre-meat and feminine timbre-plant associations through their shared semantic association of gender.

Second, the present research adds evidence to the domain of multisensory marketing by demonstrating that sogos connoting femininity can promote the plant appeal of food products. Prior research on branding communications has examined different cues such as background music, brand names and packaging, that impact consumer perception (e.g., Huang & Labroo, 2020; Pogacar et al., 2021). Still, our understanding of how sogos can shape consumer perception is limited. Our research findings add to a growing body of literature on multisensory marketing by highlighting the influence of brand attributes (sogos and brand names) created with feminine cues on the plant appeal.

10.2. Managerial implications

Our research findings provide new insight for practitioners (e.g., food manufacturers, brand managers, advertisers, sogo and brand name developers) seeking a novel sensory branding strategy. Although consumers can visually distinguish meats from plants, the simultaneous use of sogos is advantageous to brands in many circumstances, such as in audio advertisements where brands and products are out of sight. Brands often invest in developing sogos that convey desirable brand attributes. Our findings suggest that if brands want to convey meat-related attributes, they should use brass (e.g., tuba, trombone) as the main instrument in their sogos. On the other hand, if brands want to convey plant-related attributes (vegetables/fruits), they should use high woodwinds (e.g., flute, clarinet) as the main instrument instead.

Another point to consider here is the emergence of plant-based ‘meat’ foods, which are combinations of plant (the ingredients) and meat attributes (the taste, texture, and appearance). Our findings suggest that using a sogo played by a flute can promote the appeal of plants in foods which may help consumers make an instant judgement regarding food properties without spending time reading the descriptors in the advert. Further, the findings have managerial

implications for brand managers tasked with creating a brand's sound signature to match their targeted consumers. Specifically, the application of feminine instruments not only enhances the plant appeal of the product, also is apparently more attractive to female consumers.

11. Limitations and future research

Firstly, past research has demonstrated the interactions and interference of timbre and pitch with each other so that participants do not selectively process one or the other alone (Allen & Oxenham, 2014; Caruso & Balaban, 2014; Stronsick et al., 2017). Although we carefully controlled frequency range by having all instruments play the same chord and octave, it is sometimes difficult to detach timbre and pitch; that is, some masculine instruments (e.g., tuba) naturally have a lower pitch range than feminine instruments (e.g., flute, oboe). One may argue that the pitch range at which an instrument is played may activate the mental associations of lower (vs. higher) pitches with masculinity (vs. femininity) (Pernet & Belin, 2012) which in turn can affect our results. However, Pernet and Belin (2012) pointed out that gender categorization relies on the pitch only when timbre information is androgynous. Given this, it is less likely that our results can only be accounted for by pitch alone, however, further investigation is needed into this issue. Secondly, we did not investigate the role of other dimensions in the differing timbres (e.g., semantic meanings, emotions). For example, feminine timbres appear to be rated lower in potency and arousal but higher in evaluation and positivity (compared to masculine timbres). The semantic/emotional associations (along with the femininity/masculinity) might have a role in the results and need to be further investigated. Thirdly, we could not find an adequate number of vegetarians in our sample to explore whether our results are affected by consumption preference (i.e., omnivore, non-vegetarian or vegetarian eating habits). Future research is needed to explore this issue further.

In conclusion, despite these limitations, our study adds new evidence directly linking the timbre of musical instruments with meat/plant attributes and provides primary guidance for brand managers in selecting a brand sound logo congruent with the featured attribute of the food product.

CHAPTER 4

Influencing brand personality with sonic logos: The role of musical timbre

Abstract

This study examines the relationship between instrumental timbre and brand personality. Our findings demonstrate that the connotative meanings of instrumental timbre can account for the timbre-brand association based on gender stereotypes. Specifically, sogos created using feminine instruments that connote positive valence are matched with sincerity dimension. Similarly, sogos created using masculine instruments that connote potency are matched with ruggedness, and this relationship is mediated by the perception of low pitch. Further, creating sogos with instruments that match a brand's personality evokes congruence of brand attributes, which in turn positively impacts brand attitude and purchase intention. These findings contribute to the literature on branding and sensory marketing by linking instrumental timbre with the well-known Brand Personality scale and the EPA (Evaluation, Potency, and Activity) framework. Insights learnt can help brands create sogos that are congruent with their brand's personality.

Keywords: Brand personality, Sonic logos, Musical timbre, Perceived Congruency, Sensory marketing, Sonic branding

1. Introduction

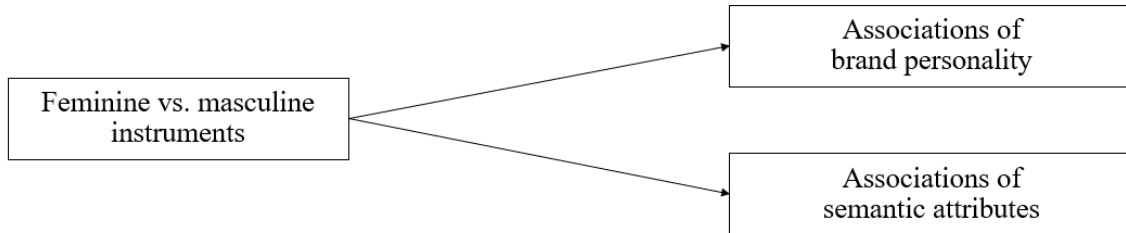
Due to cutthroat competition in the marketplace, more brands are adopting multisensory marketing to carve out a niche brand identity. Many brands nowadays use sounds in a strategic way (also called sonic branding) to appear distinctive. Sounds are either used as part of an advert (e.g., a jingle) or as short musical clips (called sonic logos or sogos) which can be considered as the auditory counterpart of a brand's visual logo. Some sogos become so familiar to consumers that they instantly recognize them as signifiers of the brands they represent (e.g., the opening "Ta-Dum" of Netflix). Sogos have been shown to be effective marketing tools to communicate appropriate brand identity or value (Bonde & Hansen, 2013). When a brand's sogo adequately aligns with other brand elements, it effectively communicates a consistent brand personality that helps build a strong brand (Müller & Kirchgeorg, 2013). In fact, a recent industry report (SoundOut, 2021) reported that almost all leading brands now utilise sogos (e.g., McDonald's, Coca-Cola, Gillette, and BMW to name but a few). Since sogos form an important part of the contemporary (and future) branding landscape, the current study explores whether brands can manipulate sogos (e.g., attributes of sound such as timbre) to influence consumers' expectations of the products they represent.

The current study differentiates from extant literature on sogos in three aspects. Firstly, while prior studies proposed the associations of timbre with a few brand personality dimensions, we were interested in understanding the associations across the brand personality traits (BPS) scale (Aaker, 1997). For example, recent research (Melzner & Raghurir, 2022; Puligadda & VanBergen, 2023) demonstrated the association of timbre and brand personality mainly focusing on ruggedness and sophistication, leaving the other dominant dimensions underexplored (e.g., sincerity). Similarly, another study (Mas, Bolls, Rodero, Barreda-Ángeles, & Churchill, 2021)

investigated the association of loudness, pitch, and tempo using different brand personality dimensions focusing on responsibility, activity, aggressiveness, simplicity, and emotionality (Geuens, Weijters, & De Wulf, 2009). Secondly, we also explored the role of connotative meanings as a mechanism behind the timbre-brand association (see Figure 1 for research framework). Thirdly, while previous research has proposed that the transference between timbral sounds and brand personality is driven by conceptual and visceral mechanisms (Puligadda & VanBergen, 2023) and abstract meanings (Melzner & Raghurir, 2022), we proposed that this effect could be attributed to the stereotypical concepts related to gender.

We examined how timbre-brand congruence might influence purchase intention for the brands they correspond to (i.e., masculine vs. feminine instruments and ruggedness vs. sincerity). Our findings contribute to both literature and practice in several ways. Specifically, we add to the literature on multisensory marketing by demonstrating how gender-stereotyped instruments are associated with brand personality dimensions through the explanation of connotative meanings. Additionally, we propose that the congruency between the instrument and specific brand personality could enhance purchase intention of the associated product. Lastly, we provide insights for practitioners in selecting instruments to create slogans which are congruent with their desired brand's personality.

Studies 1 and 2



Study 3

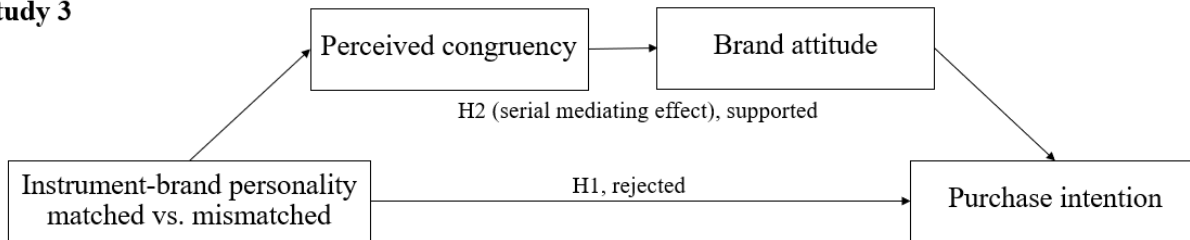


Fig. 1. Research framework. As Studies 1 and 2 are exploratory studies, the hypothesis is not stated.

2. Literature review

2.1. Sonic logo

Sounds in many forms play an important role in branding. A sogo can be considered the audio analogue of the visual logo of a brand (Krishnan, Kellaris, & Aurand, 2012). Normally, sogos are thought of as melodies lasting for a short period and may comprise ascending/descending patterns, repetition of tones or varying contours (Mas, 2019; Mas et al. 2021; SoundOut, 2021). In fact, a few distinctive notes of a sogo are sufficient to link a whole connection of social and cultural values with a product/brand (Cook, 1998). Companies like Intel, AT&T, MGM and NBC have been using sogos for decades and more and more brands are now embracing sogos due to an ever-increasing necessity to adopt a competitive social media presence.

Sogos are important for brands because often they have been shown to trigger consumers' imagination resulting in embodiment (e.g., translation of musical rhythm to bodily reactions) and function as an instant reminder of a certain brand (DeNora, 2000; Gustafsson, 2019; Tom, 1990). Besides, they can lead to a favorable consumer response on a variety of dimensions, such as brand recognition and recall (Wazir & Wazir, 2015) and alter consumers' willingness to pay (Krishnan et al., 2012), product perceptions (Techawachirakul, Pathak, & Calvert, 2022), symbolic meanings (Bonde & Hansen, 2013), and brand personality (Melzner & Raghurir, 2022; Puligadda & VanBergen, 2023).

2.2. Brand personality

Brand personality refers to the "human characteristics associated with a brand" (Aaker 1997, p. 347) and forms one of the most important differentiators of brands in this competitive marketplace (Aaker, 1997; Buresti & Rosenberger, 2006; Japutra & Molinillo, 2019; Sheena, 2012). Perceptions about a brand's personality can be formed and strengthened by any sensory touchpoint (e.g., seeing, hearing, tasting, or touching) that a brand makes with a consumer (Plummer, 1985; Sheena, 2012). Therefore, a brand's message about its intended personality will be clearer and stronger when all the sensory modalities (e.g., visual logo, auditory sogo, auditory jingle, haptic roughness) convey a coordinated and congruent message (Aaker, 1996; Batra, Lehmann, & Singh, 1993). Research suggests that strong and congruent messages about a brand's personality can enhance brand trust and affect, which in turn strengthens brand loyalty (Sung & Kim, 2010). Importantly, similar to human personality, a brand personality is enduring, and not easy to imitate, and hence the benefits associated with brand personality offer a considerable competitive advantage for a brand (Ang & Lim, 2006).

2.3. Research on sounds and brand personality

Previous research has demonstrated that phonetic and musical sounds can convey the personality traits of the associated brands (e.g., Klink & Athaide, 2012; Pathak & Calvert, 2020). For example, the front (vs. back) vowels present in brand names have been linked with sonic attributes (i.e., larger vs. smaller formant dispersion in vocalization in females vs. males) (Gordon & Heath, 1998) and thereby with feminine and masculine brand personalities (Sidhu & Pexman, 2018). Relatedly, the frequency of brand name sounds (high vs. low) has been shown to influence brand personality, whereby low-pitched sounds (e.g., voiced obstruents) are linked more with ruggedness and masculinity (vs. feminine traits with high-pitched sounds) (Pathak & Calvert, 2020). These findings implied that varied pitches could affect the perceived traits of masculinity and femininity.

In the domain of sogos, existing research has shown that consumers could link sogos differing in loudness (i.e., fade up, fade down, constant), pitch (ascending, descending, constant), and tempo (slow, fast) with brand personality traits such as aggressive and exciting and these associations could also affect the physiological attributes in consumers (e.g., enhanced electrodermal activity or heart rate) (Mas, 2019; Mas et al., 2021). Similarly, variations of timbre (e.g., rough versus smooth sound quality) or distinctive (familiar vs. unfamiliar) instruments could alter the perceived personality of a brand (Melzner & Raghbir, 2022; Puligadda & VanBergen, 2023). Despite these findings, the mechanisms behind these linkages are yet unclear. We propose to use the connotative meanings of sounds (e.g., valence and potency of the EPA framework – see below for a detailed description of this framework) as the cognitive mechanism behind the association of sogos with brand personality traits. Unlike recent research (e.g., Puligadda & VanBergen, 2023), the present study investigates the role of timbre in terms of stereotype-based musical instruments (feminine vs. masculine).

2.4. *Timbre*

Timbre is a distinctive feature of sound which helps the listener distinguish two sounds that are matched in loudness and frequency (McAdams & Giordano, 2015). For example, if the same notes are played from different musical instruments such as the flute, violin or piano, the quality of sound which acts as a differentiator is the timbre associated with that sound. As musical instruments emit different sounds even while keeping the other sonic parameters constant, the timbre of the associated music can connote different perceptual meanings (Giraldo et al., 2019). Often brands communicate to their global consumers using the timbre of musical instruments known in that culture (e.g., bagpipes in Scotland). For example, MasterCard modulates the timbre of its logo across cultures (e.g., America, China, and the Middle East) (BrandMusiq, 2022).

A wide body of research has now demonstrated that sounds can evoke abstract connotations (e.g., healthfulness (Motoki, Takahashi, Velasco, & Spence, 2022; Peng-Li, Mathiesen, Chan, Byrne & Wang, 2021; Techawachirakul et al., 2022), pleasantness (Spence, 2011)). For example, certain sounds are euphonic (sweet) and others cacophonous (harsh) and research has linked these qualities of sounds present in brand names with general perceptions held about related brands/products (e.g., sweet tastes, harsh/acidic qualities in products/brands) (Pathak & Calvert, 2020, 2021; Pathak, Calvert, & Lim, 2020). A recent study even extended the linkages of the sounds of instruments to humanistic traits (e.g., elegant with harp, mysterious with clarinet; Reymore & Huron, 2020). Thus, it is reasonable to assume that different sounds of musical instruments can be associated with the dimensions of brand personality.

Given our research goal on the association of musical timbre with brand personalities, it would be more meaningful to operationalize timbre with the known gender stereotypes (Cramer,

Million, & Perreault, 2002). In this study, we classified instruments as feminine versus masculine based on their prior known associations. Feminine instruments included the English horn (Reymore & Huron, 2020), flute (Abeles, 2009; Cramer et al., 2002; Elliot & Yoder-White, 1997; Eros, 2008; Stronsick, Tuft, Incera, & McLennan, 2017), harp (Cramer et al., 2002; Stronsick et al., 2017), oboe (Elliot & Yoder-White, 1997; Eros, 2008; Reymore & Huron, 2020), and violin (Abeles, 2009; Eros, 2008). Masculine instruments included alto saxophone (Elliot & Yoder-White, 1997; Eros, 2008), double bass (Stronsick et al., 2017), French horn (Stronsick et al., 2017), trombone (Abeles, 2009; Elliot & Yoder-White, 1997; Eros, 2008), and tuba (Cramer et al., 2002; Eros, 2008; Stronsick et al., 2017). Moreover, recent research has demonstrated that the association of gendered musical instruments with food types (i.e., meat vs. plant-based) can occur at both implicit and explicit levels of processing (Techawachirakul, Pathak, Motoki & Calvert, 2023b). Yet, to the best of our knowledge, such an association of brand personality with timbre has not been uncovered.

2.5. The role of connotative meaning

Connotative meanings refer to the emotional meanings (other than the direct or explicit meanings, which are also called denotative meanings) associated with a concept. For example, the word ‘wolf’ has the denotative meaning of an animal, however, its connotative meanings extend to danger, or certain personalities and people (e.g., big bad wolf, the wolf Wall Street etc.). Similarly, denotatively speaking McDonald’s may mean food or burger, however, connotatively it may also mean - party, birthday, fun etc. depending on the context (Baenninger, Dengelmaier, Navarrete, & Sezov, 2000). Osgood, Suci and Tannenbaum (1957) were the first to develop a scale called the Semantic Differential scale or EPA (Evaluation, Potency and Activity framework) to measure connotative meanings. The Semantic Differential Technique (SDT)

works on the premise that any concept can be defined by its connotative meaning (Klettner, 2020) and provides an objective measure of those meanings in a common semantic space (Osgood & Luria, 1954).

The EPA framework or the SDT has been applied robustly across cultures (Osgood, May, Miron, & Miron, 1975). Using this technique, people or attitudes can be quantitatively compared across three dimensions. Similarly, any stimuli (e.g., slogans) can be measured and linked with other attributes (e.g., brand personalities) in a common semantic space. Since brands and brand personality are established constructs (like human characteristics) (Aaker, 1997), many marketing scholars have now reliably used the semantic scale to arrive at conclusions (e.g., Doyle & Bottomley, 2009; Motoki et al., 2022). Recently Sidhu and colleagues (2022) extended the semantic framework by proposing ‘novelty’ as another dimension (measured by simple-complex, realistic-fantastical, ordinary-unique).

We use semantic differential as the underlying framework to explain the linkages between slogans and brand personalities. A common semantic space might help to explain the association of sonic logos, brand personalities and sounds (Osgood, 1962). Prior research has shown a robust association of sounds (e.g., those contained in the brand names) with shared connotative meanings such as the efficacy of brands/products (e.g., Park, Motoki, Pathak, & Spence, 2021). Relevant to the current paper, semantic meanings reflect symbolic characteristics that shape a brand’s personality (e.g., strong with *Mr. Muscle*) (Aaker, 1997). In evaluating a brand, consumers use their intuitive knowledge based on the prior connotative or affective meanings (e.g., EPA dimensions) (Wijnands & Gill, 2020). They interpret a brand’s connotative meaning with other linked characteristics/traits (Wijnands & Gill, 2020). For example, Ford’s connotative meaning is associated with the concepts of ‘masculine’ and ‘brother’; BMW’s is associated with

the concepts of ‘lust’ and ‘love’ (Gill, Schroeder & Wijnands, 2019; Wijnands & Gill, 2020). Research also suggests that music activates the mechanisms linked to the processing of semantic meanings (e.g., those associated with brands) as the basis behind these findings (Koelsch et al., 2004). Given these findings, it is plausible that the instrumental timbre can carry semantic associations, and that consumers may rely on the connotative meanings of instrumental sounds to form the timbre-brand personality associations.

2.6. The mediating role of pitch

Pitch is determined by the frequency of vibration of the sound waves and is an individual’s subjective perception (as high or low-pitched sound) which affects its meanings related to gender (Johar, 2015). Since men tend to have lower-pitched voices, and women tend to have higher-pitched voices (Johar, 2015; Pernet & Belin, 2012), the pitch level at which a musical instrument is played may activate the mental representations related to gender. For instance, musical instruments (and music) in high pitch are perceived as more feminine (e.g., flute) and those in low pitch as masculine (e.g., tuba) (Pernet & Belin, 2012; Reymore & Huron, 2020; Stronsick et al., 2017).

This notion is possibly rooted in the frequency code theory which suggests that the physical size of animals can be fairly judged by the voices emitted by them (Hinton, Nichols, & Ohala, 2006). Many animals use low-frequency sounds to make themselves appear more threatening and larger (vs. submissive opponents who use high-frequency sounds to appear smaller and non-threatening). A similar pattern has been observed in many languages where people use high or rising pitches for asking questions or showing politeness during a conversation (vs. the use of descending frequencies in voice to represent power in the conversation). High-frequency vocalization is often used by speakers to convey friendliness.

Similarly, musical instruments (feminine instruments such as flute, English horn, and oboe) that produce a higher pitch range are judged as exhibiting a female-like voice (Reymore & Huron, 2020). In contrast, the instruments (e.g., tuba) that fall in a lower pitch range are consistent with heavy and large objects, and largeness signals masculinity (Hinton et al., 2006; Reymore & Huron, 2020; Zhang, Li, & Ng, 2022). Taken together, high-frequency sounds resonate with characteristics of femininity and those in low frequency with masculinity.

Drawing upon this preliminary evidence, we predict that the pitch of sounds will act as a mediator in the relationship between sogos (i.e., those created using masculine vs. feminine gendered instruments) and brand meanings (i.e., brand personality and connotative meanings).

3. Method and overview of studies

The present research aimed to understand the association between the type of musical instrument (feminine vs. masculine) and brand personality and how their associations influence subsequent purchase intention. Specifically, in Study 1, we explored how sogos created using different instrument types are associated with BPS scale (Aaker, 1997). Once this association was identified, Study 2 investigated the connotative meanings of instrument types using a semantic differential scale (Sidhu et al., 2022) as an explanation for the effect of the instrument type. In both studies, we also investigated the mediating role of the pitch of the instrument used to create the sogos. In Study 3, we examined the interplay of instrument type and brand personality on purchase intention through the mediating effect of perceived congruency.

3.1. Participants

Participants in all the studies were recruited randomly using Amazon Mechanical Turk (M Turk) and participated in only one study related to the current paper. They indicated their

consent before the experiment and were paid for their effort and time. The sample size was determined using G*Power 3.1.9 (Faul, Erdfelder, Lang, & Buchner, 2007; the size of $N \approx 100$ for each study (Studies 1, 2, and 3) had the power (0.95) and $\alpha = .05$ to detect a medium-sized effect (≈ 0.20) in a mixed Repeated-measures analysis of variance (ANOVA).

3.2. Procedure and design

In Studies 1 and 2, we used a 2 (instrument: feminine vs. masculine) x 2 (food: chips vs. chocolate) mixed-design study, in which the instrument was the within-participant factor and the category of food was the between-participant factor. Participants were informed that a food company was searching for new brand slogans for its novel products (chips for half of the participants and chocolates for the other half). They then listened to two random slogans (one each created using a feminine vs. masculine instrument, which were automatically played one at a time; see Appendix H for the method to develop slogans) in a random order (i.e., feminine followed by masculine slogans or vice versa) and rated each slogan on BPS attributes (Study 1; Aaker, 1997) and the semantic differential scale (Study 2; Sidhu et al., 2022). The presentation of the attributes of the BPS (Study 1) and the semantic differential scale (Study 2) were randomized within-participants. Table 1 shows the overview of the stimulus development.

Similarly, in Study 3, we used a 2 (instrument: feminine vs. masculine) x 2 (brand: ruggedness vs. sincerity) within-participants design. Participants were instructed to listen to two slogans (one each created using feminine vs. masculine instruments) in random order and rated product attributes and their purchase intention.

Participants in all three studies were familiarized with the procedure with a practice trial where a well-known slogan (*Microsoft Windows*) was used. The studies were designed on the

Inquisit 6 platform of Millisecond.com (Studies 1 and 2) and the Qualtrics online platform (Study 3).

Table 1
Overview of stimulus development.

Study	Stimulus development	Source
1, 2	<p>10 sogos comprised of C4 to B4 notes, 95 bpm and five seconds in duration were manipulated by instruments.</p> <ul style="list-style-type: none"> - Masculine instruments: Alto saxophone, double bass, French horn, trombone, tuba. - Feminine instruments: English horn, flute, harp, oboe, and violin. 	<p>The instruments were classified following previous literature (Abeles, 2009; Cramer et al., 2002; Elliot & Yoder-White, 1997; Eros, 2008; Reymore & Huron, 2020; Stronsick et al., 2017).</p>
3	<p>Four melodies consisting of five notes with a wave-like pattern were created. Each was played by different instruments.</p> <ul style="list-style-type: none"> - Masculine instruments: French horn, tuba. - Feminine instruments: Flute, oboe. 	<p>Pretest: The four melodies did not differ in pleasantness ($F(3,147) = 2.21, p = .09$), likability ($F(3,147) = .70, p = .55$), or familiarity ($F(2.46,120.46) = 1.63, p = .20$).</p>

3.3. Statistical analyses

In all the studies, outliers were detected using Mahalanobis distance at $p < .001$ (Tabachnick & Fidell, 2013). In addition, Mardia's multivariate normality tests (George & Mallery, 2010) were used and the data was normalised using the approach described by Templeton (2011).

4. Study 1: Association of sogos with brand personality

4.1. Participants

96 participants took part in this study. Two participants who failed the attention check, which required them to type in the spoken word, were excluded from further analysis. No outliers were detected. The data of 94 participants were then analysed (*Male* = 52, *Female* = 42; *M_{age}* = 44.28 years, *SD* = 12.64, Age range = 21 – 74 years).

4.2. Procedure

After indicating the demographic information, participants proceeded to the main experiment (as detailed in the section above) where they evaluated each sogo on 15 brand personality traits (Aaker, 1997). For each scale item (see Table 2), the ratings were made on Visual Analogue Scales (VAS) from 0 (not at all) to 100 (very much). After the main task, they were presented with the same sogos again where they rated the perceived pitch of each sogo (0 = very low, 100 = very high).

4.3. Statistical analyses

A factor analysis of the 15 BPS items was used to estimate the validity of the measurement scales and the results revealed four BPS dimensions (competence, ruggedness, excitement, and sincerity) (see Appendix I). A series of ANOVAs were then used to investigate whether sogos created using feminine vs. masculine instruments differed in 1) the ratings on BPS dimensions and 2) perceived pitch. Within-participant mediation analyses (MEMORE macro, Model 1; Montoya & Hayes, 2017) were subsequently conducted to investigate how the perceived pitch mediates the relationship between the type of instrument and BPS dimensions. The indirect effect of the perceived pitch was estimated using 95% bias-corrected bootstrap intervals with 5000 bootstrap samples. The analyses were performed using IBM SPSS version 22.0 for Windows (IBM SPSS Inc., Chicago, IL, USA).

4.3.1. Results of the association of sogos with BPS dimensions

Four mixed ANOVAs (one each for a BPS dimension) were conducted which revealed significant differences between feminine and masculine instruments in all the BPS dimensions¹ (see Figure 2a and Table 2). Specifically, the sogos created using feminine instruments were rated higher in the BPS dimensions of sincerity, competence, and excitement whereas the sogos created using masculine instruments were rated higher in ruggedness (Sincerity: $F(1,92) = 7.70$, $p = .007$, $\eta_p^2 = .08$; $M_{Fem} = 69.26$, $SD = 16.84$; $M_{Masc} = 63.65$, $SD = 15.95$; Competence: $F(1,92) = 17.74$, $p < .001$, $\eta_p^2 = .16$; $M_{Fem} = 67.41$, $SD = 18.95$; $M_{Masc} = 56.16$, $SD = 20.94$; Excitement: $F(1,92) = 30.44$, $p < .001$, $\eta_p^2 = .25$; $M_{Fem} = 62.41$, $SD = 19.28$; $M_{Masc} = 49.08$, $SD = 21.09$; Ruggedness: $F(1,92) = 17.46$, $p < .001$, $\eta_p^2 = .16$; $M_{Fem} = 35.80$, $SD = 19.81$; $M_{Masc} = 45.60$, $SD = 23.52$) (also see Appendix K for an analysis of individual musical instruments). No difference in the food category (i.e., chips vs. chocolate) was observed.

As there were no differences in the food categories (i.e., chips vs. chocolate), the ratings across both were averaged into one (i.e., feminine vs. masculine instruments). Further analyses were conducted using paired t -tests (see Figure 2b and Table 2); FDR corrections were made to reduce the false discovery rates of p -values (<https://www.sdmproject.com/>; Radua & Albajes-Eizagirre, n.d.) and the corrected p -values are reported here.

Sincerity. Within the sincerity dimension, sogos created using feminine (vs. masculine) instruments were rated as significantly higher in the traits of ‘wholesome and honest’ while no difference in the trait of ‘down-to-earth and reliable’ was observed (Wholesome: $M_{Fem} = 75.54$, $SD = 19.30$, $M_{Masc} = 63.44$, $SD = 21.75$, $t(93) = 4.30$, $p < .001$, $d = .54$; Honest: $M_{Fem} = 74.09$,

¹ The results of normalised data are not different; see Appendix J for the results with normalised data. The results supported the robustness of the effect of gender-based instruments.

$SD = 16.73$, $M_{Masc} = 67.19$, $SD = 17.10$, $t(93) = 3.56$, $p = .002$, $d = .41$; Down-to-earth: $M_{Fem} = 59.70$, $SD = 26.66$, $M_{Masc} = 59.71$, $SD = 23.20$, $t(93) < 1$, $p = 1$, $d < .01$; Reliable: $M_{Fem} = 68.70$, $SD = 18.92$, $M_{Masc} = 64.28$, $SD = 17.89$, $t(93) = 1.89$, $p = .07$, $d = .24$).

Competence. Within the competence dimension, sogos created using feminine (vs. masculine) instruments were rated as significantly higher in the traits of ‘upper class, intelligent, and successful’ (Upper class: $M_{Fem} = 64.29$, $SD = 24.81$, $M_{Masc} = 50.78$, $SD = 27.13$, $t(93) = 3.72$, $p < .001$, $d = .52$; Intelligent: $M_{Fem} = 68.47$, $SD = 20.84$, $M_{Masc} = 59.18$, $SD = 21.67$, $t(93) = 3.40$, $p = .002$, $d = .44$; Successful: $M_{Fem} = 69.47$, $SD = 19.51$, $M_{Masc} = 58.52$, $SD = 20.73$, $t(93) = 4.46$, $p < .001$, $d = .54$).

Excitement. Within the excitement dimension, sogos created using feminine (vs. masculine) instruments were rated as significantly higher in the traits of ‘cheerful, spirited, imaginative, charming, and up-to-date’ (Cheerful: $M_{Fem} = 64.76$, $SD = 24.19$, $M_{Masc} = 48.40$, $SD = 27.67$, $t(93) = 4.59$, $p < .001$, $d = .63$; Spirited: $M_{Fem} = 28.33$, $SD = 24.12$, $M_{Masc} = 46.89$, $SD = 31.39$, $t(93) = 5.33$, $p < .001$, $d = .64$; Imaginative: $M_{Fem} = 28.33$, $SD = 24.12$, $M_{Masc} = 46.89$, $SD = 31.39$, $t(93) = 2.14$, $p = .04$, $d = .27$; Charming: $M_{Fem} = 65.74$, $SD = 22.45$, $M_{Masc} = 48.69$, $SD = 25.85$, $t(93) = 5.96$, $p < .001$, $d = .70$; Up-to-date: $M_{Fem} = 28.33$, $SD = 24.12$, $M_{Masc} = 46.89$, $SD = 31.39$, $t(93) = 3.55$, $p = .002$, $d = .41$).

Ruggedness. Within the ruggedness dimension, sogos created using feminine (vs. masculine) instruments were rated as significantly lower in the traits of ‘tough’ while no difference in the trait of ‘daring and outdoorsy’ was observed (Tough: $M_{Fem} = 28.33$, $SD = 24.12$, $M_{Masc} = 46.89$, $SD = 31.39$, $t(93) = 5.96$, $p < .001$, $d = .66$; Daring: $M_{Fem} = 41.22$, $SD = 29.15$, $M_{Masc} = 47.86$, $SD = 27.56$, $t(93) = 2.05$, $p = .05$, $d = .26$; Outdoorsy: $M_{Fem} = 37.84$, $SD = 29.15$, $M_{Masc} = 42.03$, $SD = 27.56$, $t(93) = 1.18$, $p = .26$, $d = .15$).

Table 2*Results of Study 1: Brand personality traits of sogos created using feminine vs. masculine instruments.*

BPS traits	Feminine instruments	Masculine instruments	<i>Corrected p</i> ¹	BPS dimensions	Feminine instruments	Masculine instruments	<i>p</i>
	<i>M (SD)</i>	<i>M (SD)</i>			<i>M (SD)</i>	<i>M (SD)</i>	
Wholesome	74.54 (19.30)	63.44 (21.75)	< .001	Sincerity ^a	69.26 (16.84)	63.65 (15.95)	.007
Honest	74.09 (16.73)	67.19 (17.10)	.002				
Down-to-earth	59.70 (26.66)	59.71 (23.20)	.998				
Reliable	68.70 (18.92)	64.28 (17.89)	.072				
Upper class	64.29 (24.81)	50.78 (27.13)	< .001	Competence ^b	67.41 (18.95)	56.16 (20.94)	< .001
Intelligent	68.47 (20.84)	59.18 (21.67)	.002				
Successful	69.47 (19.51)	58.52 (20.73)	< .001				
Tough	28.33 (24.12)	46.89 (31.39)	< .001	Ruggedness ^c	35.80 (19.81)	45.60 (23.52)	< .001
Daring	41.22 (22.75)	47.86 (28.03)	.054				
Outdoorsy	37.84 (29.15)	42.03 (27.56)	.257				
Cheerful	64.76 (24.19)	48.40 (27.67)	< .001	Excitement ^d	62.41 (19.28)	49.08 (21.09)	< .001
Spirited	66.67 (22.95)	50.88 (26.17)	< .001				
Imaginative	62.24 (24.13)	55.69 (24.01)	.048				
Charming	65.74 (22.45)	48.69 (25.85)	< .001				
Up-to-date	52.62 (27.89)	41.72 (24.70)	.002				

Note. ¹ Corrected *p*-values after using False Discovery Rate (FDR) correction reported. ^a The average means of wholesome, honest, down-to-earth, and reliable traits. ^b The average means of upper class, intelligent, and successful traits. ^c The average means of tough, outdoorsy, and daring. ^d The average means of cheerful, spirited, imaginative, charming, and up-to-date traits. The traits/dimensions in bold represent significantly different ratings.

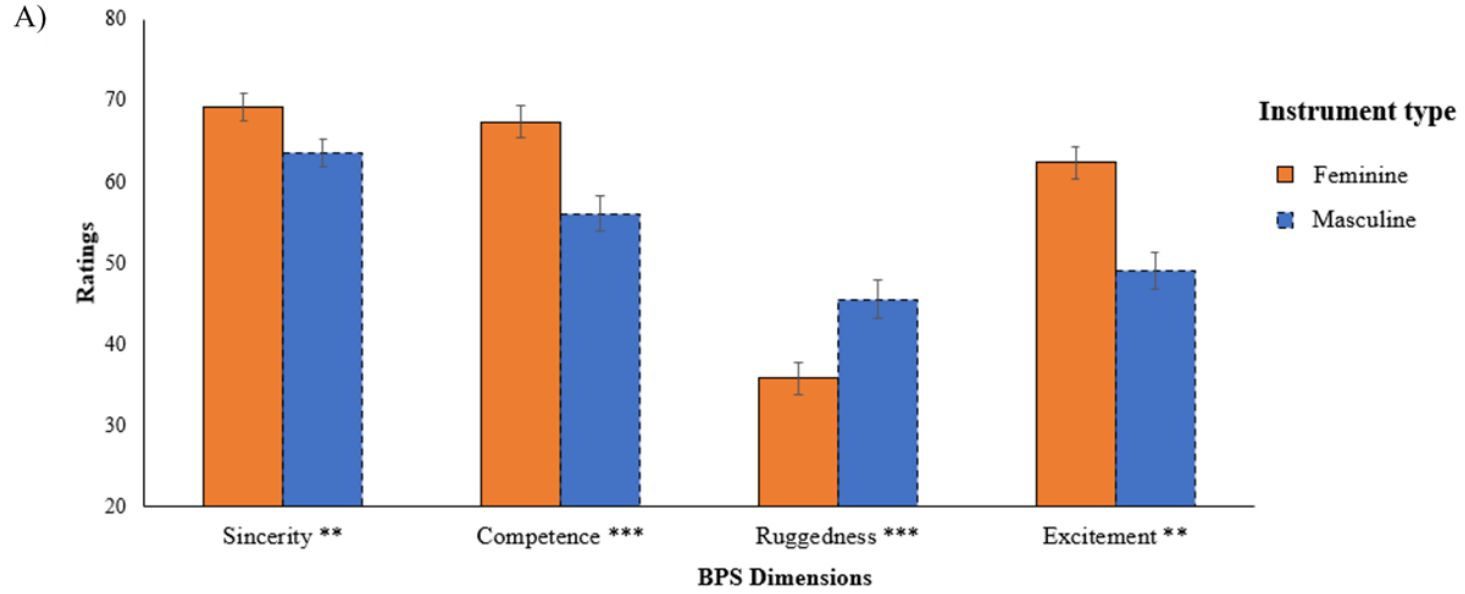


Fig. 2a. The figure represents the ratings of sogos created using feminine vs. masculine instruments on four BPS dimensions in Study 1. *** $p < .001$, ** $p < .01$.

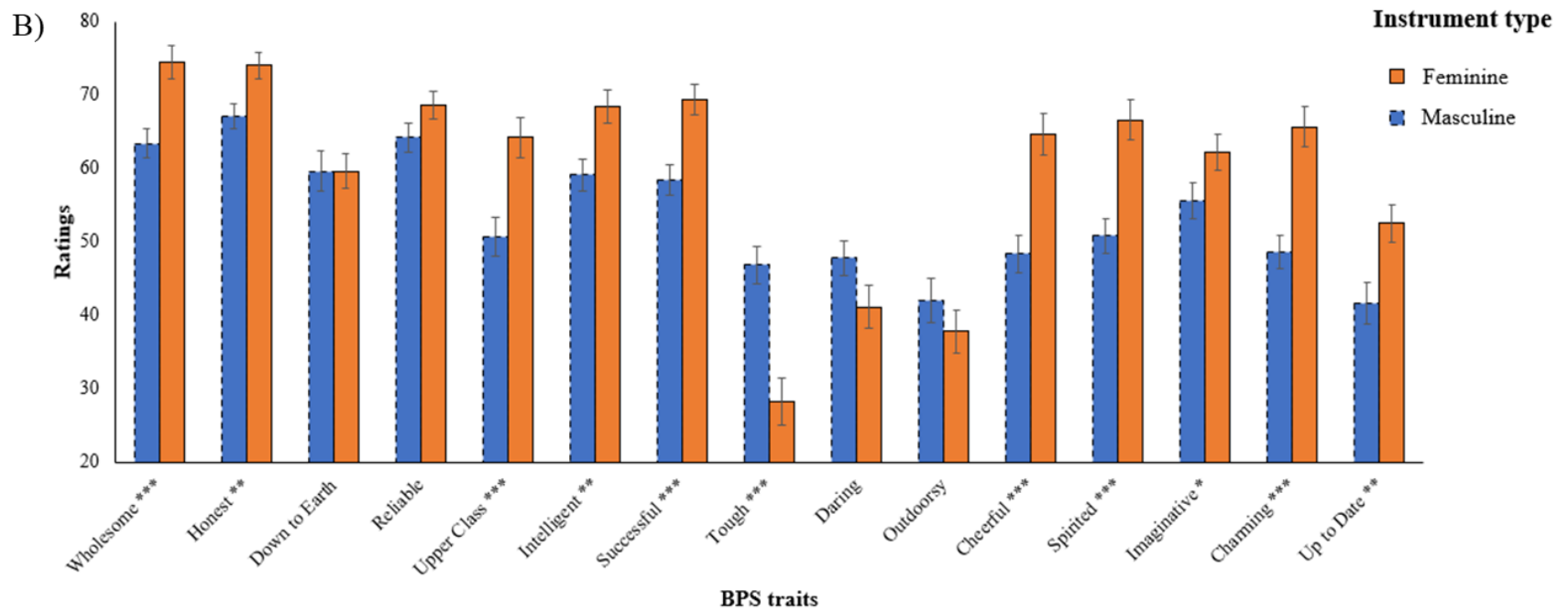


Fig. 2b. The figure represents the ratings on 15 BPS traits in Study 1. *** $p < .001$, ** $p < .01$, * $p < .05$.

4.3.2. Results of the ratings on the perceived pitch

A repeated-measures ANOVA revealed that sogos created using feminine (vs. masculine) instruments were rated as significantly higher in pitch, $F(1,93) = 34.93, p < .001, \eta_p^2 = .27; M_{Fem} = 64.56, SD = 28.91; M_{Masc} = 31.95, SD = 28.15$.

4.3.3. Results of the mediation analyses

Since the main effect of the type of instrument was observed across all four BPS dimensions, four mediation analyses (each one for a BPS dimension) were performed to investigate how perceived pitch mediates the relationship between the type of instrument and BPS dimensions (see Figure 3).

Sincerity. The direct effect of the type of instrument on sincerity was significant ($b = 6.81, SE = 2.36, t(92) = 2.88, p = .005$). The indirect effect of the type of instrument on sincerity through perceived pitch was not significant ($b = -1.21, SE = 1.29, 95\% CI [-4.01, 1.09]$). Specifically, the sogos created using feminine instruments were rated as higher in perceived pitch ($b = 32.62, SE = 5.52, t(93) = 5.91, p < .001$) and the pitch was positively related to sincerity ($b = -.04, SE = .04, t(92) = -.98, p = .33$). This indicated that the pitch did not mediate the relationship between the type of instrument and sincerity.

Competence. The direct effect of the type of instrument on competence was significant ($b = 11.18, SE = 3.13, t(92) = 3.57, p = .001$). The indirect effect of the type of instrument on competence through perceived pitch was not significant ($b = .07, SE = 1.78, 95\% CI [-3.40, 3.79]$). The sogos created using feminine instruments were rated as higher in perceived pitch ($b = 32.62, SE = 5.52, t(93) = 5.91, p < .001$), but the pitch was not significantly related to

competence ($b = .002$, $SE = .05$, $t(92) = .04$, $p = .97$). This indicated that the pitch did not mediate the relationship between the type of instrument and competence.

Ruggedness. The direct effect of the type of instrument on ruggedness was significant ($b = -6.36$, $SE = 2.74$, $t(92) = -2.32$, $p = .02$). The indirect effect of the type of instrument on ruggedness through perceived pitch was significant ($b = -3.44$, $SE = 1.60$, 95% CI [-6.95, -.74]). Specifically, the sogos created using feminine instruments were rated as higher in perceived pitch ($b = 32.62$, $SE = 5.52$, $t(93) = 5.91$, $p < .001$) and the pitch was negatively related to ruggedness ($b = -.11$, $SE = .04$, $t(92) = -2.41$, $p = .02$). This indicated that the pitch partially mediated the relationship between the type of instrument and ruggedness.

Excitement. The direct effect of the type of instrument on excitement was significant ($b = 7.73$, $SE = 2.61$, $t(92) = 2.97$, $p = .004$). The indirect effect of the type of instrument on excitement through perceived pitch was significant ($b = 5.60$, $SE = 1.75$, 95% CI [2.37, 9.15]). Specifically, the sogos created using feminine instruments were rated as higher in perceived pitch ($b = 32.62$, $SE = 5.52$, $t(93) = 5.91$, $p < .001$) and the pitch was positively related to excitement ($b = .17$, $SE = .04$, $t(92) = 4.12$, $p < .001$). This indicated that the pitch partially mediated the relationship between the type of instrument and excitement.

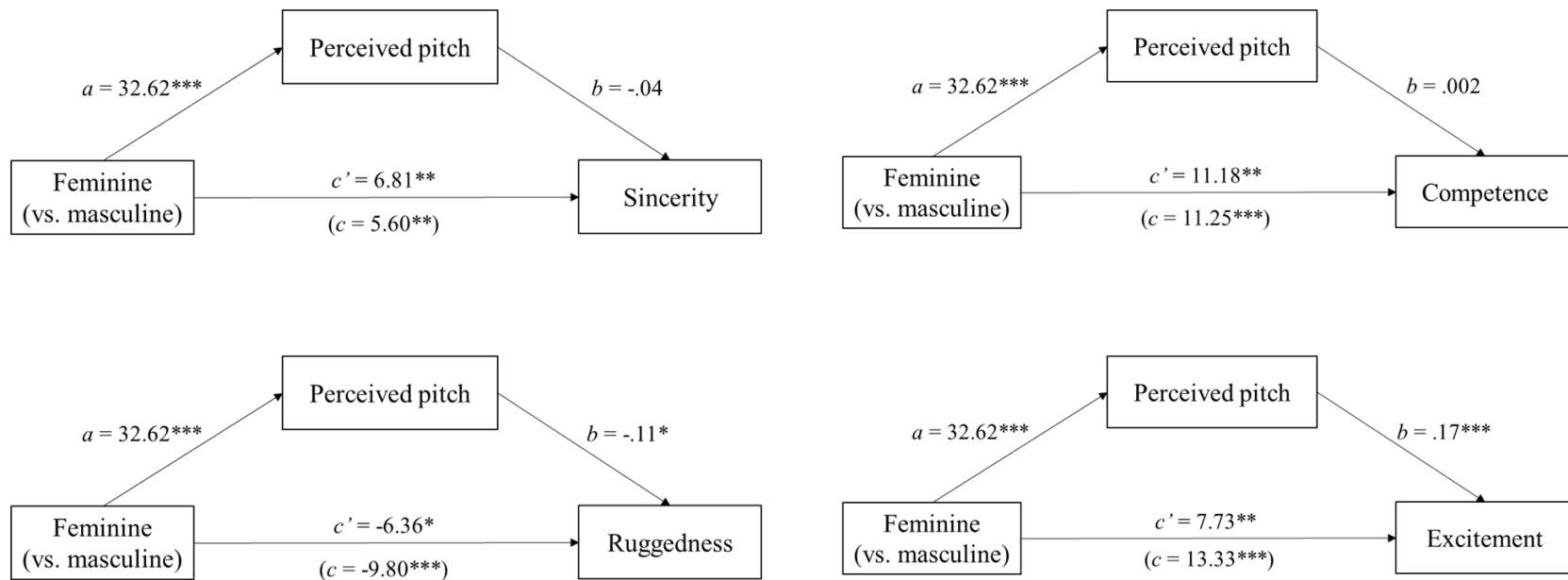


Fig. 3. The figures illustrate the mediating effect of pitch on the relationship between the type of instrument (feminine vs. masculine) and four BPS dimensions in Study 1. $*p < .05$, $**p < .01$, $***p < .001$.

4.4. Discussion

The results of Study 1 explored the relationship between the type of musical instrument (feminine vs. masculine) and BPS dimensions. Here, we have obtained a four-factor scale of brand personality (sincerity, competence, ruggedness, and excitement). Although the scale deviated from the original dimensions, it was consistent with previous research showing that sophistication was not obtained in many redefined Aaker's frameworks (e.g., Davies et al., 2018; Geuens et al., 2018). The results demonstrated that sogos created using feminine (vs. masculine) instruments were associated more with sincerity, competence, and excitement (ruggedness). The mediation analyses revealed the direct association of feminine instrumental timbre with sincerity and competence. However, the relationship between feminine (vs. masculine) instruments and excitement (ruggedness) were mediated by perceived pitch. Specifically, feminine (vs. masculine) instruments were perceived as high-pitched, which in turn enhanced the 'excitement' but lowered 'ruggedness'. This indicated that the linkage of instrument type and some brand personality traits (ruggedness and excitement) could be driven by the perceived pitch while the others (sincerity and competence) by instrumental timbre.

5. Study 2: Association of sogos with semantic attributes

So far, we have explored the linkages of sogos created using feminine vs. masculine instruments with specific BPS dimensions. In Study 2, we aimed to explore the explanation behind the findings. Given that consumers perceive a brand using intuitive knowledge based on connotative meanings (Wijnands & Gill, 2020), we posit that certain connotative meanings linked within the instrument types would account for these associations with brand personality traits. Recent studies on sound symbolism, have demonstrated connotative meanings as mechanisms driving the crossmodal associations of certain sounds (e.g., voice quality) with

sensory modalities (e.g., taste perception) (Motoki, Pathak, & Spence, 2022). If the relationship between gendered instruments and brand personality traits is attributed to the connotative meanings of musical instruments, we expect to find a similar relationship between musical instruments and gendered traits. For example, the potency dimension (e.g., masculine vs. feminine, strong vs. weak, big vs. small) and the valence dimension (e.g., beautiful vs. ugly) would be rated as higher for songs created using masculine and feminine instruments respectively. We also explored whether this association is mediated by the perceived pitch of the musical instruments.

In Study 2, we used the semantic properties scale proposed by Sidhu et al. (2022) for multiple reasons, 1) the scale builds on the well-established EPA dimensions (Osgood, 1964; Osgood et al., 1957), 2) the scale includes the adjective bipolars used frequently in sound symbolism (e.g., sharp-round; Knöferle, Li, Maggioni, & Spence, 2017; Sidhu & Pexman, 2018) and crossmodal correspondences (e.g., big-small; Walker, Walker, & Francis, 2012) and 3) the scale demonstrates robust linkages of sounds with higher order factors (i.e., activity, valence, potency and novelty).

5.1. Participants

98 participants took part in this study. Two participants who failed the attention check, which required them to type in the spoken word, were excluded from further analysis. No outliers were detected. The data of final 96 participants were analysed (*Male* = 54, *Female* = 42; $M_{age} = 41.52$ years, $SD = 11.78$, Age range = 26 – 71 years).

5.2. Procedure

The procedure used was similar to Study 1 where instead of BPS, the participants evaluated the sogos on 25 higher-order semantic attributes (see Table 3, Sidhu et al., 2022). The evaluation was made on a VAS scale from 0 to 100. The adjectives presented at the left end were scored as 0, and those at the right were scored as 100. To ensure that the participants were reading and responding to all questions throughout the session, attributes of some dimensions (i.e., active-passive, safe-dangerous, free-inhibited, rugged-delicate) were anchored reversely.

5.3. Statistical analyses

The ratings for active-passive, safe-dangerous, free-inhibited, and rugged-delicate were first reversed to make the interpretation meaningful. It is important to note that the rating scores were interpreted following the anchors on the semantic differential scales. Specifically, the lower rating scores tend to be more associated with the adjectives presented on the left label (e.g., inhibited and bad) while the higher scores were more associated with those on the right (e.g., free and good).

Similar to Study 1, a factor analysis of the 25 semantic differential items was conducted to estimate the validity of the measurement scales (see Appendix L). Then, a series of ANOVAs were performed to investigate whether feminine vs. masculine sogos were different in 1) the ratings on dimensions of semantic attributes (i.e., activity, valence, potency, and novelty) and 2) perceived pitch. Within-participants mediation analyses (MEMORE macro, Model 1; Montoya & Hayes, 2017) were subsequently conducted to investigate how perceived pitch mediated the relationship between the type of instrument and dimensions of semantic attributes. The indirect effect of the perceived pitch was estimated using 95% bias-corrected bootstrap intervals with 5000 bootstrap samples.

5.3.1. Results of the association of sogos with the dimensions of semantic attributes

Five mixed ANOVAs (one each for a semantic dimension) were conducted which revealed significant differences between feminine and masculine instruments in the dimensions of valence, potency, and stability, but not in activity and novelty² (see Figure 4a and Table 3). Specifically, the sogos created using feminine (vs. masculine) instruments were more associated with positive valence ($F(1,94) = 19.14, p < .001, \eta_p^2 = .17; M_{Fem} = 71.17, SD = 19.60; M_{Masc} = 57.12, SD = 22.42$), lower potency ($F(1,94) = 121.55, p < .001, \eta_p^2 = .56; M_{Fem} = 40.71, SD = 17.81; M_{Masc} = 69.02, SD = 16.67$) and lower stability ($F(1,94) = 17.92, p < .001, \eta_p^2 = .16; M_{Fem} = 51.76, SD = 12.75; M_{Masc} = 58.66, SD = 11.83$). However, no difference in the activity and novelty dimension was observed (Activity: $F(1,94) = .95, p = .33; M_{Fem} = 42.97, SD = 21.83; M_{Masc} = 45.97, SD = 20.52$; Novelty: $F(1,94) = 1.86, p = .18; M_{Fem} = 59.14, SD = 20.88; M_{Masc} = 55.05, SD = 22.50$) (also see Appendix N for analysis of individual musical instruments). Moreover, no difference in the food category (i.e., chips vs. chocolate) was observed for any of the dimensions.

As there were no differences in the food categories (i.e., chips vs. chocolate), the ratings across both were averaged into one (i.e., feminine vs. masculine instruments). The multiple comparisons across attributes were analysed using paired *t*-tests (see Figure 4b and Table 3) and the corrected *p*-values (using FDR corrections) are reported.

² The results of normalised data are not different; see Appendix M for the results with normalised data. The results supported the robust effect of gender-based instruments.

Table 3*The results of Study 2: Associations between sogos created using feminine vs. masculine instruments and semantic attributes.*

Semantic attributes	Feminine instruments	Masculine instruments	Corrected p^1	Semantic dimensions	Feminine instruments	Masculine instruments	p				
	$M (SD)$	$M (SD)$			$M (SD)$	$M (SD)$					
Inhibited-Free	68.98 (24.44)	54.84 (25.11)	< .001	Valence^a	71.17 (19.60)	57.12 (22.42)	< .001				
Bad-Good	70.40 (23.52)	57.05 (27.70)	.001								
Sad-Happy	66.14 (23.68)	51.51 (24.31)	< .001								
Dangerous-Safe	79.73 (18.85)	67.79 (26.48)	.001								
Unpleasant-Pleasant	71.97 (24.87)	58.96 (28.65)	.003								
Ugly-Beautiful	69.80 (22.41)	52.58 (27.61)	< .001	Activity^b	42.97 (21.83)	45.97 (20.52)	.332				
Calming-Exciting	38.41 (27.03)	39.56 (25.15)	.808								
Round-Sharp	52.04 (29.86)	40.55 (29.34)	.036								
Mellow-Harsh	33.90 (29.70)	44.16 (30.20)	.057								
Slow-Fast	52.02 (21.93)	45.23 (23.05)	.057								
Relaxed-Tense	35.67 (28.92)	42.59 (30.45)	.186								
Passive-Active	52.06 (26.37)	51.72 (26.31)	.929								
Soft-Hard	36.68 (28.76)	57.98 (26.81)	< .001					Potency^c	40.71 (17.81)	69.02 (16.67)	< .001
Light-Heavy	31.52 (25.10)	70.43 (24.72)	< .001								
Small-Big	48.15 (21.62)	71.57 (22.38)	< .001								
Weak-Strong	56.61 (20.98)	68.48 (23.28)	< .001								
Feminine-Masculine	36.40 (25.53)	74.84 (20.46)	< .001								
Delicate-Rugged	30.85 (25.95)	59.76 (24.03)	< .001	Stability^d	51.76 (12.75)	58.66 (11.83)	< .001				
Disorganised-Structured	82.05 (16.98)	76.40 (22.83)	.067								
Fantastical-Realistic	43.82 (28.40)	55.99 (24.56)	.003								
NonSolid-Solid	56.04 (25.93)	72.68 (22.31)	< .001								
Continuous-Abrupt	25.12 (21.90)	29.56 (24.80)	.222								
Ordinary-Unique	54.52 (24.78)	52.28 (26.14)	.539	Novelty^e	59.14 (20.88)	55.05 (22.50)	.176				
Uninteresting-Interesting	63.76 (23.86)	57.82 (26.67)	.100								

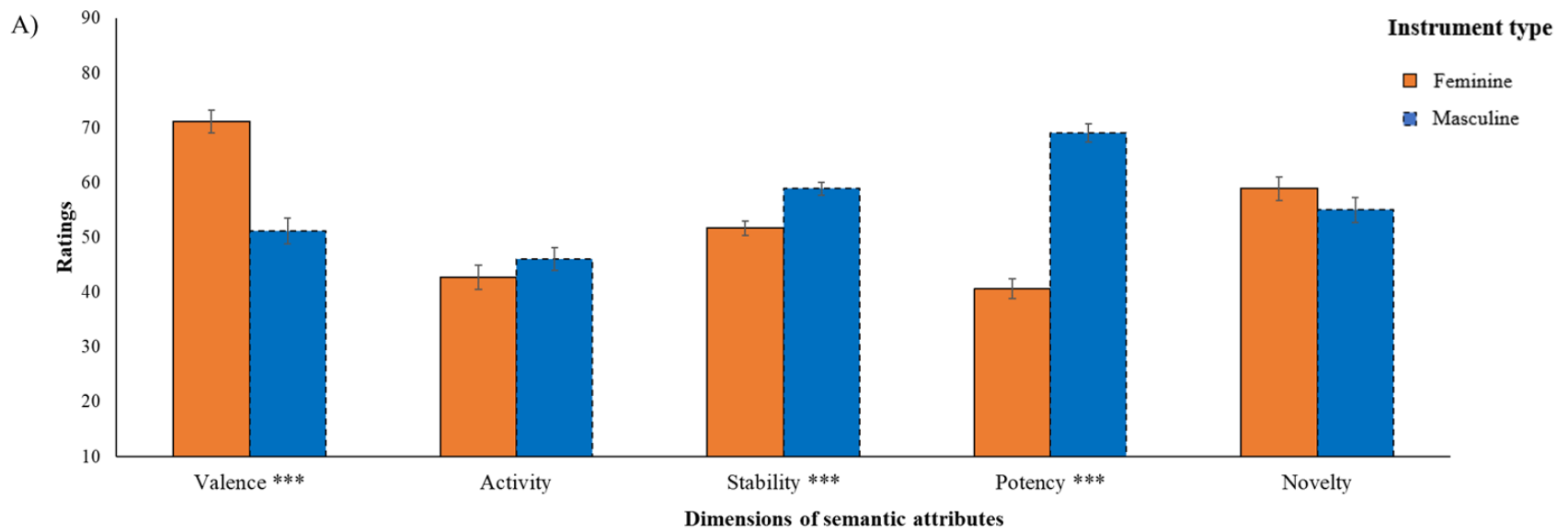


Fig. 4a. The figure represents the ratings of sogos created using feminine vs. masculine instruments on five semantic dimensions in Study 2. *** $p < .001$.

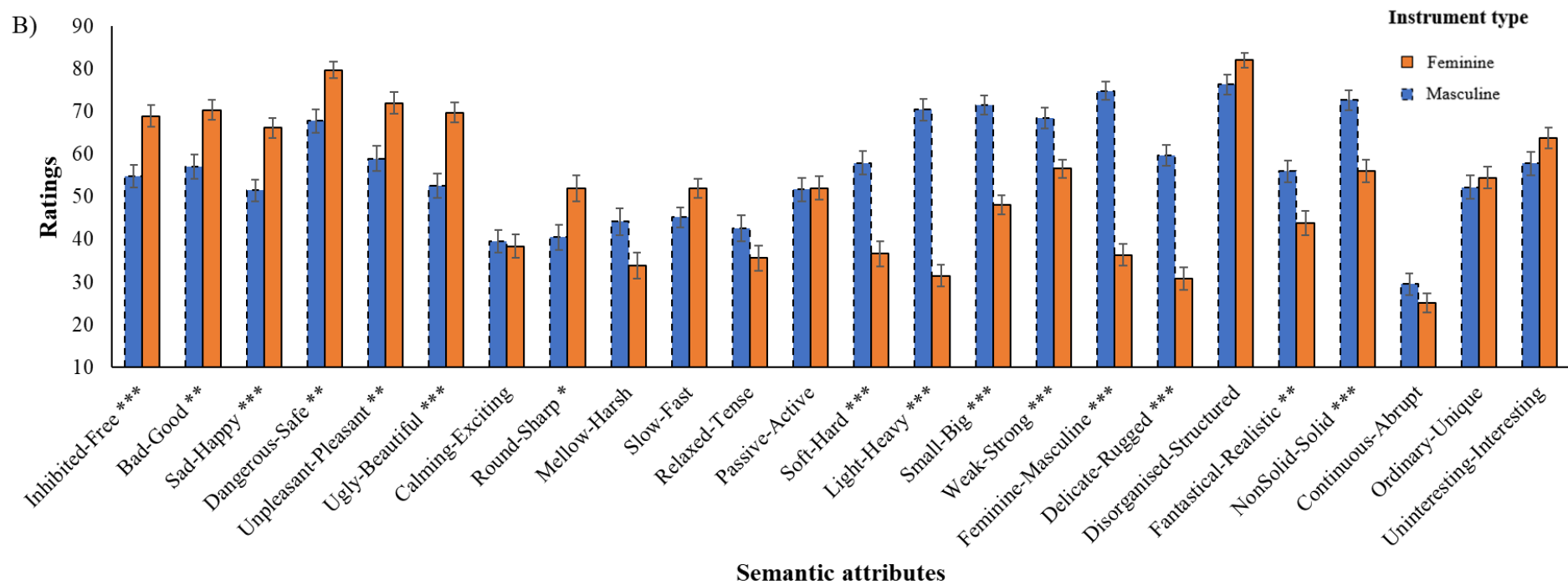


Fig. 4b. The figure represents the ratings on 24 semantic attributes in Study 2. *** $p < .001$, ** $p < .01$, * $p < .05$.

Valence. Within the valence dimension, sogos created using feminine (vs. masculine) instruments were rated as significantly higher in the ugly-beautiful, inhibited-free, bad-good, sad-happy, unpleasant-pleasant, and dangerous-safe scales (Ugly-beautiful: $t(95) = 4.66, p < .001, d = .68$; Inhibited-free: $t(95) = 3.94, p < .001, d = .57$; Bad-good: $t(95) = 3.54, p = .001, d = .52$; Sad-happy: $t(95) = 4.25, p < .001, d = .61$; Unpleasant-pleasant: $t(95) = 3.23, p = .003, d = .48$; Dangerous-safe: $t(95) = 3.62, p = .001, d = .52$).

Activity. Within the activity dimension, sogos created using feminine (vs. masculine) instruments were rated as significantly lower in the soft-hard and higher in round-sharp scales, while no differences were observed in the passive-active, calming-exciting, slow-fast, mellow-harsh, and relaxed-tense scales (Soft-hard: $t(95) = 4.61, p < .001, d = .77$; Round-sharp: $t(95) = 2.33, p = .036, d = .39$; Passive-active: $t(95) = .09, p = .929$; Calming-exciting: $t(95) = .29, p = .808$; Slow-fast: $t(95) = 2.09, p = .057$; Mellow-harsh: $t(95) = 2.11, p = .057$; Relaxed-tense: $t(95) = 1.46, p = .186$).

Potency. Within the potency dimension, sogos created using feminine (vs. masculine) instruments were rated as significantly lower in the light-heavy, small-big, feminine-masculine, delicate-rugged, and weak-strong scales (all $ps < .001$, Light-heavy: $t(95) = 10.16, d = 1.56$; Small-big: $t(95) = 7.24, d = 1.06$; Feminine-masculine: $t(95) = 11.51, d = 1.66$; Delicate-rugged: $t(95) = 7.69, d = 1.16$; Weak-strong: $t(95) = 4.00, d = .54$).

Stability. Within the stability dimension, sogos created using feminine (vs. masculine) instruments were rated as significantly lower in fantastical-realistic and nonsolid-solid scales but not in disorganised-structured and continuous-abrupt (Fantastic-realistic: $t(95) = 3.21, p = .003, d = .46$; Nonsolid-solid: $t(95) = 4.68, p < .001, d = .69$; Disorganised-structured: $t(95) = 2.00, p = .067$; Continuous-abrupt: $t(95) = 1.33, p = .222$).

Novelty. Within the novelty dimension, sogos created using feminine (vs. masculine) instruments did not differ in the ratings of the ordinary-unique and uninteresting-interesting scales (Ordinary-unique: $t(95) = .72, p = .539$; Uninteresting-interesting: $t(95) = 1.79, p = .100$).

5.3.2. Results of the ratings on the perceived pitch

A repeated-measures ANOVA revealed that feminine (vs. masculine) instruments were rated as significantly higher in perceived pitch, $F(1,94) = 61.27, p < .001, \eta_p^2 = .40$; $M_{Fem} = 68.67, SD = 27.41$; $M_{Masc} = 30.28, SD = 25.81$.

5.3.3. Results of the mediation analyses

Three mediation analyses (one for each dimension) were performed to investigate how the perceived pitch of a sogo mediated the relationship between the type of instrument and the semantic dimensions (see Figure 5).

Valence. The direct effect of the type of instrument on valence was significant ($b = 12.95, SE = 4.11, t(93) = 3.15, p = .002$). The indirect effect of the type of instrument on valence through perceived pitch was not significant ($b = 1.09, SE = 3.20, 95\% CI [-5.47, 7.14]$). Specifically, the sogos created using feminine instruments were rated as higher in perceived pitch ($b = 38.50, SE = 4.84, t(95) = 7.95, p < .001$), and the pitch was not related to valence ($b = .19, SE = .03, t(93) = .68, p = .50$). This indicated that the pitch did not mediate the relationship between the type of instrument and valence.

Potency. The direct effect of the type of instrument on potency was significant ($b = -19.09, SE = 2.97, t(93) = -6.43, p < .001$). The indirect effect of the type of instrument on potency through perceived pitch was significant ($b = -9.22, SE = 2.42, 95\% CI [-14.57, -5.08]$). Specifically, the sogos created using feminine instruments were rated as higher in perceived

pitch ($b = 38.50, SE = 4.84, t(95) = 7.95, p < .001$) and the pitch was negatively related to potency ($b = -.24, SE = .05, t(93) = -4.91, p < .001$). This indicated that the pitch partially mediated the relationship between the type of instrument and potency.

Stability. The direct effect of the type of instrument on stability was significant ($b = -5.62, SE = 2.16, t(93) = -2.60, p = .01$). The indirect effect of the type of instrument on stability through perceived pitch was not significant ($b = -1.28, SE = 1.75, 95\% CI [-4.85, 2.01]$). Specifically, the sogos created using feminine instruments were rated as higher in perceived pitch ($b = 38.50, SE = 4.84, t(95) = 7.95, p < .001$), and the pitch was not related to stability ($b = -.03, SE = .04, t(93) = -.93, p = .35$). This indicated that the pitch did not mediate the relationship between the type of instrument and stability.

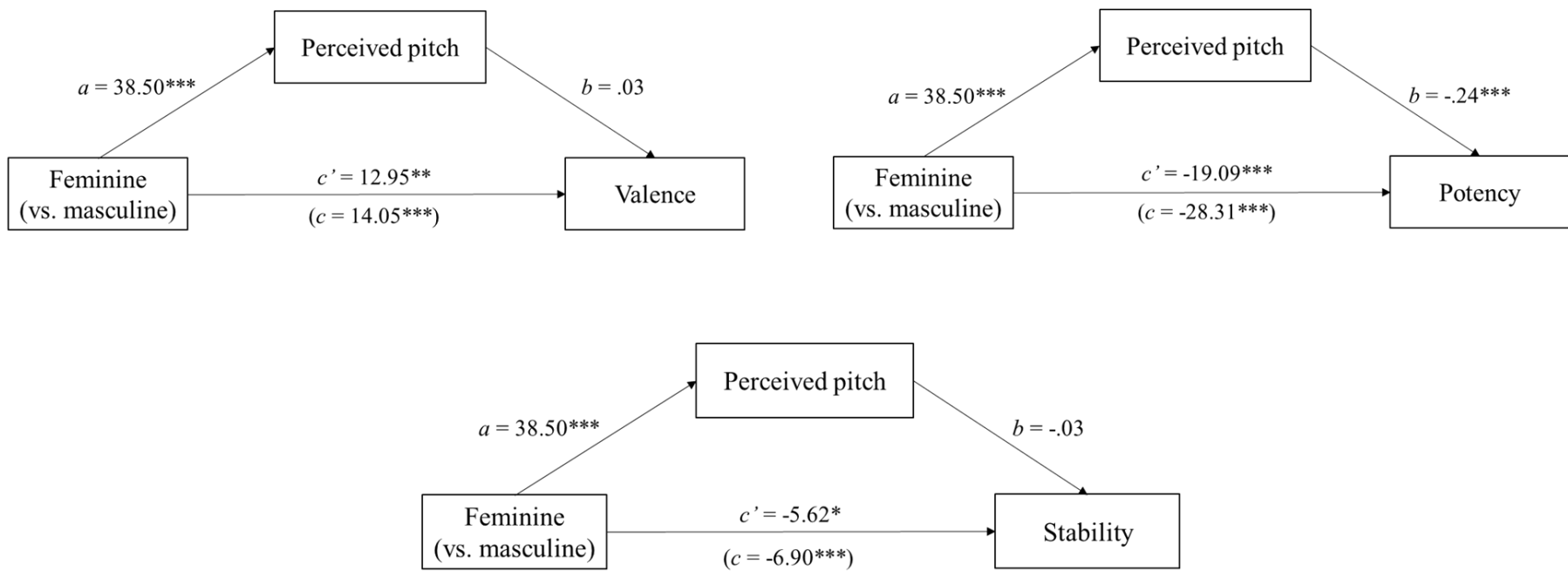


Fig. 5. The figures illustrate the mediating effect of pitch on the relationship between sogos created using feminine vs. masculine musical instruments and valence, potency, and stability dimensions in Study 2. $*p < .05$, $**p < .01$, $***p < .001$.

5.4. Discussion

The results of Study 2 demonstrated the relationship between the type of musical instrument (feminine vs. masculine) and dimensions of semantic attributes. Sogos created using feminine (vs. masculine) instruments were positively associated with valence (stability). As expected, there were similar relationships between musical instruments and gendered traits. Firstly, sogos created using feminine instruments were associated with ‘sincerity’ (Study 1) and results suggest that the connotations of positive valence (Study 2) embedded in feminine instruments underlie the feminine-sincerity association. Secondly, sogos created using masculine instruments were associated with the connotation of potency and this relationship was mediated by perceived pitch (these results were consistent with those in Study 1). It suggests that the connotations of potency embedded in masculine instruments underlie the masculine-ruggedness association through the perceived low-pitch. Altogether, the relationship between gendered instruments and brand personality traits can be attributed to the connotative meanings of musical instruments. Although the results of activity and novelty dimensions were not significant, they provide a direction for future research which would be discussed further in the sections on limitations.

6. Study 3: Purchase intention

In the first two studies, we have shown the associations between instrument type and brand meanings (i.e., brand personality and connotative meanings). This study aimed to 1) examine how the interplay of instruments and brand personality influences purchase intention 2) examine whether this relationship is mediated by perceived congruency, and 3) improve the generalizability of the study.

Given that gendered instruments cue associations with brand concepts (Study 1 and 2), the combination of certain instrument types and a brand personality is possibly perceived as conceptually/metaphorically congruent. This assumption was drawn from the effect of metaphor congruency (Meier & Robinson, 2004; Motoki, Nakahara, & Velasco, 2023). The idea of this effect is that people ordinarily use metaphors to understand abstract concepts and the metaphors act as conceptual mappings between two superficially dissimilar concepts (e.g., height and power) (Landau, Meier, & Keefer, 2010). As such, the concepts that are matched metaphorically are processed more quickly than those that are mismatched (Meier & Robinson, 2004; Motoki et al., 2023; Schubert, 2005). In fact, this effect can apply to auditory stimuli. In other words, an abstract meaning (i.e., brand personality) can be triggered by a musical feature (i.e., timbre) that is congruent with the meaning at a non-conscious level (Melzner & Raghbir, 2022).

In addition to rapid responses, when the objects are semantically matched (vs. mismatched), they are easier to process (e.g., Belke, Leder, Strobach, & Carbon, 2010) and are strongly preferred (Schwarz, Jalbert, Noah, & Zhang, 2021). This can be attributed to the feeling-as-information theory which suggests the role of subjective experiences (e.g., ease of information processing) in judgment. Consumers are likely to attend to their feelings (derived from processing experience) as a source of information when making judgements (see Schwartz et al., 2021 for a review). Specifically, ease (vs. difficulty) in processing, which is more pleasant, tends to elicit a positive affective response. This notion is consistent with research on brand personality and shows a crucial role of perceived congruency in enhancing the effect of marketing cues; specifically, higher levels of congruency between brand elements result in positive consumer responses (e.g., Luffarelli, Stamatogiannakis, & Yang, 2019; Wang, Zhang, & Jiang, 2022) towards brand attitude, purchase intention, and actual sales (Motoki et al., 2023;

Melzner & Raghurir, 2022). For instance, when the timbre of the instrument (i.e., piano) used in the advertisement is congruent (vs. incongruent) with the advertised product/service (e.g., cosmetic surgery service), it enhanced the positive affective response towards the advertisement (Oakes & North, 2006). Similarly, when sweet foods were advertised with sincere (vs. competent) personalities, their higher perceived congruency led to a positive brand attitude and increased the actual sales volume (Motoki et al., 2023).

Taken together, we assumed that presenting a sogo created with an instrument that matches the brand personality (e.g., masculine instruments with ruggedness), would be perceived as congruent with the brand and would lead to a positive brand attitude and higher purchase intention.

H1: Exposure to a sogo matched (vs. mismatched) with a brand personality attribute leads to an increase in stated purchase intention.

H2: This sogo-brand personality relationship is serially mediated by perceived semantic congruency and brand attitude.

We tested this assumption by focusing on ruggedness and sincerity because they are matched with masculine and feminine instruments respectively (Study 1). To enhance generalizability, we tested the hypotheses using various product categories (between-category products [e.g., hiking boots, strong beers vs. flowers, toys] for Study 3 and within-category products [e.g., gloves] for replicate studies (see Appendices P and Q). We hypothesised that if the effect holds, the interplay of the instrument and brand personality on purchase intention should be observed regardless of product type.

In terms of sogo stimuli, we created new melodic notes that imitated the pattern of commercial sogos and used various instrument types (wind instruments including woodwinds and brass for Study 3 and string instruments for a replicate study – see Appendix Q). All the melodies used in these studies were controlled for likability, pleasantness, and familiarity (see Appendix O for a pretest of melodies and Appendix H for software used in sogo development). All sogos used in this study are available at <https://on.soundcloud.com/wWPqr>.

In this study, we aimed to investigate how the interplay of the instrument and brand personality influences purchase intention, and whether this relationship is mediated by the degree of perceived congruency and attitude towards the brand. Masculine (tuba, French horn) and feminine instruments (flute, oboe) that matched the ratings in ruggedness and sincerity (see Appendix K) were used. In product categories, hiking boots and strong beers were selected as rugged products (e.g., Klink, 2000; Pathak, Calvert, & Lim, 2020). Since sincere brand personality is also linked with childhood memories (Maehle, Otnes, & Supphellen, 2011) and is often referred to as warm (Aaker, 1997) and friendly (Maehle et al., 2011; Klink & Athaide, 2012), flowers and toys were used as sincere products.

6.1. Participants

113 participants took part in this study. Data of four participants who spent $> 2SD$ of the average time taken to complete the task were discarded. Two outliers were excluded. The final data of 107 participants (*Male* = 64, *Female* = 41, Unspecified gender = 2; Age range = 21 – 66 years, $M = 36.94$, $SD = 10.67$) were further analysed.

6.2. Design and procedure

A 2 (instrument: masculine vs. feminine) x 2 (product: rugged vs. sincere) within-participant design was used. Participants were told that a company was looking for slogans that perfectly matched the advertised products. They were then presented with four pairs of slogans and products in random order without repetition. This led to four conditions: masculine-rugged condition (tuba or French horn with hiking boots or strong beers), masculine-sincere condition (tuba or French horn with flowers or toys), feminine-rugged condition (flute or oboe with hiking boots or strong beers) and feminine-sincere condition (flute or oboe with flowers or toys).

Participants were instructed to take a moment to listen to each slogan, which was played automatically, and then rated the product attributes (brand attitude and purchase intention) using a VAS scale (Brand attitude: 0 = Do not like it at all/Very unfavourable, 100 = Like a lot/Very favourable, $\alpha = .94$; Purchase intention: 0 = Not buy it at all, 100 = Definitely buy it) (Luffarelli et al., 2019). Next, they rated the extent of perceived congruency between slogans and products using an 8-point graphical scale (Bergami & Bagozzi, 2000; Motoki et al., 2023). The scale illustrates eight levels of overlap between two circles (1 = Far apart, 8 = Complete overlap). Participants then rated the slogans for masculinity vs. femininity and products for ruggedness vs. sincerity on a VAS scale (slogan: 0 = Very masculine, 100 = Very feminine; product: 0 = Very rugged, 100 = Very sincere).

6.3. Statistical analyses

The data were first normalised using the method described in the section 4.3. A series of repeated measures was used to investigate the effect of the instrument and product type on brand attitude, purchase intention and perceived congruency. A within-participant mediation analysis (Montoya & Hayes, 2017) was conducted to investigate how the perceived congruency and brand attitude mediates the effect of the instrument and product type on purchase intention.

6.3.1. Results of the effect of instrument and product type

Manipulation check. A paired-sample t -test revealed that masculine instruments (i.e., French horn and tuba) were significantly rated as more masculine and feminine instruments (i.e., flute and oboe) as more feminine ($t(106) = 6.62, p < .001, d = .67; M_{\text{masc}} = 52.59, SD = 26.95, M_{\text{fem}} = 69.59, SD = 15.41$). Moreover, rugged products (hiking boots and strong beers) were significantly rated as more rugged and sincere products (toys and flowers) as more sincere ($t(106) = 7.30, p < .001, d = .71; M_{\text{rugged}} = 55.31, SD = 31.44, M_{\text{sincere}} = 77.27, SD = 12.76$).

Brand attitude. The results revealed the main effect of instrument type on brand attitude ($F(1,106) = 14.78, p < .001, \eta_p^2 = .12$). Specifically, masculine instruments ($M = 59.21, SD = 24.37$) were rated as significantly lower in brand attitude than feminine ones ($M = 64.37, SD = 20.46$). However, there was no difference between products ($F(1,106) = .36, p = .55$). Further, a significant interaction between instrument and product type was observed ($F(1,106) = 18.44, p < .001, \eta_p^2 = .15$). Specifically, a paired sample t -test showed that in the masculine instrument condition, the rugged products were rated as significantly higher in brand attitude than sincere products ($t(106) = 3.10, p = .002, d = .30; M_{\text{rugged}} = 61.81, SD = 23.92, M_{\text{sincere}} = 56.62, SD = 27.67$). In the feminine instrument condition, the sincere products were rated as significantly higher in brand attitude than rugged products ($t(106) = 3.50, p = .001, d = .34; M_{\text{sincere}} = 67.65, SD = 19.17, M_{\text{rugged}} = 61.09, SD = 25.64$).

Purchase intention. The results revealed the main effect of instrument type on purchase intention ($F(1,106) = 9.00, p = .003, \eta_p^2 = .08$). Specifically, masculine instruments ($M = 59.03, SD = 26.51$) were rated as significantly lower in purchase intention than feminine ones ($M = 63.61, SD = 19.79$). However, the difference between products was not observed in the main effect of instrument type on purchase intention ($F(1,106) = 2.45, p = .12$). Moreover, the

significant interaction between instrument and product type was observed ($F(1,106) = 33.58, p < .001, \eta_p^2 = .24$). Further, a paired t -test revealed that in the masculine instrument condition, the rugged products were rated as significantly higher in purchase intention than sincere products ($t(106) = 2.83, p = .006, d = .27; M_{rugged} = 61.66, SD = 26.84, M_{sincere} = 56.39, SD = 29.51$). In the feminine instrument condition, the sincere products were rated as significantly higher in purchase intention than rugged products ($t(106) = 5.50, p < .001, d = .53; M_{sincere} = 68.20, SD = 22.19, M_{rugged} = 59.02, SD = 20.96$).

Perceived congruency. The results revealed a significant interaction between instrument and product type ($F(1,106) = 58.23, p < .001, \eta_p^2 = .36$). Further, paired t -tests revealed that the congruence between masculine instruments and rugged products was rated as significantly higher than with sincere products ($t(106) = 33.83, p < .001, d = 3.27; M_{rugged} = 4.07, SD = 1.84, M_{sincere} = 3.57, SD = 1.99$), and the congruence between feminine instruments and sincere products were rated as significantly higher than with rugged products ($t(106) = 5.13, p < .001, d = .50; M_{sincere} = 4.90, SD = 1.92, M_{rugged} = 3.90, SD = 1.93$).

6.3.2. Results of the mediation analyses

If gendered instruments and brand personality hold strong semantic associations, we expect that when instrument type (e.g., masculine) matches the brand personality (e.g., ruggedness), it would be perceived as more congruent than when they are mismatched (e.g., masculine instrument type with sincerity). We thus created matched and mismatched conditions; the matched condition was the combination of masculine (feminine) instruments and rugged (sincere) products and the mismatched condition was the combination of masculine (feminine) instruments and sincere (rugged) products. A serial mediation analysis (MEMORE macro, Model 1; Montoya & Hayes, 2017) was then used where the matched vs. mismatched conditions

were the IVs, purchase intention was the DV, and perceived congruency and brand attitude were the mediators. The indirect effect of the perceived congruence and brand attitude was estimated using 95% percentile bootstrap intervals with 5000 bootstrap samples.

The results revealed that the direct effect of the conditions (matched vs. mismatched) on purchase intention was not significant ($b = 2.43, SE = 1.27, t(102) = 1.91, p = .06$) (see Figure 6). The indirect effect of the conditions on purchase intention through perceived congruency and brand attitude was significant ($b = 1.34, SE = .71, 95\% CI [.34, 3.10]$). Specifically, when the instrument type matched the product type, they were perceived as more congruent ($b = .77, SE = .16, t(106) = 4.95, p < .001$), and the perceived congruency was positively related to brand attitude ($b = 3.40, SE = .90, t(104) = 3.80, p < .001$) leading to higher purchase intention ($b = .51, SE = .08, t(102) = 6.22, p < .001$). This indicated that perceived congruency and brand attitude serially mediated the effect of the match between the instrument type and product type on eventual purchase intention. As expected, when rugged (vs. sincere) products were advertised with slogans created in masculine (feminine) instruments, brand attitude and purchase intention were enhanced due to the perceived congruence between the instruments and products.

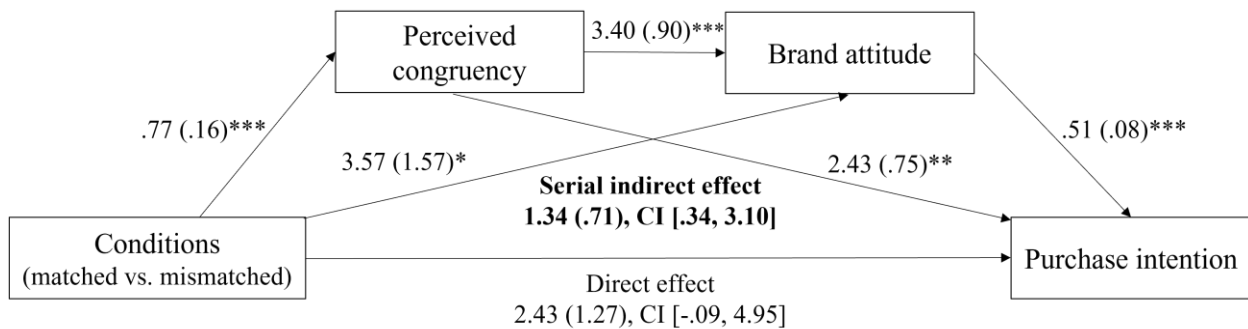


Fig. 6. The figure illustrates the serial mediating effect of perceived congruency and brand attitude on the relationship between the matched vs. mismatched conditions on purchase intention in Study 3. The matched condition was the combination of masculine (feminine) instruments and rugged (sincere) products. The mismatched condition was the combination of masculine (feminine) instruments and sincere (rugged) products. Unstandardized coefficients are represented. The values in parentheses indicate the standard error. The values in bold show significant effects at $p < .05$. $^{***}p < .001$, $^{**}p < .01$, $^*p < .05$.

6.4. Discussion

This study examined the influence of instrument type and brand personality on purchase intention using products between categories. The results indicated that when a product was advertised with a brand personality that matched (vs. mismatched) the instrument type, consumers perceived them as congruent leading to enhanced brand attitude and purchase intention (see also Appendices P and Q for replicate studies using products within a category).

7. General discussion

Previous research on sound and music has demonstrated that pitch, loudness, and tempo variations can be linked with brand and product attributes. Across three studies, this work extends these findings further and reveals that brand personality traits can also be communicated through instrumental timbre and influence brand attitude and purchase intention. We explored various dimensions of brand personality traits (Study 1) and connotative meanings (Study 2) and linked those with the attributes associated with the timbre and pitch of sogos. The results of Study 1 demonstrated that sogos created using feminine instruments are better matched with brand personality dimensions of ‘sincerity, competence, and excitement’ while sogos created using masculine instruments are better (or “more often”) matched with ruggedness. Study 2 demonstrated that sogos created using feminine (vs. masculine) instruments are associated more with positive valence (potency and stability). Altogether, the findings suggest that gender-based instruments can tap into the common semantic space of higher-order factors (e.g., valence, potency) (Sidhu et al., 2022) to effectively communicate a brand’s personality traits. That is, the connotation of positive valence (potency) in feminine (masculine) instruments can convey a sincere (rugged) personality. Further, when a product is advertised using sogos played by

instruments that matches its brand personality, this congruency enhances brand attitude and purchase intention (Study 3).

7.1. The timbre associations with brand personality

Given that people hold different stereotypes towards males and females, we assumed that those meanings could explain the relationship between instrumental timbre and brand attributes. As expected, we found that the sogos created using feminine (vs. masculine) instruments are more associated with sincerity. The direct association between feminine-stereotyped instruments (e.g., flute, English horn, and oboe) and sincerity are possibly explained by the quality of the sound of feminine instruments, which is similar to female voice (Reymore & Huron, 2020; Stronsick et al., 2017) and connotes positive valence (Study 2). The sound of feminine-like sogos would activate the concepts of feminine traits that overlap with those of sincerity. Langford and Mackinnon (2000) suggest that the cluster of feminine traits (e.g., good, caring; Langford & Mackinnon, 2000; kindness, warmth; Conway, Pizzamiglio, & Mount, 1996; friendliness, and willingness to spread goodwill; Klink, 2000) is consistent with the higher level of “goodness” (i.e., positive valence) or termed as “benevolent”. Similarly, sincerity also encapsulates the idea of warmth (Aaker, 1997) and friendliness (Maehle et al., 2011; Klink & Athaide, 2012). In line with these findings, we demonstrated that sogos created using feminine instruments (flute, English horn, oboe, harp, and violin) that connote positive valence are matched with sincerity.

Further, we also demonstrated that sogos created with masculine (vs. feminine) instruments are more associated with ruggedness. This relationship is mediated by perceived low pitch. The ruggedness dimension can best be expressed by the concept of masculinity (Grohmann, 2009). Existing literature suggests the association between low-pitched sounds and masculine characteristics (Hinton et al., 2006; Ryani, 2021; Zhang et al., 2022). Low-frequency

sounds are consistent with larger objects (Hinton et al., 2006), and largeness cues masculinity (Zhang et al., 2022). Similarly, research on sogos has demonstrated that sogos with descending pitch are judged as more rugged (Ryani, 2021). Moreover, our study proposed that the connotation of potency in the masculine instruments also accounts for the masculine-ruggedness association as the cluster of masculine traits (e.g., powerful, strong; Rodero et al., 2012; aggressive; Reymore & Huron, 2020) overlaps with the concept of ‘power’ or ‘potency’ (Langford & Mackinnon, 2000). Our findings reveal that, the sogos created using masculine-stereotyped instruments (i.e., alto saxophone, double bass, French horn, trombone, and tuba) connote potency and are mapped with ruggedness (a relationship mediated by the perceived low-pitch of sogos). Altogether, we highlight that the connotative meanings of instrumental timbre act as the cognitive process that may account for the timbre-brand association and gender stereotypes.

Lastly, we also found that sogos created using feminine (vs. masculine) instruments were better matched to competence and excitement. We assumed that the connotation of ‘goodness’ in the feminine instrumental sounds could underlie the feminine associations. In other words, the sogos created using feminine instruments connote goodness, resulting in a positive evaluation, even for competence and excitement. Future research could examine other possible underlying mechanisms (e.g., likability, pleasantness) in depth.

7.2. The influence of timbre-brand congruency on brand attitude and purchase intention

Previous multisensory research has revealed that when two concepts (e.g., sensory cues and brand personality) are semantically matched, their congruency makes the processing easy, which in turn elicits positive consumer responses (Schwarz et al., 2021; Motoki et al., 2023; Luffarelli et al., 2019). In support, our findings demonstrate that when the instrumental timbre is

congruent with the brand's personality (masculine instrument with ruggedness and feminine with sincerity), consumers hold a positive attitude towards the brand and are likely to purchase the advertised product.

8. Contributions

8.1. Theoretical contributions

The current research has two main theoretical contributions. Firstly, this work contributes to branding and multisensory marketing by revealing the association of instrumental timbre with brand attributes (brand personality and connotative meanings). Prior research has shown that the perception of a brand's personality can be influenced by sensory cues (e.g., visual: logo, packaging design; Grohmann, 2009; Luffarelli et al., 2019; Seimiene & Kamarauskaite, 2014; the brand name sounds: Klink & Athaide, 2012; tastes: Motoki et al., 2023). Recent research has also suggested that changes in pitch, tempo, loudness, and timbre of sogos could play a role (e.g., Mas et al., 2021). Despite this, research so far has mainly focused on exploring the perception of ruggedness and sophistication (Melzner & Raghurir, 2022; Puligadda & VanBergen, 2023). The present research takes a step forward by further exploring the relationship across other dimensions of brand personality. Besides brand personality, this work also reveals that different instrumental timbres can carry the connotations of valence, potency and stability.

Secondly, this study reveals that connotative meaning embedded in instrumental sounds can alter the perception of brand personality. Existing literature on sogos showed that the influence of sogos on brand personality is formed by the conceptual and visceral effects of a sound (Puligadda & VanBergen, 2023) and abstract meanings of rough and smooth (Melzner & Raghurir, 2022). We extend this stream and suggest that the association of gendered instruments

and brand personality could be explained by correspondences in a common semantic space. In other words, the connotations related to gender stereotypes that jointly link with instrumental timbre and brand personality could determine consumer perception and behaviours. Since consumers rely on prior connotative meanings to evaluate a brand (Aaker, 1997; Wijnands & Gill, 2020), hearing a brand's sogo (masculine) could activate a corresponding semantic meaning (potency) and link to the brand personality (ruggedness). As a consequence, such congruency could facilitate positive brand attitude and purchase intention.

8.2. Managerial implications

Sonic logos are digital auditory assets and more brands are now investing in the creation of a distinct sonic identity. Once the sogo is congruent with a brand's personality, it could effectively result in a favourable brand attitude and eventual purchase intention. Otherwise, it simply is perceived as noise and confounds consumers, leading to a disconnect between brands and consumers (Khamis & Keogh, 2021). Our research provides insights to brand managers to create sonic logos that are congruent with their brand's personality; specifically ruggedness and sincerity. To illustrate, if a brand wants to convey an impression of a 'rough and tough' image, a sogo created using masculine instruments (e.g., trombone) seems more effective. Similarly, sogos created using the flute could be more suitable to convey the sincerity of a brand.

9. Limitations and future research

Firstly, the factor analysis of brand personality yielded four dimensions without the 'sophistication' dimension. Similar findings have been reported earlier (e.g., Davies, Rojas-Méndez, Whelan, Mete, & Loo, 2018; Geuens et al., 2009). Since we tested our hypotheses using Aaker's dimensions of sincerity and ruggedness (Study 3), future research may investigate the

effect of sogos on different brand personality frameworks (Davies et al., 2018; Geuens et al., 2009). Secondly, while our findings demonstrated that brands could benefit from the congruency between instrumental timbre and brand personality, this is not always the case. Some specific brand attributes, such as excitement and novelty, potentially leverage more from visual-tactile incongruency (Ludden, Schifferstein, & Hekkert, 2009; Sundar & Noseworthy, 2016). Future studies may address this issue by investigating the incongruency effect in the auditory context. Thirdly, timbre is the combination of multi-musical features (pitch, soft/loud, tense/lax, Van Leeuwen, 1999). Our study investigated its effect in terms of instrument type and pitch; however future research can investigate the effect of sound quality (timbre) in other acoustic dimensions. Also, we speculated that the connotation of activity might involve movement-related features (e.g., rhythm, tempo, ascending/descending pitch). Future research might find it interesting to examine these issues. Lastly, due to experimental and technological constraints, each sogo was created with a single instrument. Future research could broaden the stimuli base by mixing the instrument types, which might enhance the compositional complexity as well as the ecological validity of the research.

CHAPTER 5

General discussion

The thesis investigates the influence of sogos on perceived product attributes (i.e., healthfulness and meat/plant attributes) and brand attributes (i.e., brand personality). The findings demonstrated that variations of sogo elements (i.e., frequency and instrumental timbre) can affect the perception of food products, brand personality and subsequent behaviours. The main findings of each chapter are discussed as follows.

Chapter 2 revealed that high- (vs. low-) frequency sogos are associated with healthy (vs. unhealthy) and less (vs. more) filling foods. According to the spreading activation theory, given the semantic link between high frequency and healthfulness, hearing the high-frequency sogos would activate the healthy-related concept which is linked with healthy and less filling foods. As a result, the high-frequency sogos are perceived as matched with healthy and less filling foods, whereas their low-frequency counterparts are matched with less healthy but more filling foods. Moreover, high- (vs. low-) frequency sogos tend to influence consumers with a healthy (vs. satiation) goal to purchase the associated foods through perceived semantic congruence. According to the congruence theory, the strong connection between semantic and sensory cues results in positive evaluation and purchase behaviour. Thus, hearing a high- (vs. low-) frequency sogo that connotes healthful (vs. satiability) attributes enhances the intention to buy foods advertised with a high (vs. low) frequency in consumers with a healthy (vs. satiation) consumption goal.

Chapter 3 demonstrated that sogos with masculine instrumental timbre are associated with meat-based foods and feminine instrumental timbre with plant-based foods. The findings can also be explained by the spreading activation theory. Given the shared gender stereotypes between the instrumental timbre and food type, presenting a gender-stereotyped instrumental

sound could activate a gender-related concept which is linked with certain foods. Thus, sogos played by masculine (vs. feminine) instruments are associated with meat-based (vs. plant-based) foods. The associations occur at both explicit and implicit levels; however, the association between feminine timbre and plant-based foods is stronger than between masculine timbre and meat-based foods at the implicit level. We thus further demonstrated that, for plant-based meats that are semantically ambiguous in gender ascription, the presentation of sogos with feminine timbre can enhance the plant appeal of the product. This is due to the priming effect of the femininity of the sogos. Moreover, our study showed that plant-based meats advertised with feminine (vs. masculine) timbre are found to be suitable for female (vs. male) consumers, given the tendency that consumers have to select foods that conform with their social identity according to the social identity theory (Gal & Wilkie, 2010; Rodrigues et al., 2020; Tajfel, 1981).

Lastly, Chapter 4 revealed the role of instrumental timbre (masculine vs. feminine) on perceived brand personality. The study provides initial evidence of the associations across five brand personalities (i.e., competence, ruggedness, excitement and sincerity). The findings further showed the associations between feminine (vs. masculine) timbre and sincerity (vs. ruggedness) are based on the connotative meanings of the timbre in which feminine timbre connotes positive valence, and masculine timbre connotes potency. Moreover, the presentation of sogos that are matched with brand personality (i.e., feminine sogos and sincere products, masculine sogos and rugged products) can elicit positive brand attitude and purchase intention through the perceived congruency.

Taken together, the thesis has demonstrated that when sogos are semantically congruent with product/brand attributes, brief exposure to the sogos is sufficient to influence consumer perception and behaviour towards associated products/brands, including healthy

foods, meat/plant-based foods, plant-based meats, and products with sincere/rugged personalities.

1. Theoretical contributions

The thesis has two main theoretical contributions. First, the thesis contributes to the body of knowledge on multisensory marketing by exploring how sogos, a brief melodic tune, can connote food and brand attributes. Previous research has thoroughly investigated how various brand elements, such as packaging design and brand naming, impact consumers' perceptions of the associated brands. However, this study introduces the novel perspective that the frequency and timbre at which sogos are presented are also significant factors in conveying product/brand identities. Across three essays, convergent evidence highlights the vital role of shared semantic meaning between the sogo elements and product/brand attributes in driving the effectiveness of sonic branding in various contexts, such as healthy consumption, meat/plant-based foods and brand perception.

With regards to healthy consumption, the thesis presents preliminary findings that suggest sogo frequency can influence perceived healthfulness and satiability of associated foods. It underscores the importance of the semantic link between sogo frequency, healthfulness and the feeling of fullness in shaping consumer perception and purchase intention. In particular, changes in sogo frequency can imply food healthfulness and satiability, thereby affecting consumers' purchase intention when the connotation of sogo aligns with consumption goals, whether for health or satiation.

Regarding meat/plant-based foods, the present research extends the food and gender literature by establishing a link between the gendered qualities of instrumental timbres and food categories, specifically meat and plant-based foods. This offers a fresh viewpoint on the direct relationship between sound and the intrinsic nature of foods through the shared

meaning of gender stereotypes. The findings also suggest the specific role of sogo timbre in shaping consumer perceptions, particularly in reinforcing the plant-based qualities of food through feminine auditory cues.

In terms of brand perception, our findings also shed light on how instrumental timbre is linked with connotative meanings and brand personality, expanding our understanding of the relationship between sogos and brand attributes. Until now, sogo research has predominantly examined how ruggedness and sophistication are perceived in relation to instrumental sounds (Melzner & Raghbir, 2022; Puligadda & VanBergen, 2023). However, the current research advances our understanding by exploring additional brand personalities including sincerity, excitement and competence. Moreover, it has revealed that different instrumental timbres are associated with distinct connotations such as valence, potency, and stability, broadening the scope of how sound influences brand perception. The identification of connotative meanings in instrumental sounds is important since it acts as a new factor that can shape brand personality perceptions. This suggests that when consumers encounter a brand's sogo with masculine characteristics (i.e., timbre), it may evoke related semantic meanings, such as potency, which in turn can enhance the brand's rugged personality. This alignment between sound and brand personality could lead to more favourable brand attitudes and a higher likelihood of purchase.

Second, the findings advance the literature on sound symbolism by demonstrating the direct associations between sogo elements and food attributes; specifically, frequency (high vs. low) and healthfulness, instrumental timbre (masculine vs. feminine) and meat/plant attributes. Extant research on crossmodal correspondence between sounds and foods has extensively focused on flavours and tastes (see Spence et al., 2019 for a review). For instance, the association of high-pitched music with sweetness and low-pitched music with bitterness (Spence et al., 2019). Our findings enrich this research stream by providing two

novel perspectives of sound-food associations. One is the frequency-healthfulness association, and the other is masculine timbre-meat and feminine timbre-plant association. Such associations can occur through the shared semantic meaning between the sogo elements (i.e., frequency and timbre) and food attributes (i.e., healthfulness and meat/plant attributes).

2. Managerial implications

The research offers several valuable insights for brand managers on the strategic use of effective sogos. First, the study suggests that for effective health promotion, brands should consider high-frequency sogos to highlight health benefits, while low-frequency sogos may be better suited for products aimed at active individuals like teenagers or athletes who require satiety. Second, for food branding, the research recommends brass instruments for meat-based foods and woodwinds for plant-based ones to aid in product differentiation, particularly in audio-only advertisements. Additionally, for emerging plant-based ‘meat’ products, the use of a flute in a sogo can quickly communicate the plant-based nature of ‘meat’ products, facilitating consumer judgment without reading detailed descriptions. Relatedly, incorporating feminine instruments into sogos can appeal to female consumers and boost the plant appeal of the product.

Lastly, in terms of brand personality communication, aligning a sogo with a brand’s personality, such as using masculine instruments for a ‘tough’ image or a flute for sincerity, can lead to positive brand attitudes and increased purchase intention. This thesis underscores the importance of congruency between a brand’s sonic identity and its unique selling points, which can significantly influence consumer perception and behaviour.

3. Limitations and future research directions

One limitation of the thesis is that it primarily focuses on the theoretical implications of sogos and their perceived attributes, rather than empirical evidence of actual consumer

behaviour. Future research could build upon these findings by examining how these sonic elements influence real-world consumer choices and actions. It would be particularly interesting to investigate, for example, whether the associations between sonic logos and brand personality traits, as suggested by the study, can lead to measurable changes in purchasing or selection behaviour towards associated products or brands. Whether a low-frequency sogo that connotes satiability can lead to a smaller amount of consumption also awaits future research.

Another limitation of the current study is its focus on the associations between sogos and food-related perceptions (e.g., healthfulness). For future research, it would be intriguing to explore whether these associations extend to non-food products or brands. For instance, examining if a logo that conveys healthfulness could influence perceptions of a gym would broaden the applicability of sonic branding across different industries. The insight could help reveal how auditory cues impact consumer perceptions and behaviours in various contexts beyond the food sector. Relatedly, it would also be interesting to investigate the psychological mechanisms that drive these associations. Future research could address this gap by investigating the underlying psychological pathways that connect sogos with consumer responses. This could involve examining how sogos interact with emotions (Wang & Spence, 2018 - Endnote), attention capture (Spence, Reinoso-Carvalho, Velasco, & Wang, 2019) and physiological responses (Mas et al., 2021; Spence, Reinoso-Carvalho, Velasco, & Wang, 2019) to influence product/brand evaluation and choice.

Moreover, the methodology of a within-participants design is possibly of concern. Although the within-participants design employed in the studies offered several advantages, it also presented certain methodological limitations, which I addressed to ensure the validity and reliability of the findings. The first limitation was the order effect. Participants may be influenced by the sequence in which they experienced the conditions, leading to learning or

boredom. To mitigate this, I employed counterbalancing by presenting the conditions in a random order across participants. This approach helps distribute any order effects evenly, thereby minimizing their impact on the results. Another concern is the practice effect. Since participants' performance might improve over time simply due to repeated exposure to similar tasks, I controlled for this by including practice trials before the actual experimental tasks. This allowed participants to become familiar with the tasks beforehand, thereby reducing the impact of learning during the experiment. Finally, analyzing data from within-participants designs can pose a challenge due to correlations between repeated measures. To handle these issues, I employed advanced statistical techniques, such as a mixed-effects model (e.g., Study 3 in Chapter 3) to account for both fixed and random effects and a generalized linear model (e.g., Study 2 in Chapter 2), providing a robust analysis of the results. Although the solutions may not fully address the concerns, those methodological and statistical strategies sufficiently enhance the validity and reliability of the study's findings.

Despite the limitations, the findings of this thesis provide fundamental evidence that future research can develop upon, such as the investigation of the relationship between instrumental timbre and protein alternatives, which is one of my ongoing projects. There are two types of protein alternatives: meat-based (e.g., insects) vs. plant-based (e.g., tofu). The idea of this research was developed based on the findings of timbre and meat/plant associations. Given the masculine-meat and feminine-plant associations, it would be plausible to assume that masculine (vs. feminine) instruments would play a role in consumer responses to insect-based (vs. tofu-based) protein alternatives. Past research has demonstrated that there are contributing factors to the acceptance of such novel and unfamiliar foods as protein alternatives, such as social companions and eating venue (Motoki, Park, Spence, & Velasco, 2022), taste and texture (Michel, Hartmann, & Siegrist, 2021) and cute packaging (Marquis, Reinoso Carvalho, & Pantin-Sohier, 2024). How the sound of sogo can affect consumer

perception and behaviour has remained unexplored. The findings of this study would contribute to the literature on protein alternatives and food marketing by adding evidence of the potential role of a brand sound sogo in facilitating consumers' willingness to accept the novel foods.

It has been known that the congruence between brand attributes is a successful factor for branding. While this thesis indicates that the congruence between sogos and brand identity has a positive effect on purchase intention, whether the congruence between sogos and other brand attributes (e.g., visual logos and brand names) would facilitate the effect has been unanswered. Prior research showed that extensive product and brand attributes can communicate healthfulness, such as brand names with high-frequency phonemic sounds (Motoki et al., 2021), angular-shaped foods (Wang et al., 2022), slim-humanoid-body package (Yarar, Machiels, & Orth, 2019). Nevertheless, whether combining all those cues can enhance the perception of food healthfulness (i.e., the additive effect) or just one prominent cue is sufficient. It would be interesting for future research to investigate, for instance, whether presenting food in a slim package with a high-frequency sogo and a healthy brand name would enhance the perception of healthfulness. Otherwise, if the ceiling effect exists, which of these is the most important cue awaits future research.

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Appendix

Appendix A: Visual stimuli used in Chapter 2

Study 1: Images of healthy vs. unhealthy foods.

Healthy foods:

Green salad



Fruit salad



Cucumber and tomato salad



Unhealthy foods:

Cheeseburger



French fries



Chocolate cookies



Study 2: Images of healthy vs. less healthy foods within the same category.

Burger:

Healthy burger (soy burger)



Less healthy burger (bacon burger)



Salad bowl:

Healthy salad (spring salad)



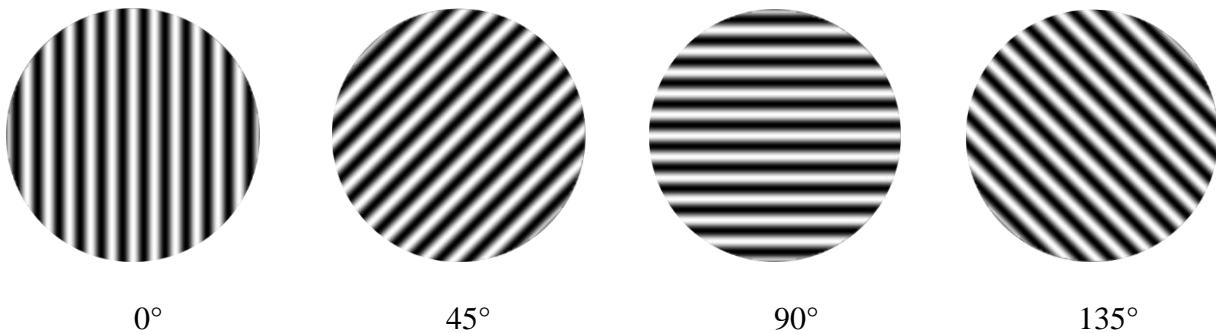
Less healthy salad (salad with fries)



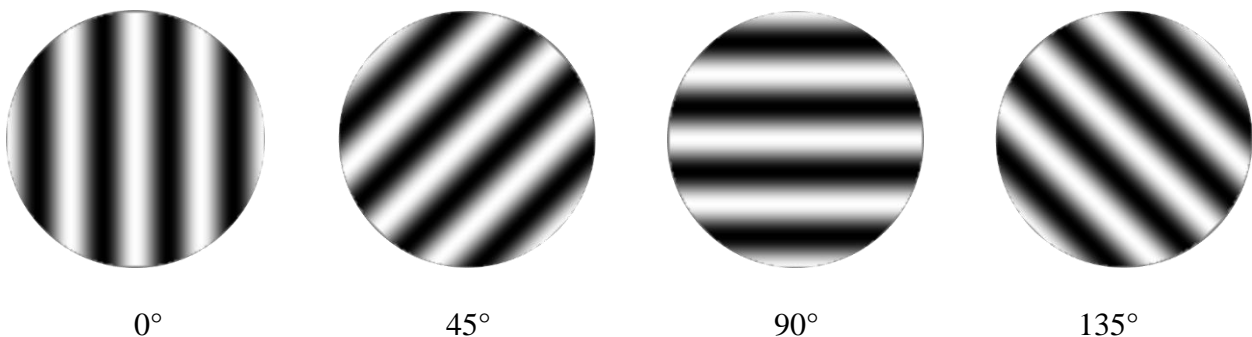
Study 3: Images of visual frequency gratings.

In the psychophysics literature, the graphical representation of sound waves are simple sinusoidal (sine) waveforms. The sine wave represents the area of compression and rarefaction of medium molecules (e.g., air) occurring while the sounds are transmitted. This resembles a visual image known as a sine wave grating (stripes of black and white) where the bands represent the low (i.e., black stripes) and high intensity of light (i.e., white stripes) and its frequency is also measured in terms of the number of cycles per visual degree. That is, the more stripes of black and white, the higher spatial frequency is. As a result, a higher spatial frequency grating is visually represented by thinner and more black-white stripes, and a lower spatial frequency grating is by broader and fewer black-white stripes.

High-frequency sine-wave gratings (spatial frequency = 12)



Low-frequency sine-wave gratings (spatial frequency = 4)



Study 3: Images of healthy vs. unhealthy foods.

Healthy foods:

Green salad



Fruit salad



Salad with shrimps



Tuna salad



Unhealthy foods:

French fries



Brownies



Cheeseburgers



Donuts



Appendix B: Results of Studies 1 and 2 by instruments, Chapter 3

Table B.1

Results of the Wilcoxon signed-rank test comparing the percentage of food selection (Study 1)

Instruments	<i>M (%)</i>		<i>SD</i>	<i>z</i>	<i>p</i>
	Meat-based meals	Plant-based meals			
<i>Masculine</i>					
Sax	50.88	49.12	50.44	.90	.130
Trumpet	54.39	45.61	50.25	.66	.510
Trombone	68.42	31.58	46.90	2.78	.005
Tuba	71.93	28.07	45.33	3.31	.001
<i>Feminine</i>					
Violin	47.37	52.63	50.37	-.40	.690
Flute	22.81	77.19	42.33	-4.11	< .001
Clarinet	38.60	61.40	49.11	-1.72	.085
Oboe	42.11	57.89	49.81	-1.20	.230

n = 57

Table B.2

Results of the Wilcoxon signed-rank test comparing the averaged percentage of animal-based product selection (Study 2a)

Instruments	<i>M (%)</i>		<i>SD</i>	<i>z</i>	<i>p</i>
	Masculine food items	Feminine food items			
<i>Masculine</i>					
Sax	54.39	45.61	50.25	.66	.508
Trumpet	52.63	47.37	50.37	.40	.691
Trombone	80.70	19.30	39.81	4.64	< .001
Tuba	75.44	24.56	43.43	3.84	< .001
<i>Feminine</i>					
Violin	43.86	56.14	50.06	-.93	.354
Flute	22.81	77.19	42.33	-4.11	< .001
Clarinet	35.09	64.91	48.15	-2.25	.024
Oboe	42.11	57.89	49.81	-1.19	.233

n = 57

Table B.3

Results of the Wilcoxon signed-rank test comparing the averaged percentage of plant-based product selection (Study 2b)

Instruments	<i>M (%)</i>		<i>SD</i>	<i>z</i>	<i>p</i>
	Masculine food items	Feminine food items			
<i>Masculine</i>					
Sax	53.33	46.67	50.31	.52	.606
Trumpet	60.00	40.00	49.40	1.55	.121
Trombone	75.00	25.00	43.67	3.87	< .001
Tuba	76.67	23.33	42.65	4.13	< .001
<i>Feminine</i>					
Violin	40.00	60.00	49.40	-1.55	.121
Flute	25.00	75.00	43.67	-3.87	< .001
Clarinet	38.33	61.67	49.03	-1.81	.071
Oboe	50.00	50.00	50.42	.00	1.000

n = 60

Appendix C: Pretest of Studies 2a and 2b, Chapter 3

The objective of the pretest was to verify the masculinity and femininity appeal of animal-based and plant-based foods selected. 22 items each of animal-and plant-based foods were selected from previous literature (Heisley, 1990; Jensen & Holm, 1999; Levy, 1981; Rozin et al., 2012). Two separate pretests were conducted for animal-based and plant-based foods. Participants were shown the name of the food items (text stimuli) and were instructed to rate the extent they thought the food item was masculine or feminine (on a visual analogue scale [VAS] from 0 = very masculine to 100 = very feminine).

50 participants completed the pretest of animal-based food category (*Males* = 29, *Females* = 21; M_{age} = 39.18 years, SD = 11.87, age range = 23 - 70 years). Outliers outside 2SD were excluded; a one-sample *t*-test revealed that the following eight food items were perceived as masculine and feminine (masculine: sausage, beef, bacon, salami, pork, bologna, ham, turkey; feminine: yoghurt, cream, milk, egg, lamb, clam, butter, fish; see Table 5 for the statistical results). All perceived traits (masculine vs. feminine) differed significantly from the midpoint of 50.

Table C.1

Results of One Sample t-test showing perceived masculinity vs. femininity of the animal-based foods

Perceived						
trait	Food item	<i>M</i>	<i>SD</i>	<i>df</i>	<i>t</i>	<i>p</i>
Masculine	Sausage	20.25	20.67	47	-9.97	< .001
	Beef	21.09	16.37	46	-12.11	< .001
	Bacon	24.38	17.12	49	-10.58	< .001
	Salami	27.20	17.75	48	-8.99	< .001
	Pork	29.16	18.31	49	-8.05	< .001
	Bologna	34.66	17.27	46	-6.09	< .001
	Ham	35.08	20.19	49	-5.22	< .001
	Turkey	38.55	20.02	48	-4.00	< .001
Feminine	Fish	58.00	14.81	45	3.66	.001
	Butter	58.94	18.23	48	3.43	.001
	Clam	59.74	17.52	46	3.81	< .001
	Lamb	61.81	19.84	47	4.12	< .001
	Egg	65.31	20.74	48	5.17	< .001
	Milk	65.98	21.93	48	5.10	< .001
	Cream	75.48	15.45	47	11.43	< .001
	Yoghurt	77.96	14.54	46	13.18	< .001

Another 50 participants were recruited for the other pretest of the plant-based food category; responses of four participants who provided the same rating for all questions were excluded (*Males* = 22, *Females* = 24; *M_{age}* = 40.57 years, *SD* = 11.93, age range = 24 - 74 years). Outliers outside 2 *SD* were excluded; a one-sample *t*-test revealed that the following eight food items were perceived as masculine and feminine (masculine: potato, onion, corn, mushroom, broccoli, green bean, bell pepper, asparagus; feminine: peach, cherry, strawberry, plum, cantaloupe, grape, lettuce, tomato; see Table 6 for the statistical results). All perceived traits (masculine vs. feminine) differed significantly from the midpoint of 50.

Table C.2

Results of One Sample t-test showing perceived masculinity vs. femininity of plant-based foods

Perceived						
trait	Food item	<i>M</i>	<i>SD</i>	<i>df</i>	<i>t</i>	<i>p</i>
Masculine	Potato	27.73	17.93	44	-8.33	< .001
	Onion	35.77	16.16	43	-5.84	< .001
	Corn	35.91	15.47	43	-6.04	< .001
	Mushroom	39.82	17.21	43	-3.92	< .001
	Broccoli	40.80	16.61	44	-3.71	.001
	Green bean	42.23	11.97	42	-4.25	< .001
	Bell pepper	43.49	13.41	42	-3.18	.003
	Asparagus	43.62	17.91	44	-2.39	.021
Feminine	Tomato	57.25	14.67	43	3.28	.002
	Lettuce	58.88	15.88	42	3.67	.001
	Grape	61.38	11.34	41	6.50	< .001
	Cantaloupe	63.86	13.48	41	6.66	< .001
	Plum	69.27	15.97	43	8.01	< .001
	Strawberry	75.80	12.70	44	13.63	< .001
	Cherry	79.00	14.95	44	13.01	< .001
	Peach	80.07	15.24	44	13.23	< .001

Subsequently, the gendered animal-based and plant-based food items were selected for Study 2a and 2b respectively.



Appendix D: Pretest of Study 4 for sogo development, Chapter 3

We conducted a pretest to ensure that all melodies used in Study 4 were controlled for likability, pleasantness, and familiarity of the tunes. As the majority of commercial sogos are composed of 5 notes (Anzenbacher, 2016) in a wave-like melodic pattern (i.e., notes up, down, and up and vice versa) (SoundOut, 2021), all the melodies in this study followed this pattern. We created 12 new and different tunes played in a piano using *Noteflight*. The tunes were of 2.5 seconds each and comprised five notes of Cmajor (C4 to B4) with moderate tempo (90 bpm). Loudness was normalised to standard perceived loudness (-15 LUFS) using *Audacity* (<https://www.audacityteam.org/>).

A total of 50 participants (*Males* = 24, *Females* = 22, gender unspecified = 2; M_{age} = 36.24 years, SD = 8.29, age range = 24 -60 years) were recruited for a within-participants study. They were instructed to listen to 12 different tunes in random order and rated each of them on a VAS scale for likeability, pleasantness, and familiarity (0 = not at all, 100 = very much). Three paired sample *t*-tests (one for each attribute) revealed that no difference was found in the likeability ($t(49) = .14, p = .89$), pleasantness ($t(49) = .48, p = .63$), and familiarity rating ($t(49) = .82, p = .41$) in two melodies (see Table D.1). Hence, these melodies were retained for Study 4.

Table D.1

Descriptive statistics showing the evaluations of melodies in the pretest.

	Like	Pleasantness	Familiarity
	<i>M (SD)</i>	<i>M (SD)</i>	<i>M (SD)</i>
Melody 1 	43.96 (27.06)	45.86 (27.45)	34.48 (32.13)
Melody 2 	43.64 (25.51)	44.32 (25.76)	36.96 (31.39)

Appendix E: Pretest of Study 4 for food image selection, Chapter 3

This pretest aimed to ensure that food images used in Study 4 were neutral in meat vs. plant appeal. We selected 15 images of ambiguous foods from online sources. The food images consisted of sausages, burgers, wraps, steaks, meatballs, tacos, and falafels. Participants were randomly presented with one image at a time and rated whether they thought the food is made of meat or vegetable on VAS (0 = Definitely meat, 100 = Definitely vegetable).

50 participants completed the pretest (*Males* = 25, *Females* = 25; M_{age} = 41.04 years, SD = 12.06, age range = 22- 77 years). A one-sample *t*-test was used to exclude foods that were significantly different from the midpoint of 50 as these would have implied obvious meat or plant appeal. Two burger images (see Figure D.1) that matched in the neutral attribute ($t(49) = .04, p = .96, M_{burger1} = 47.90, SD = 32.07; M_{burger2} = 48.06, SD = 29.13$) were finally selected for Study 4.



Fig. E.1. Both ambiguous burgers were used in Study 4 and only the right one was used in Appendix G.

Appendix F: Generalisation of the feminine instrument association to brand names,

Chapter 3

As with sogos, firms invest considerable resources to craft a brand name that signals desirable brand attributes (Pogacar, Angle, Lowrey, Shrum, & Kardes, 2021). Prior research in linguistic symbolism has proved that sounds, stress, grammar, and length of brand name can convey the traits of masculinity and/or femininity and can subsequently influence brand perceptions and judgments (Klink, & Athaide, 2012; Mecit, Shrum, & Lowrey, 2021; Pathak & Calvert, 2020; Pogacar et al., 2021). Therefore, it is plausible to assume that brand names can also signal meat and plant attributes of food products.

In a follow-up study, we aimed to examine the association between the type of brand name (masculine vs. feminine) and food type (meat- vs. plant-based foods), and whether the congruence between the type of brand name and food type is the underlying mechanism. The significance of this study is twofold. First, it provides evidence of a direct association between brand names and meat and plant attributes. Second, it demonstrates that the gender effect observed in sogos generalises to other brand attributes such as brand names. We predicted that if the semantic correspondence between gendered cues and food type holds, this association should be observed with brand names. Thus, we used gendered brand names as proxies for the sogo stimuli used earlier and hypothesized that:

H1: Masculine (vs. feminine) brand names would be associated more with meat-based (vs. plant-based) foods.

H2: The congruence between the type of brand name and food type mediates the name-food association.

1. Participants

A total of 100 participants took part; data of three participants who spent time 3SD above the average completion time were excluded (*Males* = 59, *Females* = 38; M_{age} = 39.91 years, SD = 12.31, age range = 23 -71 years). Most participants were native English speakers, and two participants used Marathi and Tamil as primary languages.

2. Design and procedure

We used a one-way within-participant design in which brand names were manipulated at two levels (masculine vs. feminine). Gendered brand names from a prior study (Pogacar et al., 2021) were used; masculine names used were Nimeld, Telric, Siltac, and Nelmin, and feminine names were Nimilia, Tilna, Seca, and Nemri. The food stimuli were those used in Study 1 (see Table 2 in Chapter 3).

Participants were instructed to read the brand names out loud and select the food products that were best suited for those names. They then rated how strongly they thought the brand name matched the food. The evaluations were made on VAS (food association: 0 = Definitely [Name of meat-based food], 100 = Definitely [Name of vegetable-based food]; name-food congruence: 0 = No match at all, 100 = Perfectly matched) where the end-values (0 or 100) were invisible to the participants. There were 14 trials in total (including six trials with filler names), lasting for approximately three minutes. After the main task, they were presented with the target brand names again where they rated how masculine or feminine they thought the names were (0 = very masculine, 100 = very feminine). Then, they provided their demographic information. The presentation (left vs. right) of food names and the anchors of the masculine/feminine rating scale were counterbalanced between participants.

3. Results and discussion

Manipulation check. A paired-sample *t*-test revealed that feminine brand names were perceived as more feminine ($M_{fem} = 67.45, SD = 17.49$) and masculine brand names as more masculine ($M_{masc} = 38.86, SD = 17.82; t(96) = 12.13, p < .001, d = 1.23$).

Food association. A paired-sample *t*-test revealed that feminine brand names were associated more with plant-based foods ($M_{fem} = 58.9, SD = 18.43$) than masculine names ($M_{masc} = 55.08, SD = 18.05; t(96) = 2.22, p = .03, d = .23$) (see Table F.1 for analyses by names), partially supporting H1.

Table F.1

Results of the paired samples t-tests comparing the average rating of food association.

Feminine - Masculine brand names	Food association		<i>t</i>	<i>p</i>	<i>d</i>
	<i>M</i> (<i>SD</i>)	<i>M</i> (<i>SD</i>)			
Nimilia - Nimeld	62.84(28.70)	52.25(28.42)	2.82	.006	.29
Tilna - Telric	57.27(30.89)	58.56(29.00)	.37	.715	.04
Seca - Siltac	58.01(30.80)	56.98(27.34)	.28	.777	.03
Nemri - Nelmin	57.49(27.78)	52.54(28.26)	1.55	.124	.16

n = 97

Perceived congruence between names and foods. Another paired-sample *t*-test was used to compare the averaged congruence between the type of brand name and foods. The results revealed that feminine brand names matched more strongly with plant-based foods ($M_{Fem} = 64.05, SD = 19.36$) and masculine names with meat-based foods ($M_{Masc} = 58.46, SD = 22.03; t(96) = 4.35, p < .001, d = .44$).

Mediation. A within-participants mediation analysis (MEMORE macro, Model 1; Montoya & Hayes, 2017) was performed with the type of brand name as the independent variable (IV), food association as the dependent variable (DV), and name-food congruence as the mediator, to investigate how the name-food congruence mediates the relationship between the

type of brand name and food association. The indirect effect of the perceived congruence was estimated using 95% bias-corrected bootstrap intervals with 5000 bootstrap samples. The results revealed that the direct effect of the type of brand name on food association was not significant ($b = 2.04$, $SE = 1.84$, $t(95) = 1.11$, $p = .27$). In support of H2, the indirect effect of the type of brand name on food association through perceived congruence was significant ($b = 1.78$, $SE = .76$, 95% CI [.55, 3.52]). Specifically, the feminine (vs. masculine) brand names were rated as more matched with plant-based foods ($b = 5.60$, $SE = 1.29$, $t(96) = 4.35$, $p < .001$) and the congruence was positively related to the food association ($b = .32$, $SE = .13$, $t(95) = 2.39$, $p = .02$). These findings indicate that the name-food congruence fully mediate the relationship between the type of brand name and food association.

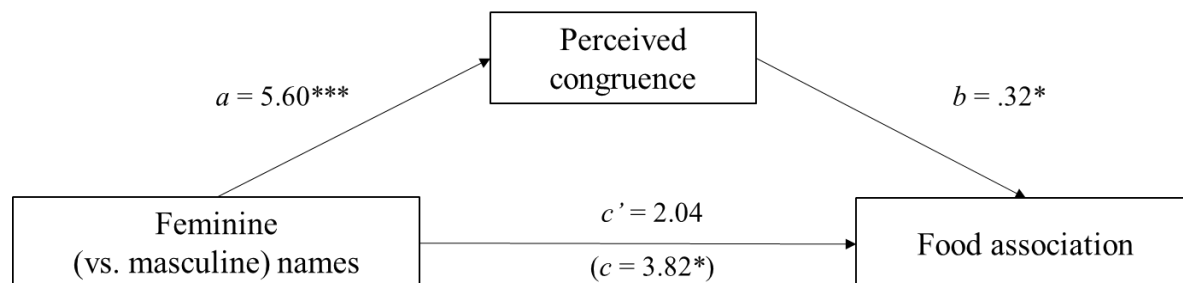


Fig. F.1. The figures illustrate the mediating effect of perceived congruence on the relationship between the type of brand name (masculine vs. feminine) and food association. * $p < .05$, *** $p < .001$.

This study demonstrated that feminine brand names were associated more with plant-based foods than masculine names because of a stronger congruence between feminine names and plants than between masculine names and meats. These findings affirm the generalization of our findings with sogos to another brand attribute (i.e., brand names). In a subsequent study (Appendix G), we would examine whether manipulation of brand names could alter the perception of food appeal.

Appendix G: The influence of feminine brand names on the perception of plant appeal,

Chapter 3

This study aimed to demonstrate that the effect of femininity on the perception of plant appeal could generalise to brand names. Thus, we hypothesized that:

H1: Feminine brand names would enhance the perception of plant appeal in ambiguous foods.

H2: Perceived gender of brand names mediates the influence of feminine instruments on the perception of plant appeal.

1. Participants and procedure

One hundred and four participants were recruited; data of one participant who spent 2 SD time above the average completion time was excluded (*Males* = 40, *Females* = 62, Gender not specified = 1; $M_{age} = 44.78$ years, $SD = 13.25$, age range = 22- 74 years). The procedure and design were similar to Study 4 where brand names were used as stimuli in place of sogos. *Nimilia* and *Nimeld* were used as masculine and feminine names (see Table F.1 in Appendix F)

2. Results and discussion

Manipulation checks for the perceived gender of the brand names. A paired-sample *t*-test revealed that the feminine brand name was perceived as more feminine ($M_{Nimilia} = 81.80$, $SD = 16.14$) and the masculine brand name as more masculine ($M_{Nimeld} = 32.70$, $SD = 26.81$; $t(102) = 14.08$, $p < .001$, $d = 1.39$).

Perception of plant appeal. A paired-sample *t*-test revealed that the burger image when presented with the feminine brand name was rated as a vegetable burger ($M_{fem} = 72.94$, $SD = 22.18$) more than when presented with a masculine brand name ($M_{masc} = 66$, $SD = 24.34$; $t(102) = 2.83$, $p = .006$, $d = .28$), supporting H1. However, the feminine name was rated as more

pleasant ($M_{fem} = 58, SD = 23.82$) than the masculine name ($M_{masc} = 40.36, SD = 26.98; t(102) = 6.59, p < .001, d = .65$), supporting prior studies that feminine names are generally perceived as more pleasant (Newman, Tan, Caldwell, Duff, & Winer, 2018; Pogacar et al., 2021; Stroessner & Benitez, 2019; Whissell, 2001).

Mediation. A mediation analysis (MEMORE macro, Model 1; Montoya & Hayes, 2017) was performed with the type of brand name as the IV, perception of plant appeal as the DV, and perceived gender of the brand names as the mediator, to investigate how perceived gender of the brand names mediates the relationship between the type of brand name and perception of plant appeal. The indirect effect of the perceived gender was estimated using 95% bias-corrected bootstrap intervals with 5000 bootstrap samples. The results showed that the direct effect of the type of brand name on the perception of plant appeal was not significant ($b = -1.26, SE = 4.51, t(100) = -.28, p = .78$). In support of H2, indirect effect of the type of brand name on the perception of plant appeal through perceived gender was significant ($b = 8.21, SE = 3.89, 95\% CI [.30, 15.67]$). Specifically, the feminine (vs. masculine) brand name was rated as more feminine ($b = 49.10, SE = 3.49, t(102) = 14.08, p < .001$) and the perceived gender was positively related to the perception of plant appeal ($b = .17, SE = .08, t(100) = 2.16, p = .03$) (see Fig. 3). This indicated that the feminine attribute of the brand name fully mediated the relationship between the type of brand name and perception of plant appeal.

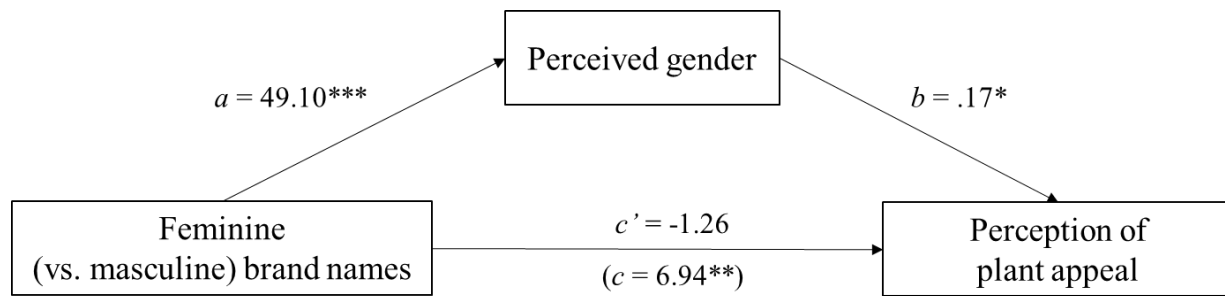


Fig. G.1. The figures illustrate the mediating effect of perceived gender on the relationship between instrument type (masculine vs. feminine) and food perception. * $p < .05$, ** $p < .01$, *** $p < .001$.

Given convergent evidence of feminine instruments (Study 4) and brand names, the findings confirmed that femininity in gendered cues could enhance the perception of plant appeal in foods. Specifically, sogos with feminine (vs. masculine) instruments and feminine (vs. masculine) brand names were perceived as more feminine, resulting in the enhanced perception of plant appeal in ambiguous foods. Moreover, feminine attributes drive the effect of timbre and brand names on food perception.

Appendix H: Sogo development in Chapter 4

Sogos were created using a short melody that comprised major notes ranging from C4 to C5 (262-527 Hz), a moderate tempo (95 beats per minute), and five seconds in duration (Techawachirakul et al., 2022; Wang & Spence, 2017). The same melody was played in five different feminine and masculine musical instruments to create ten sogos (feminine instruments: English horn, flute, harp, oboe, and violin; masculine instruments: alto saxophone, double bass, French horn, trombone, and tuba).

Sogos with the instrumental sounds of oboe, violin, alto sax, and trombone were created with *Noteflight* (<https://www.noteflight.com>), and all the others with *FL Studio* software (*Morphine* plugin for English horn and flute; *Sonatina Orchestra* for harp, double bass, and tuba; and *VSCO 2* for French horn). *Audacity* (<https://www.audacityteam.org/>) was used to 1), normalize the peak amplitude of all sogos to -8 dB and 2), equalize the loudness to -15 LUFS (these were made to control for the amplitude differences arising from the timbre dissimilarity and to standard the perceived loudness). All sogos used in this study are available at <https://soundcloud.com/musicclipss/sets/timbre-and-bps>.

Appendix I: Measurement validity and reliability for Study 1, Chapter 4

The results of Bartlett's test of sphericity indicated that the correlation matrix was not random, $\chi^2(105) = 855.43, p < .001$. The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy was .81, which indicated that the data set was meritorious and suitable for exploratory factor analysis (EFA). The extraction method of principal axis factoring (Oblimin rotation, Fabrigar & Wegener, 2012) was selected because it does not require the normality of data distribution (Brown, 2015). The analysis revealed four factors with Eigenvalues > 1 , which together accounted for 75% of the total variance (see Table I.1 for the factor loadings). The first factor consisted of the upper class, intelligence, and successful items that measured competence. The second factor consisted of tough, daring, and outdoorsy items that measured ruggedness. The third factor consisted of cheerful, spirited, imaginative, charming, and up-to-date items that measured excitement. The fourth factor consisted of down-to-earth, wholesome, reliable, and honest items that measured sincerity. Notably, the results indicated four dimensions of BPS without the sophistication dimension (Davies, Rojas-Méndez, Whelan, Mete, & Loo, 2018). We then performed a reliability analysis to estimate the internal consistency of the extracted factors (see Table I.1 for the reliability of each BPS dimension).

Table I.1*Factor loadings and reliability estimates for Study 1.*

Factor	Item	Factor loading				Cronbach's alpha
		1	2	3	4	
Competence	Upper Class	.902				.88
	Intelligent	.789				
	Successful	.771				
Ruggedness	Tough		.878			.74
	Daring		.712			
	Outdoorsy		.592			
Excitement	Cheerful			.931		.88
	Spirited			.801		
	Imaginative			.686		
	Charming			.619		
	Up-to-Date			.511		
Sincerity	Down-to-Earth				.748	.80
	Wholesome				.628	
	Reliable				.599	
	Honest				.547	

Appendix J: Results of mixed ANOVAs with normalised data in Study 1, Chapter 4

Four mixed ANOVAs (one each for a BPS dimension) revealed significant differences between feminine and masculine instruments in all the BPS dimensions. Specifically, the sogos created using feminine instruments were rated higher in the BPS dimensions of sincerity, competence, and excitement whereas the sogos created using masculine instruments were rated higher in ruggedness (Sincerity: $F(1,92) = 7.54, p = .007, \eta_p^2 = .08; M_{Fem} = 69.76, SD = 16.84; M_{Masc} = 64.29, SD = 16.46$; Competence: $F(1,92) = 16.76, p < .001, \eta_p^2 = .15; M_{Fem} = 68.15, SD = 19.55; M_{Masc} = 56.98, SD = 21.60$; Excitement: $F(1,92) = 25.31, p < .001, \eta_p^2 = .22; M_{Fem} = 63.17, SD = 19.91; M_{Masc} = 49.95, SD = 22.64$; Ruggedness: $F(1,92) = 16.29, p < .001, \eta_p^2 = .15; M_{Fem} = 36.59, SD = 20.45; M_{Masc} = 46.53, SD = 24.27$). No difference in the food category (i.e., chips vs. chocolate) was observed.

Appendix K: Analysis of individual instruments in Study 1, Chapter 4

Although the sample sizes were not adequate for intra-instrument comparisons, we nevertheless provide this analysis for completeness. We further analysed the effect of individual instruments on the BPS dimensions using two multivariate analyses of variance (MANOVA) (one each for feminine and masculine instruments). The type of instrument was a between-participant IV and ratings of the sogos on four BPS dimensions were the DVs.

Within the feminine instruments, the results revealed no differences between instruments for all four dimensions ($ps > .05$) (see Table K.1 and Figure K.1). However, within the masculine instruments, the results revealed variations and significant differences in the BPS dimensions of competence and excitement, while no difference was observed in the sincerity and ruggedness dimensions (Sincerity: $F(4,89) = 2.26, p = .07, \eta_p^2 = .09$; Competence: $F(4,89) = 2.70, p = .04, \eta_p^2 = .11$; Ruggedness: $F(4,89) = 1.44, p = .23, \eta_p^2 = .06$; Excitement: $F(4,89) = 6.34, p < .001, \eta_p^2 = .22$).

Post hoc tests (using Hochberg's GT2 as the sample sizes of each group were different) were conducted to compare the differences between masculine instruments. For the competence dimension, sogos created using a French horn ($M = 72.37, SD = 15.83$) were rated as significantly higher than trombone ($M = 60.39, SD = 16.83, p = .04$) while it did not differ significantly from the other instruments. For the excitement dimension, sogos created using alto sax ($M = 63.19, SD = 17.80$) were rated as significantly higher than the double bass ($M = 44.40, SD = 17.55, p = .03$), trombone ($M = 41.21, SD = 22.66, p = .01$), and tuba ($M = 37.28, SD = 17.48, p = .001$) while it did not differ significantly from French horn ($M = 57.89, SD = 18.90, p = 1$). Also, sogos created using a French horn ($M = 57.89, SD = 18.90$) were rated as

significantly higher than tuba ($M = 37.28$, $SD = 17.48$, $p = .01$) while it did not differ significantly from the other instruments.

These findings suggest that the evaluations of sogos created using feminine instruments did not differ across BPS dimensions between instruments, whereas in sogos created using masculine instruments, there were between-instrument differences in competence and excitement dimensions.

Table K.1*Brand personality dimensions of sogos played by various instruments.*

Instruments	Sincerity	Competence	Ruggedness	Excitement	<i>n</i>
	<i>M (SD)</i>	<i>M (SD)</i>	<i>M (SD)</i>	<i>M (SD)</i>	
<i>Feminine</i>					
English horn	74.93 (13.81)	70.27 (15.49)	37.75 (19.85)	61.92 (17.22)	21
Flute	67.86 (13.81)	63.85 (22.08)	34.29 (19.17)	67.41 (18.89)	22
Harp	74.09 (13.53)	68.85 (15.50)	35.28 (20.29)	60.10 (14.96)	20
Oboe	61.25 (25.21)	62.64 (23.53)	35.45 (22.16)	59.82 (24.49)	11
Violin	64.41 (18.29)	69.50 (19.77)	36.12 (20.57)	61.14 (23.09)	20
<i>Masculine</i>					
Alto saxophone	62.63 (15.06)	53.00 (22.98)	43.83 (20.59)	63.19 (17.80) ^{a,b,c}	18
Double bass	59.45 (13.06)	60.51 (18.50)	42.88 (28.24)	44.40 (17.55) ^a	19
French horn	72.37 (15.83) ^a	62.94 (23.75)	40.51 (24.64)	57.89 (18.90) ^d	21
Trombone	60.39 (16.83) ^a	44.23 (16.46)	56.72 (17.63)	41.21 (22.66) ^b	19
Tuba	62.32 (16.65)	59.61 (17.78)	44.35 (23.73)	37.28 (17.48) ^{c,d}	17

Note. Paired superscripted letters (e.g., a, b) in each column represent the mean difference between instruments in each BPS dimension at $p < .05$. The pairwise comparisons were performed using Hochberg's GT2.

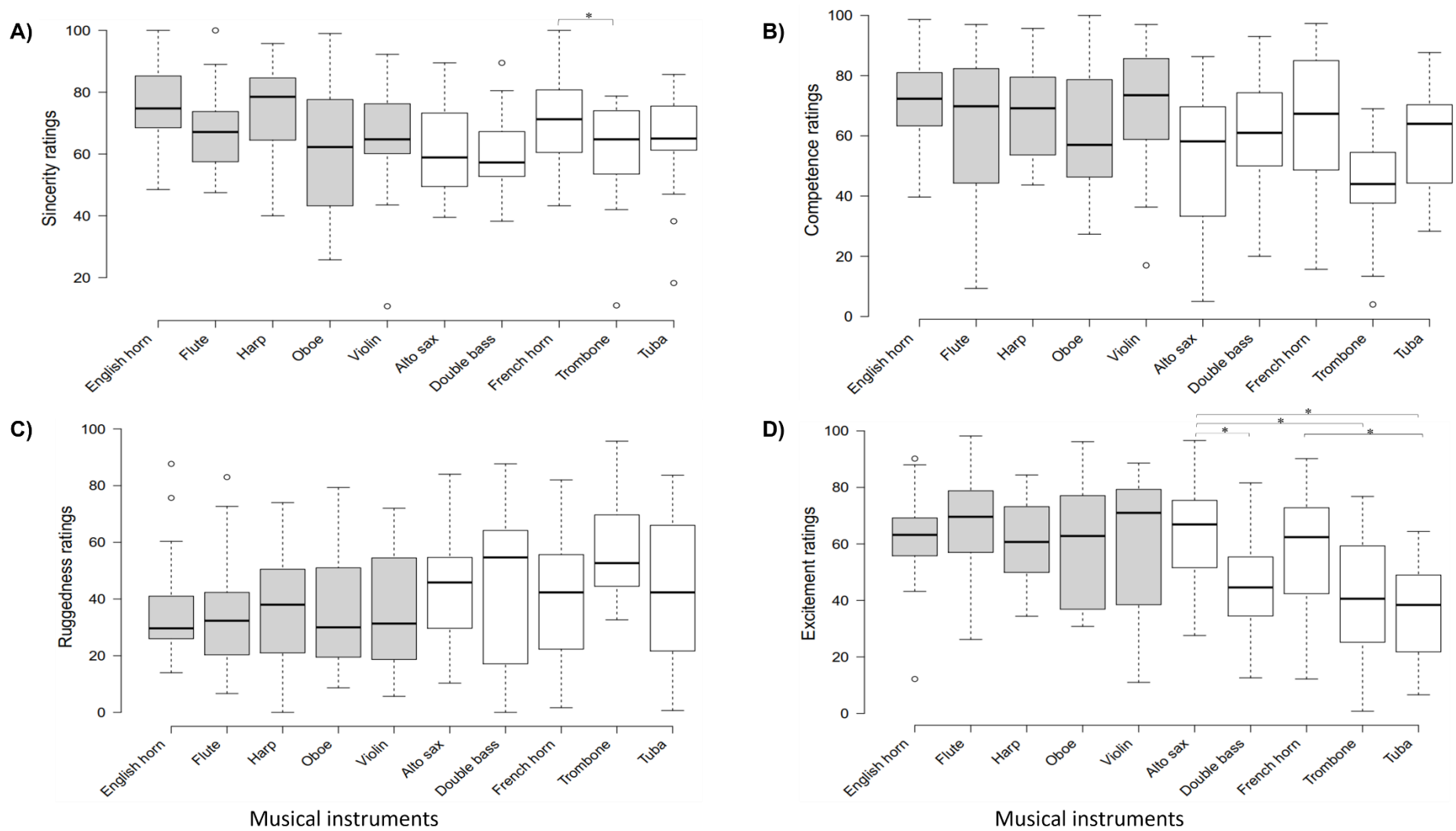


Figure K.1. Box plots illustrate the evaluations of sogs created using different instruments on A) sincerity, B) competence, C) ruggedness, and D) excitement dimensions. Grey boxes represent feminine instruments and white boxes represent masculine instruments. Center lines show the medians; box limits indicate the 25th and 75th percentiles as determined by R software (<http://shiny.chemgrid.org/boxplotr/>); whiskers extend 1.5 times the interquartile range from the 25th and 75th percentiles. Outliers are represented by dots. * $p < .05$.

Appendix L: Measurement validity and reliability for Study 2, Chapter 4

The results of Bartlett's test of sphericity indicated that the correlation matrix was not random, $\chi^2(276) = 1544.64, p < .001$. The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy was .84, which indicated that the data set was meritorious. One item of simple-complex item was removed due to the low MSA ($< .50$). Next, 24 items were submitted for EFA where the principal axis factoring method was used for extraction (Oblimin rotation, Fabrigar & Wegener, 2012). The analysis revealed five factors with Eigenvalues > 1 , which together accounted for 70% of the total variance (see Table L.1 for the factor loadings). The first factor consisted of sad-happy, inhibited-free, bad-good, dangerous-safe, unpleasant-pleasant and ugly-beautiful items that measured valence. The second factor consisted of calming-exciting, round-sharp, mellow-harsh, slow-fast, relaxed-tense, passive-active, and soft-hard items that measured activity. The third factor consisted of light-heavy, small-big, weak-strong, feminine-masculine, and delicate-rugged items that measured potency. The fourth factor consisted of disorganised-structure, realistic-fantastical, nonsolid-solid, and continuous-abrupt items that measured stability. The fifth factor consisted of ordinary-unique and uninteresting-interesting items that measured novelty. Notably, the results indicated five dimensions which are different from the original dimensionality of semantic scales (Sidhu et al., 2022). The reliability of the extracted factors was then estimated (see Table L.1 for the reliability of each dimension).

Table L.1*Factor loadings and reliability estimates for Study 2.*

Factor	Item	Factor loading					Cronbach's alpha
		1	2	3	4	5	
Valence	Inhibited-Free	.831					.92
	Bad-Good	.689					
	Sad-Happy	.554					
	Dangerous-Safe	.545					
	Unpleasant-Pleasant	.524					
	Ugly-Beautiful	.459					
Activity	Calming-Exciting		.814				.87
	Round-Sharp		.798				
	Mellow-Harsh		.703				
	Slow-Fast		.695				
	Relaxed-Tense		.628				
	Passive-Active		.585				
	Soft-Hard		.543				
Potency	Light-Heavy			.718			.77
	Small-Big			.700			
	Weak-Strong			.672			
	Feminine-Masculine			.628			
	Delicate-Rugged			.512			
Stability	Disorganised-Structured				.633		.68
	Fantastical-Realistic				.541		
	NonSolid-Solid				.525		
	Continuous-Abrupt				.467		
Novelty	Ordinary-Unique					.737	.62
	Uninteresting-Interesting					.570	

Appendix M: Results of mixed ANOVAs with normalised data in Study 2, Chapter 4

Five mixed ANOVAs (one each for a semantic dimension) revealed significant differences between feminine and masculine instruments in the dimensions of valence, potency, and stability, but not in activity and novelty. Specifically, the sogos created using feminine (vs. masculine) instruments were associated more with positive valence ($F(1,94) = 18.19, p < .001, \eta_p^2 = .16; M_{Fem} = 71.92, SD = 20.20; M_{Masc} = 57.78, SD = 22.43$), lower potency ($F(1,94) = 115.50, p < .001, \eta_p^2 = .55; M_{Fem} = 41.40, SD = 18.36; M_{Masc} = 69.66, SD = 17.20$) and lower stability ($F(1,94) = 16.51, p < .001, \eta_p^2 = .15; M_{Fem} = 52.25, SD = 13.41; M_{Masc} = 59.11, SD = 12.20$). However, no difference in the activity and novelty dimension was observed (Activity: $F(1,94) = .93, p = .34; M_{Fem} = 43.81, SD = 22.52; M_{Masc} = 46.76, SD = 21.15$; Novelty: $F(1,94) = 1.58, p = .21; M_{Fem} = 59.94, SD = 21.51; M_{Masc} = 55.91, SD = 23.17$). Moreover, no difference in the food category (i.e., chips vs. chocolate) was observed for any of the dimensions.

Appendix N: Analysis of individual instruments in Study 2, Chapter 4

Although the sample sizes were not adequate for intra-instrument comparisons, we nevertheless provide this analysis for completeness. We further analysed the effect of individual instruments on the semantic attributes ratings using MANOVA (one each for sogos created using feminine and masculine instruments). The type of instrument was a between-participant IV and ratings of the sogos on five dimensions were the DVs.

Within feminine instruments, the results revealed significant differences in the activity, potency, and stability dimensions, whereas no difference was observed in the valence and novelty dimensions (see Table N.1 and Figure N.1) (Activity: $F(4,91) = 7.44, p < .001, \eta_p^2 = .25$; Potency: $F(4,91) = 3.01, p = .022, \eta_p^2 = .12$; Stability: $F(4,91) = 4.47, p = .002, \eta_p^2 = .16$; Valence: $F(4,91) = 2.41, p = .055$; Novelty: $F(4,91) = 2.17, p = .079$). Moreover, the results revealed significant differences in the valence, activity, potency, and stability dimensions, whereas no difference was observed in the novelty dimension (Valence: $F(4,91) = 3.54, p = .01, \eta_p^2 = .14$; Activity: $F(4,91) = 8.92, p < .001, \eta_p^2 = .28$; Potency: $F(4,91) = 8.06, p < .001, \eta_p^2 = .26$; Stability: $F(4,91) = 2.56, p = .044, \eta_p^2 = .10$; Novelty: $F(4,91) = .50, p = .736$).

Post hoc tests (using Hochberg's GT2 as the sample size of each group was different) were performed to compare the differences in the activity, potency, and stability dimensions within the feminine instruments. For the activity dimension, sogos created using violin ($M = 58.31, SD = 17.76$) were rated as significantly higher than flute ($M = 40.15, SD = 20.26, p = .035$) and harp ($M = 27.42, SD = 17.16, p < .001$), and sogos created using oboe ($M = 48.58, SD = 24.34$) were rated as significantly higher than harp ($M = 27.42, SD = 17.16, p = .015$). For the potency dimension, sogos created using a flute ($M = 30.62, SD = 11.55$) were rated as significantly lower than a harp ($M = 46.79, SD = 22.40, p = .032$). For the stability dimension,

sogos created using flute ($M = 43.59$, $SD = 7.64$) were rated as significantly lower than harp ($M = 57.28$, $SD = 13.16$, $p = .004$) and violin ($M = 55.68$, $SD = 12.86$, $p = .016$).

We also performed post hoc tests to compare the differences in the valence, activity, potency, and stability dimensions within the masculine instruments. For the valence dimension, sogos created using French horn ($M = 64.99$, $SD = 14.12$) were rated as significantly higher than trombone ($M = 40.32$, $SD = 24.42$, $p = .005$). For the activity dimension, sogos created using the alto saxophone ($M = 60.84$, $SD = 18.79$) were rated as significantly higher than the double bass ($M = 40.07$, $SD = 20.94$, $p = .004$), French horn ($M = 34.11$, $SD = 11.78$, $p < .001$), and tuba ($M = 36.94$, $SD = 17.65$, $p = .001$), and sogos created using trombone ($M = 52.10$, $SD = 19.42$) were rated as significantly higher than French horn ($M = 34.11$, $SD = 11.78$, $p = .023$). For the potency dimension, sogos created using the alto saxophone ($M = 55.57$, $SD = 16.14$) were rated as significantly lower than the double bass ($M = 77.93$, $SD = 12.11$, $p < .001$), French horn ($M = 70.88$, $SD = 14.28$, $p = .005$), trombone ($M = 74.19$, $SD = 15.66$, $p = .001$), and tuba ($M = 74.23$, $SD = 13.60$, $p = .002$). For the stability dimension, sogos created using a trombone ($M = 63.28$, $SD = 7.22$) were rated as significantly higher than tuba ($M = 51.47$, $SD = 14.14$, $p = .044$).

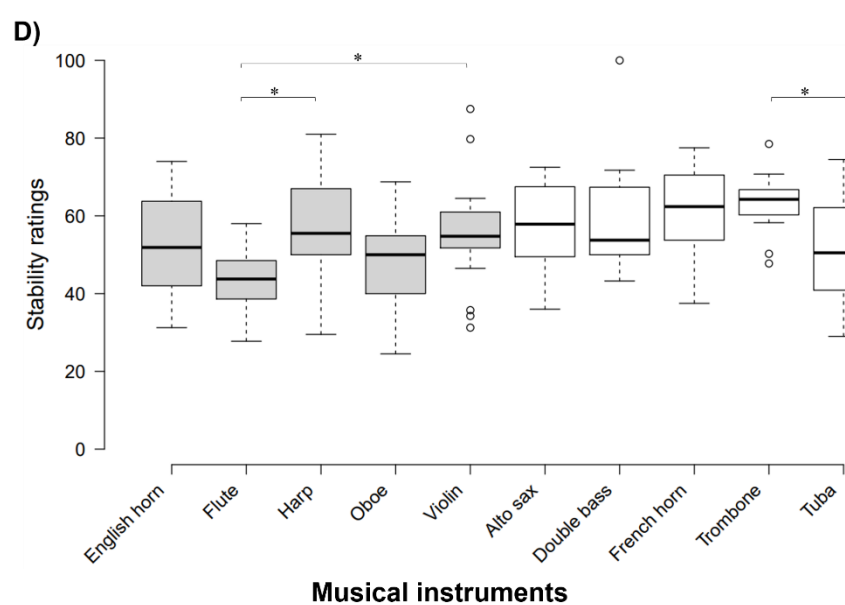
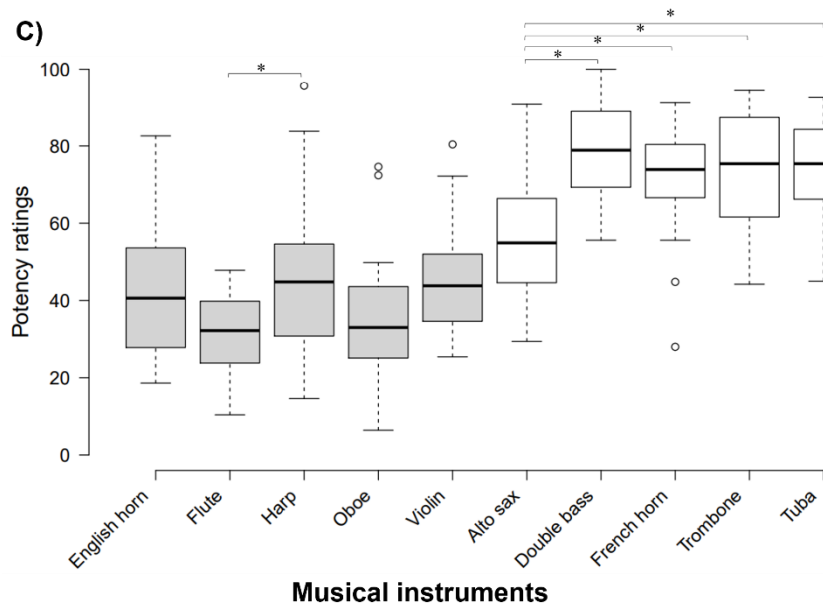
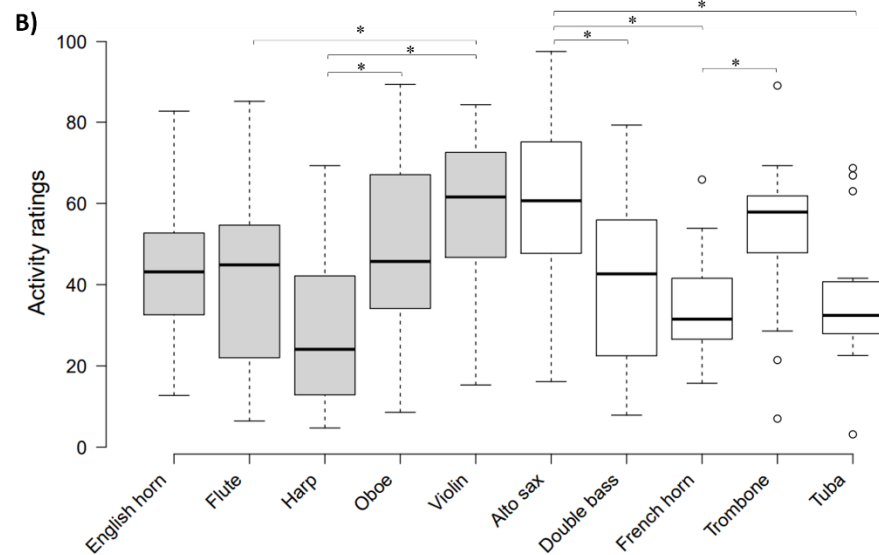
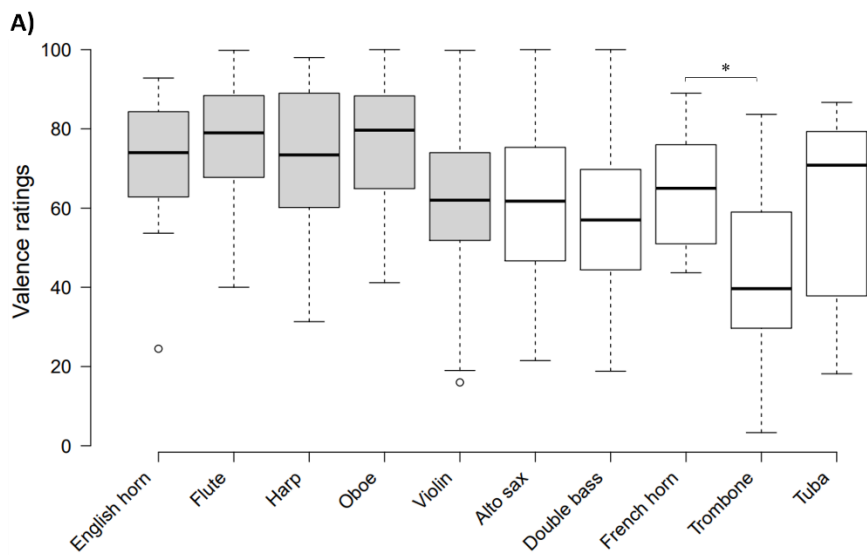
These findings suggest that the evaluations of sogos created using feminine and masculine instruments differed between-instruments in the semantic dimensions except in the novelty dimension.

Table N.1

The post hoc tests comparing the ratings of sogos created using different instruments on the semantic dimensions used in Study 2.

Instruments	Valence <i>M (SD)</i>	Activity <i>M (SD)</i>	Potency <i>M (SD)</i>	Stability <i>M (SD)</i>	Novelty <i>M (SD)</i>	<i>n</i>
<i>Feminine</i>						
English horn	71.67 (16.49)	41.52 (18.21)	41.73 (16.94)	52.26 (12.51)	53.03 (21.16)	18
Flute	77.11 (14.98)	40.15 (20.26) ^a	30.62 (11.55) ^a	43.59 (7.64) ^{a,b}	60.82 (17.31)	19
Harp	72.73 (19.89)	27.42 (17.16) ^{b,c}	46.79 (22.40) ^a	57.28 (13.16) ^a	62.73 (23.68)	22
Oboe	76.08 (19.19)	48.58 (24.34) ^c	36.47 (18.91)	47.63 (12.21)	69.27 (21.55)	15
Violin	60.71 (22.77)	58.31 (17.76) ^{a,b}	45.38 (13.40)	55.68 (12.86) ^b	52.20 (17.64)	22
<i>Masculine</i>						
Alto saxophone	58.83 (21.39)	60.84 (18.79) ^{a,b,c}	55.57 (16.14) ^{a,b,c,d}	57.29 (10.40)	52.58 (23.53)	26
Double bass	58.21 (21.15)	40.07 (20.94) ^a	77.93 (12.11) ^a	59.08 (14.42)	57.06 (16.73)	16
French horn	64.99 (14.12) ^a	34.11 (11.78) ^{b,d}	70.88 (14.28) ^b	61.30 (10.91)	51.70 (24.51)	22
Trombone	40.32 (24.42) ^a	52.10 (19.42) ^d	74.19 (15.66) ^c	63.28 (7.22) ^a	55.94 (22.50)	17
Tuba	60.50 (25.97)	36.94 (17.65) ^c	74.23 (13.60) ^d	51.47 (14.14) ^a	61.10 (24.36)	15

Note. Paired superscripted letters (e.g., a, b) in each column represent mean difference between instruments in each dimension at $p < .05$. The pairwise comparisons were performed using Hochberg's GT2.



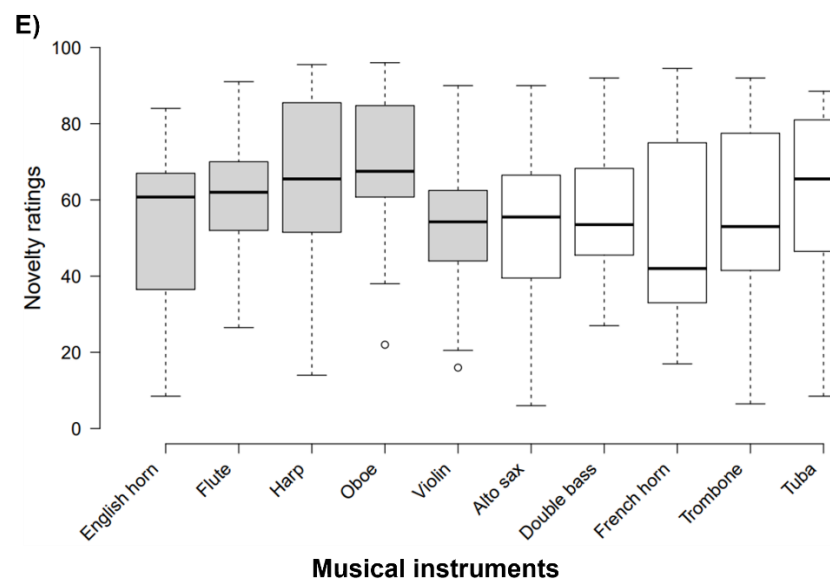


Figure N.1. Box plots illustrate the evaluations of sogos created using different instruments on A) valence, B) activity, C) potency, D) stability, and E) novelty dimensions. Grey boxes represent feminine instruments and white boxes represent masculine instruments. Center lines show the medians; box limits indicate the 25th and 75th percentiles as determined by R software (<http://shiny.chemgrid.org/boxplotr/>); whiskers extend 1.5 times the interquartile range from the 25th and 75th percentiles. Outliers are represented by dots. * $p < .05$.

Appendix O: Pretest for sogos used in Study 3, Chapter 4

This pretest aimed to verify that all the melodies used in Study 3 and replicate studies (Appendices P and Q) were equivalent in pleasantness, likability, and familiarity. To improve the generalisability of the study, the melodies followed the character of commercial sogos, which normally comprised of five notes (Anzenbacher, 2016) in a wave-like melodic pattern (i.e., notes up, down, and up and vice versa) (SoundOut, 2021). We generated 12 random melodies played on a piano and comprised of notes from C4 to B4 using *Random Music Generator* online software (<https://random-music-generators.herokuapp.com/melody>) and *Noteflight* (<https://www.noteflight.com>). Loudness was normalised to standard perceived loudness (-15 LUFS) using *Audacity* (<https://www.audacityteam.org/>).









50 participants (*Males* = 24, *Females* = 22, gender unspecified = 2; M_{age} = 36.24 years, SD = 8.29, age range = 24-60 years) took part in this study. They were asked to listen to 12 different sogos randomly and evaluated them on pleasantness, likability, and familiarity on a VAS scale (0 = Not at all, 100 = Very much). Next, we performed statistical analyses to select the melodies that did not differ in pleasantness, likability, and familiarity for 3 studies (Study 3a, 3b, and a replicate study) (see Table O.1).

Study 3. A series of repeated measures analyses (one for each attribute) revealed that there were four melodies that did not differ in any of the attributes (pleasantness: $F(3,147) = 2.21, p = .09$); likability: $F(3,147) = .70, p = .55$; familiarity: $F(2.46,120.46) = 1.63, p = .20$).

Replicate study A. Paired t -tests (one for each attribute) revealed that the other two melodies did not differ in any of the attributes (pleasantness: $t(49) = .86, p = .39$; likability: $t(49) = .23, p = .82$; familiarity: $t(49) = .13, p = .89$).

Replicate study B. Paired *t*-tests revealed that the other two melodies were not different in all the attributes (pleasantness: $t(49) = .28, p = .78$; likeability: $t(49) = .27, p = .79$; familiarity: $t(49) = 1.32, p = .19$).

Table O.1
Descriptive statistics of the melody's evaluations in the pretest.

Study	Melodic notes	Likability	Pleasantness	Familiarity
		<i>M (SD)</i>	<i>M (SD)</i>	<i>M (SD)</i>
Study 3		43.34 (26.85)	41.82 (29.49)	35.22 (31.97)
		42.84 (26.16)	41.94 (26.46)	28.90 (29.62)
		44.62 (26.92)	41.82 (27.01)	32.84 (30.29)
		46.10 (22.52)	47.78 (27.34)	35.02 (30.09)
Replicate study A		38.36 (26.23)	38.30 (28.00)	29.86 (29.83)
		38.96 (26.62)	41.22 (28.05)	29.48 (27.29)
Replicate study B		45.38 (25.56)	46.22 (26.83)	34.10 (30.19)
		44.72 (24.54)	45.22 (24.13)	31.32 (29.99)

Appendix P: Replicate Study A, Chapter 4

In Study 3, we provided convergent evidence that when the instrument type semantically matched (vs. mismatched) the brand personality, it enhanced consumer purchase intention through the underlying perceived congruency. This study aimed to demonstrate that the effect of instrument type on purchase intention (driven by the perceived congruency) would be modulated by the brand personality. Trombone was selected for a masculine instrument and English horn for feminine. Given the power = 95% and $\alpha = .05$ to detect a medium-sized effect ($\approx .25$) in ANOVA, the size of $N \approx 210$ was determined.

1. Participants

222 participants took part in this study. Data of twelve participants were discarded: three provided the same response for all the questions and nine spent > 2 SD of the average completion time. The data of one outlier were also discarded. The data of 209 participants (*Male* = 103, *Female* = 105, Unspecified gender = 1; Age range = 22-81 years, $M = 43.81$, $SD = 12.72$) were retained and normalised for further analyses.

2. Design and procedure

A 2 (instrument: masculine vs. feminine) x 2 (brand personality: rugged vs. sincere) mixed design was used where the instrument type was the within-participant factor and brand personality was the between-participant factor. To manipulate the brand personality, we created two versions of adverts for gloves adapted from a previous study (Sundar & Noseworthy, 2016) and the adverts consisted of two key contrasting qualities, ruggedness vs. sincerity (Aaker, 1997; Maehle et al., 2021; Puligadda & VanBergen, 2023; Sundar & Noseworthy, 2016). Participants were randomly assigned to either of the following conditions-

The rugged personality condition. *“YULE is made for a masculine consumer. The YULE brand is considered tough, strong, and daring brand. This durable brand promises an outdoorsy experience. YULE is a leading maker of gloves and apparel. Since its first year of operation in 1995, YULE has forged a close relationship with one of the world’s largest apparel companies. As a result, many long-lived gloves are now made exclusively by YULE!”*

The sincere personality condition. *“YULE is made for a heartfelt consumer. The YULE brand is considered candid, honest, and sensible brand. This practical brand promises a fulfilling experience. YULE is a leading maker of gloves and apparel. Since its first year of operation in 1995, YULE has forged a close relationship with one of the world’s largest apparel companies. As a result, many long-lived gloves are now made exclusively by YULE!”*

Participants who failed the attention check for the advertised product were filtered out of the experiment. They were then instructed to listen to slogans presented with each advert and rated their purchase intention for gloves on a VAS scale (0 = Not buy it at all, 100 = Definitely buy it) and perceived congruency on an 8-point graphical scale (1 = Far apart, 8 = Complete overlap) (Bergami & Bagozzi, 2000; Motoki et al., 2023). Participants also responded to the questions on manipulation check at the end of the experiment.

3. Statistical analyses

A series of mixed ANOVAs were used to test the effect of the instrument and brand personality on purchase intention and perceived congruency, followed by mediation analyses to test whether the perceived congruency mediates the interaction effect of instrument type and brand personality on purchase intention.

3.1. Results of the effect of instrument type and brand personality

Manipulation check. A paired *t*-test revealed that the trombone was significantly rated as more masculine and the English horn as more feminine ($t(208) = 17.03, p < .001, d = 1.18; M_{trombone} = 26.12, SD = 21.61, M_{horn} = 55.93, SD = 20.27$). An independent *t*-test revealed that the glove with a rugged personality was significantly rated as more rugged and one with a sincere personality as more sincere ($t(203.801) = 4.71, p < .001, \text{Hedge's } g^1 = .65; M_{rugged} = 43.51, SD = 28.96, N = 109, M_{sincere} = 60.60, SD = 23.40, N = 100$).

Purchase intention. The results revealed that there were no main effects of instrument type and brand personality on purchase intention (Instrument: $F(1,207) = 3.67, p = .06$; Brand personality: $F(1,207) = .31, p = .58$). However, the significant interaction effect of instrument type and brand personality was observed ($F(1,207) = 9.36, p = .003, \eta_p^2 = .04$). Specifically, when the gloves had a rugged personality, purchase intention was significantly higher when the advert was presented with masculine than feminine instruments ($t(108) = 4.11, p < .001, d = .39; M_{masc} = 44.21, SD = 27.81, M_{fem} = 35.76, SD = 27.21$). However, it did not differ in the sincere personality condition ($t(99) = 1.18, p = .24; M_{masc} = 39.24, SD = 27.89, M_{fem} = 41.98, SD = 26.48$).

Perceived congruency. The results showed the significant main effect of instrument type on perceived congruency ($F(1,207) = 4.61, p = .03, \eta_p^2 = .02$), although there was no main effect of brand personality ($F(1,207) = 2.09, p = .15$). Specifically, masculine (vs. feminine) instrument was perceived significantly as more congruent with gloves ($M_{masc} = 3.73, SD = 1.91, M_{fem} = 3.41, SD = 1.80$). Further, the significant interaction effect of instrument type and brand personality was observed ($F(1,207) = 23.85, p < .001, \eta_p^2 = .10$). Specifically, when the gloves

¹ Due to the difference in sample sizes

had a rugged personality, the masculine instrument was perceived as more congruent than the feminine counterpart ($t(108) = 5.60, p < .001, d = .54; M_{trombone} = 4.23, SD = 2.00, M_{horn} = 3.25, SD = 1.72$). However, when the gloves had a sincere personality, the feminine instrument was perceived as more congruent at a marginally significant level ($t(99) = 1.97, p = .05, d = .20; M_{trombone} = 3.21, SD = 1.70, M_{horn} = 3.62, SD = 1.90$).

3.2. Results of the mediation analysis

A moderated mediation analysis (MEMORE macro, Model 15, Montoya, 2022) was conducted where the instrument type was used as the IV (0 = masculine, 1 = feminine), brand personality as the moderator (0 = rugged, 1 = sincere), perceived congruency as the mediator, and purchase intention as the DV. The results revealed a significant index of moderated mediation = -6.24, $SE = 1.58, 95\% CI [-9.57, -3.44]$ with 5000 bootstrapped samples (see Figure P.1). There were significant indirect effects when the gloves had a rugged personality ($b = 4.36, SE = 1.07, 95\% CI [2.51, 6.72]$) but not a sincere personality ($b = -1.88, SE = 1.02, 95\% CI [-3.97, 0]$). The direct effect of instrument type on purchase intention was not significant ($b = 1.59, SE = 1.42, t(206) = 1.12, p = .26, 95\% CI [-1.20, 4.38]$) (see Table P.1). This suggests that when the gloves were advertised as rugged and with a sogo created in the masculine instrument, the ruggedness of the sogo matched that of the gloves (i.e., it was perceived as congruent) and it resulted in a higher purchase intention. However, this effect was not observed when the gloves with sincerity were advertised with a sogo created in the feminine instrument.

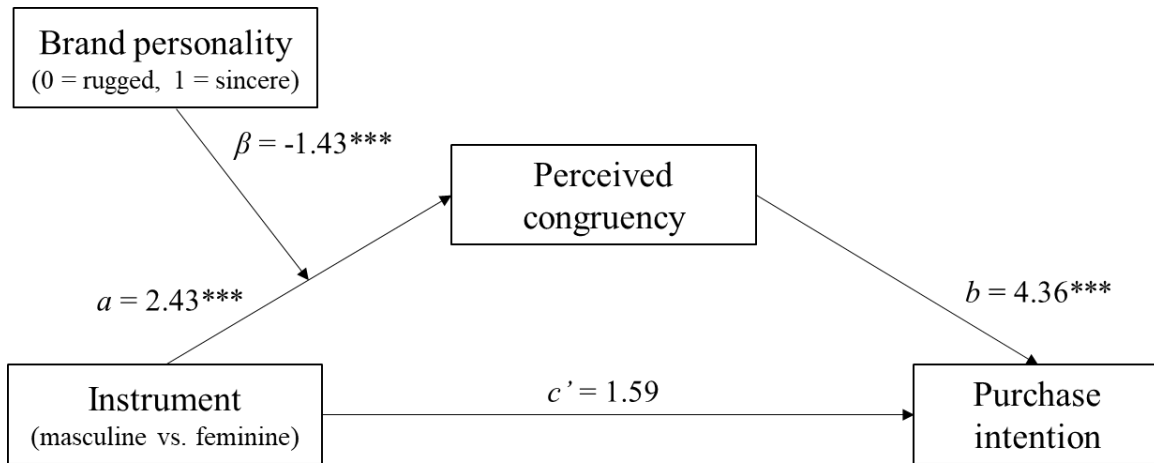


Figure P.1. The figure illustrates the indirect effect of instrument type on purchase intention through perceived congruency moderated by brand personality in Replicate study A. *** $p < .001$.

4. Discussion

This study examined the influence of instrument type and brand personality on purchase intention using products within a category. The results supported Study 3 demonstrating that when a product was advertised with a brand personality that matched (vs. mismatched) the instrument type, consumers perceived them as congruent leading to enhanced purchase intention. Specifically, this effect was more pronounced in masculine-rugged association than in feminine-sincerity association. This is possibly due to the product category interfering with the perception of brand personality. Gloves could generally be related to outdoor sports (i.e., rugged and tough), such that a feminine instrument was not perceived as congruent with the gloves even when it was advertised as sincere.

Table P.1*Results of moderated mediation analysis and mediation analyses.*

Variable	<i>b</i>	BootSE	BootLLCI	BootULCI		
Instrument x Brand → Congruency → Purchase intention	-6.24	1.58	-9.57	-3.44		
Instrument → Congruency → Purchase Intention						
Ruggedness	4.36	1.07	2.51	6.72		
Sincerity	-1.88	1.02	-3.97	0.00		
	<i>b</i>	<i>SE</i>	<i>t</i>	<i>p</i>	LLCI	ULCI
Instrument → Congruency						
Ruggedness	1.00	.19	5.36	< .001	.63	1.37
Sincerity	-.43	.22	-1.92	.06	-.88	.02
Congruency → Purchase intention						
Ruggedness	3.89	1.03	3.77	< .001	1.84	5.94
Sincerity	4.29	.88	4.85	< .001	2.53	6.04
Instrument → Purchase intention						
Ruggedness	4.59	2.23	2.06	.04	.16	9.01
Sincerity	-1.20	1.99	-.60	.55	-5.15	2.75

Appendix Q: Replicate Study B, Chapter 4

This study investigated the influence of instruments on brand personality in a different context. Specifically, we measured the effect of perceived congruency of the instrument type and personality on the purchase intention of board games (string instruments were used, double bass for masculine instruments and harp for feminine). Following prior research, an action game was used as the rugged product (Melzner & Raghurir, 2022) and a family game as a sincere one (family and childhood memories have been shown to be strongly associated with sincerity; Maehle et al., 2011).

1. Participants

110 participants took part in the study. Data of nine participants were discarded – eight participants spent > 2SD of the average time taken to complete the task and one outlier was detected. The final data of 101 participants (*Male* = 60, *Female* = 41; Age range = 19-70 years, *M* = 38.64, *SD* = 11.40) were used for further analyses.

2. Design and procedure

A 2 (instrument: masculine vs. feminine) x 2 (game: action vs. family) mixed design was used where the instrument was the within-participant factor and game type was the between-participant factor. To manipulate the game personality, we adapted scenarios from a previous study (Melzner & Raghurir, 2022). Participants were randomly assigned to either of the following conditions.

The rugged personality condition. *“Imagine that the birthday of your friend is coming up and he/she is into board games. Your friend loves action games; that is, games that involve fast reactions to surprising turns of events and physical activity.”*

The family game condition. “*Imagine that the birthday of your friend is coming up and he/she is into board games. Your friend loves family games; that is, games that involve cooperation and childhood nostalgia.*”

For the attention check, participants were asked to identify which product they were buying for a friend, and those who failed the attention check were not allowed to continue further. Participants then listened to the slogans in random order and rated how likely would they buy the game for their friend (on a VAS scale from 0 = Not buy it at all to 100 = Definitely buy it). Subsequently, they rated to what extent the slogans and products are congruent using an 8-point graphical scale (1 = Far apart, 8 = Complete overlap) (Bergami & Bagozzi, 2000; Motoki et al., 2022) similar to Study 3. Finally, they rated the masculinity vs. femininity, pleasantness and ruggedness vs. sincerity of slogans (slogans: 0 = Very masculine, 100 = Very feminine; pleasantness: 0 = Not pleasant at all, 100 = Very pleasant; brand personality: 0 = Very rugged, 100 = Very sincere).

3. Statistical analyses

A series of mixed ANOVAs were used to test the effect of instrument and game type on purchase intention and perceived congruency, followed by a mediation analysis to test whether perceived congruency mediates this relationship.

3.1. Results of the effect of instrument and game type

Manipulation check. A paired *t*-test revealed that the pleasantness did not differ between masculine and feminine instruments ($t(100) = 1.57, p = .12; M_{\text{masc}} = 41.18, SD = 27.39, M_{\text{fem}} = 51.03, SD = 25.08$), indicating that the effect of pleasantness was ruled out. Further, the double bass was rated as significantly more masculine and the harp as more feminine ($t(100) = 3.40, p$

= .001, $d = .34$; $M_{bass} = 31.26$, $SD = 25.83$, $M_{harp} = 41.20$, $SD = 23.93$) and action game was rated as significantly more rugged and family one as more sincere ($t(96.72) = 6.81$, $p < .001$, Hedge's $g^2 = 1.33$; $M_{action} = 38.69$, $SD = 27.76$, $N = 54$, $M_{family} = 71.60$, $SD = 20.63$, $N = 47$).

Purchase intention. The result showed that the main effect of instrument type ($F(1,99) = .76$, $p = .39$) and game type were not observed ($F(1,99) = .08$, $p = .78$). Moreover, the interaction between the instrument and game type was significant ($F(1,99) = 6.89$, $p = .01$, $\eta_p^2 = .07$). Specifically, purchase intention was significantly higher when the action game was presented with masculine instrument (vs. feminine) ($t(53) = 2.33$, $p = .02$, $d = .32$; $M_{masc} = 48.43$, $SD = 27.31$, $M_{fem} = 41.50$, $SD = 29.59$). However, purchase intention for the family game did not differ between instruments ($t(46) = 1.37$, $p = .18$; $M_{masc} = 44.72$, $SD = 29.27$, $M_{fem} = 48.19$, $SD = 28.36$).

Perceived congruency. The results revealed that although there was no main effect of the instrument type ($F(1,99) = .25$, $p = .62$), the effect of game type was significant ($F(1,99) = 8.89$, $p = .004$, $\eta_p^2 = .08$; $M_{action} = 3.97$, $SD = 1.55$, $M_{family} = 2.98$, $SD = 1.80$). Specifically, the action game was perceived as significantly higher in perceived congruency than the family game. Moreover, the interaction effect of the instrument and game type was significant ($F(1,99) = 4.78$, $p = .03$, $\eta_p^2 = .05$). Specifically, the masculine instrument was perceived as significantly more congruent with the action than the family game ($t(99) = 3.71$, $p < .001$, Hedge's $g = .74$; $M_{action} = 4.28$, $SD = 2.10$, $N = 54$, $M_{family} = 2.79$, $SD = 1.91$, $N = 47$), whereas feminine instrument did not differ in perceived congruence with action and family game ($t(99) = 1.23$, $p = .22$, Hedge's $g = .25$; $M_{action} = 3.67$, $SD = 1.91$, $N = 54$, $M_{family} = 3.17$, $SD = 2.16$, $N = 47$).

² Due to the difference in sample sizes

3.2. Results of the mediation analysis

Similar to Study 3, we first created the matched vs. mismatched conditions to examine the underlying mechanism of perceived congruence. The matched condition was the action (family) game advertised with the masculine (feminine) instrument, and the opposite of it was the mismatched condition. A mediation analysis (MEMORE macro, Model 1; Montoya & Hayes, 2017) was performed where the matched and mismatched conditions were the IVs, purchase intention was the DV and perceived congruency was the mediator. The indirect effect of the perceived congruence was estimated using 95% percentile bootstrap intervals with 5000 bootstrap samples.

The results revealed that the direct effect of the conditions on purchase intention was significant ($b = 3.86$, $SE = 1.93$, $t(98) = 2.00$, $p = .048$) (see Figure 3). The indirect effect of the conditions on brand attitude through perceived congruency was significant ($b = 1.45$, $SE = .85$, 95% CI [.13, 3.49]). Specifically, when the instruments were matched with the game type, they were perceived as more congruent ($b = .51$, $SE = .23$, $t(100) = 2.24$, $p < .028$), and the perceived congruency was positively related to purchase intention ($b = 2.88$, $SE = .84$, $t(98) = 3.43$, $p = .001$). This indicated that the perceived congruency mediated the match between the instrument and game type on purchase intention.

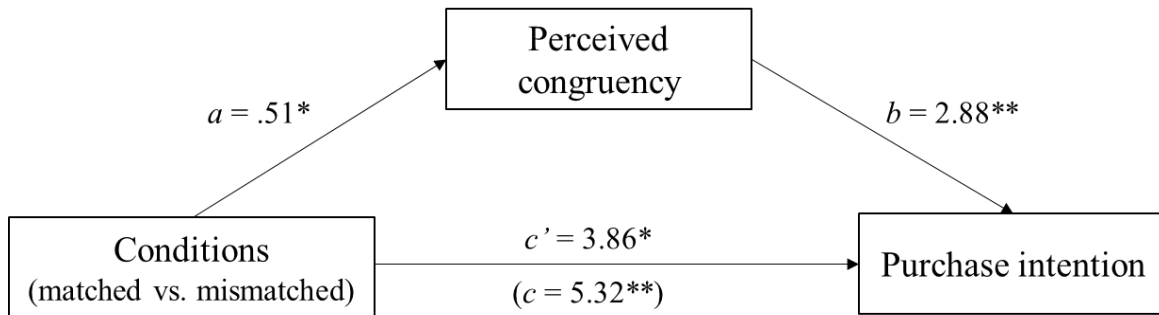


Figure Q.1. The figure illustrates the mediating effect of perceived congruency on the relationship between the matched vs. mismatched conditions on purchase intention. * $p < .05$, ** $p < .01$, *** $p < .001$.

4. Discussion

This study investigated the influence of instrument and brand personality on purchase intention in contexts different from Study 3 and replicated Study A (string instruments were used to create sogos and board games were stimuli). Consistent with Study 3, when the instrument with which sogos were created matched the brand personality of the product, it could enhance the perceived congruency of brand elements (i.e., sogos and product type), which in turn led to a higher purchase intention of the advertised product. Specifically, participants were more likely to buy the board game for their friend when the action (rugged) game was advertised with a sogo played by masculine instruments than feminine ones. However, a similar purchase intention was not found in the family (sincere) game. The differential effect between game types was possibly derived from the experimental procedure, which manipulated game type as the between-participant factor and the small sample size for the factor could also have led to these effects.