EXPLORING SONIC SEASONING: THE INFLUENCE OF BACKGROUND MUSIC ON THE CHARACTERISTICS OF WINE

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MAY, 2025

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Thesis
Submitted in Partial Fulfillment of the
Requirements for the Degree of

Master of Science

in
Design, Technology, and Society

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May, 2025

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This thesis is dedicated to my family, past and present; thank you for their promise, inspiration, and belief in me.

DECLARATION OF ORIGINALITY

I hereby declare that I am the sole author of this thesis and that this is the true copy of my thesis, including the final revisions, approved by my thesis committee. All data and information have been obtained, produced, and presented in accordance with the rules of research ethics and principles of academic honesty. As required by these rules, to the best of my knowledge I have acknowledged ideas, thoughts, and any copyrighted material in accordance with the standard referencing rules. I certify that any part of this thesis has not been submitted for a degree or diploma in another educational institution.

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ABSTRACT

This study investigates the influence of background music on the sensory and hedonic evaluation of Turkish red wine (Kalecik Karası). In a controlled experiment, 39 Gastronomy students assessed the same wine under three conditions: silence (control), Tchaikovsky's Waltz of the Flowers, and Mussorgsky's A Night on Bald Mountain. Participants evaluated the wine by rating its acidity, tannin, body, and overall liking, while also judging the music's likeability and its perceived congruence with the wine. Results indicate that Waltz of the Flowers does not significantly alter ratings of acidity, tannin, or body, although it is consistently associated with a mellow, refined character. In contrast, A Night on Bald Mountain increases perceived tannin levels by 9% without substantially affecting acidity or body. Moreover, the hedonic response to the wine moderates these effects: participants who favor the wine under the more intense musical condition report an 8% increase in perceived body and a 7% increase in tannin. Acidity remains unaffected across all conditions. This study represents the first investigation conducted in Turkey to explore how culturally universal music is employed to influence wine perception. The findings align with previous work suggesting that darker, more dynamic music can enhance certain wine attributes, and they offer strategic insights for optimizing wine presentation in restaurants, bars, and wineries, as well as for developing targeted marketing strategies.

Keywords: Gastrophysics, sonic seasoning, sensory marketing, wine tasting, crossmodal effects

ÖZET

Bu çalışma, arka plan müziğinin Türk kırmızı şarabı (Kalecik Karası) üzerindeki duyusal ve hedonik değerlendirme etkisini araştırmaktadır. Kontrollü bir deneyde, 39 Gastronomi öğrencisi aynı şarabı üç koşul altında değerlendirmiştir: sessizlik (kontrol), Tchaikovsky'nin *Waltz of the Flowers* eseri ve Mussorgsky'nin *A Night on Bald Mountain* eseri. Katılımcılar, şarabın asidite, tanen, gövde ve genel beğeni düzeylerini puanlamış; ayrıca müziğin beğenilirliğini ve şarapla olan algısal uyumunu değerlendirmiştir. Sonuçlar, *Waltz of the Flowers* eserinin asidite, tanen veya gövde puanlamalarını anlamlı biçimde değiştirmediğini göstermektedir; bununla birlikte bu eser, tutarlı bir şekilde yumuşak ve rafine karakterle ilişkilendirilmiştir. Buna karşılık, *A Night on Bald Mountain* parçası, şarabın algılanan tanen seviyesini %9 oranında artırmakta, ancak asidite ya da gövde üzerinde belirgin bir etki göstermemektedir. Dahası, bu etkiler şaraba yönelik hedonik tepkiyle de değişmektedir: yoğun müzikal koşul altında şarabı daha çok beğenen katılımcılar, algılanan gövdede %8 ve tanende %7 oranında artış bildirmiştir. Asidite, tüm koşullar boyunca sabit kalmıştır. Bu çalışma, Türkiye'de kültürel olarak evrensel kabul edilen müziğin şarap algısı üzerindeki etkilerini inceleyen ilk araştırmadır. Bulgular, daha önceki araştırmalarla örtüşmektedir: karanlık ve dinamik müzikler, şarabın bazı yapısal özelliklerini güçlendirebilmektedir. Bu durum, restoran, bar ve şaraphane gibi ortamlarda şarap sunumunu optimize etmeye yönelik stratejik içgörüler sunmakta; aynı zamanda hedefli pazarlama stratejilerinin geliştirilmesine katkı sağlamaktadır.

Anahtar Kelimeler: Gastrofizik, işitsel tatlandırma, duyusal pazarlama, şarap tadımı, duyulararası etkileşimler

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1. INTRODUCTION

1.1 Background and Motivation

My interest in this topic began on a winter day in the mountains while I was savoring a vintage Dom Perignon at a lively party. Despite its renowned quality, the champagne tasted unexpectedly flat. Initially, I suspected factors such as serving temperature or unsuitable food pairings, yet none adequately explained the diminished flavor. This anomaly led me first to gastrophysics—a field that explores how multisensory cues shape our culinary experiences—and ultimately to the concept of sonic seasoning, the idea that specific sounds or music can enhance or suppress certain flavor attributes in food and beverages.

Gastrophysics provides a compelling framework for understanding these phenomena. Research in this field has demonstrated that ambient noise, visual cues, and even tactile sensations can significantly alter our perception of taste and enjoyment (Spence, 2021). Such insights naturally extend to beverages, raising a fundamental question: if auditory stimuli can modify the taste of simple foods, how might they interact with a beverage as complex as wine?

Wine is far more than just a drink; it is a cultural and social cornerstone, integral to celebrations, intimate gatherings, and even solitary moments of reflection (Ravenscroft & Van Westering, 2001). Its sensory profile; encompassing taste, aroma, texture, and visual appeal, is dynamically influenced by the environment in which it is consumed (Yuan et al., 2024). In most wine-drinking settings, music, conversation, and ambient sounds are constant companions, suggesting that these auditory elements could play a significant role in shaping the wine-tasting experience.

Over the past decade, research has increasingly focused on the interplay between sensory modalities in culinary contexts (Reinoso-Carvalho et al., 2020; Piqueras-Fiszman, 2014). However, while much attention has been given to how sound influences food perception, the connection between auditory stimuli and wine remains less explored. Addressing this gap is essential not only for advancing our scientific understanding but also for refining marketing strategies and enhancing consumer experiences within the wine industry. Notably, no similar research has been conducted in Turkey, and there is a lack of studies examining Turkish wines in this context. Although previous studies have demonstrated the impact of music on wine perception in various European contexts, the effects on Turkish consumers remain unexplored. Existing research has not addressed whether the same crossmodal mechanisms apply to local wines and local consumer profiles. This study fills that gap by investigating how Turkish consumers respond to music during wine tasting, using both foreign musical stimuli and a Turkish wine with a distinct sensory profile.

This thesis investigates crossmodal correspondences and the systematic associations between sensory attributes, focusing on how sound interacts with wine characteristics (Spence, 2022). Specifically, it examines the influence of sonic seasoning on the perception of tannins, with particular attention to attributes such as body and astringency. Music can shape expectations prior to tasting and modulate sensory perception during consumption, potentially transferring its emotional qualities onto the wine itself. By bridging the domains of sensory marketing and gastrophysics, this research aims to offer both theoretical insights and practical applications. A deeper understanding of how auditory stimuli affect wine perception can help producers, marketers, and restaurateurs design more engaging and memorable tasting experience.

1.2 Purpose of the Study

The purpose of this study is to investigate whether music, as an external auditory stimulus, influences the perception of key mouthfeel attributes—specifically acidity, astringency, and body—and to explore how participants' liking of the music interacts with these attributes. By addressing this gap, the research aims to provide deeper insights into the potential of music to shape sensory perception and enrich the multisensory wine experience, both within the Turkish market and in a broader cross-cultural context. More specifically, the study (1) seeks to determine how background music influences specific wine attributes such as acidity, tannin, and body, and (2) assesses whether different music genres alter hedonic evaluations, thereby shaping the wine's overall character.

From a sensory perspective, taste is the primary factor influencing consumers' decisions on whether to drink wine (Bruwer, Saliba, & Miller, 2011). Consumers have historically consumed wine not only for hedonic pleasure but also to experience the wide spectrum of sensations it offers—a complexity stemming from the interplay of numerous intrinsic and extrinsic factors that shape its overall sensory profile (Yang & Lee, 2020). In fact, studies indicate that millennials particularly prioritize taste as the main reason for their wine consumption, while non-drinkers often cite dislike of its taste as a decisive factor (Castellini & Samoggia, 2018).

Given the central role of taste, any external influence capable of altering taste perception becomes crucial in shaping consumer experience and preference. In this context, mouthfeel—a composite of tactile sensations such as acidity, astringency, and body—plays a pivotal role in how wine is perceived and evaluated (Niimi et al., 2017). Understanding the interaction between these attributes and external factors, such as music, is essential for advancing our knowledge of multisensory wine experiences.

Notably, while numerous studies have investigated how auditory stimuli affect food perception, research on the impact of music on wine tasting remains limited. Moreover, no similar study has been conducted in Turkey, and there is a complete absence of research focusing on Turkish wines in this context. From a cross-cultural perspective, it is critical to examine whether music carries universal emotional cues that can modulate taste perception similarly across diverse consumer groups, including Turkish consumers, or if cultural nuances lead to different sensory outcomes.

1.3 Structure of Thesis

This thesis is organized into six chapters. Chapter 1 introduces the research background, rationale, and objectives. Chapter 2 outlines the conceptual foundations of gastronomy, neurogastronomy, and gastrophysics, setting the interdisciplinary context for the study. Chapter 3 explores the influence of music and sound on taste perception, including discussions on background noise, music, and the concept of sonic seasoning. Chapter 4 provides theoretical and methodological perspectives, with a particular focus on crossmodal correspondences, emotional mediation, and sensation transference. Chapter 5 presents the experimental study, detailing the design, procedure, and statistical results related to the influence of background music on wine perception. Chapter 6 concludes the thesis with key findings, implications for the wine and hospitality industries, and suggestions for future research.

2. DEFINING GASTRONOMY AND FOOD SCIENCES

2.1 Gastronomy - Definition and Historical Roots

The word "gastronomy" comes from the ancient Greek terms "gaster," which means stomach, and "nomos," which refers to rules or laws. However, it can be argued that gastronomy truly began when our ancestors discovered cooking. This discovery not only enhanced the taste and nutritional value of food but also played a key role in human evolution. Cooking shaped social and cultural structures, as well as our physical and mental development (Pedersen, Hansen, & Clausen, 2021; Carmody & Wrangham, 2009). Mastering the art of cooking marked a turning point in human history, forming the foundation for gastronomy as a complex field connected to biological, cultural, and social growth.

A key moment in the development of gastronomy as a concept came with the publication of Berchoux's poem *La Gastronomie*. This work is recognized for its major role in popularizing the term "gastronomy" and embedding it into cultural discussions. While the idea of refined culinary practices existed long before Berchoux, his poem created a clear cultural and intellectual framework for understanding gastronomy as a field (Berchoux, 1801). By doing this, Berchoux not only secured the term's place in cultural language but also highlighted the importance of pleasure, sophistication, and aesthetic enjoyment in food. This conceptual foundation laid the groundwork for a broader understanding of gastronomy, extending beyond culinary refinement to encompass scientific, artistic, and cultural dimensions. This holistic perspective was later fully articulated by Brillat-Savarin, who in *La Physiologie du goût* (Savarin, 1842), defined gastronomy as a multidisciplinary field that unites practice, science, and philosophical reflection—positioning it as an intellectual pursuit as much as a sensual one. (Brillat-Savarin, 1842)

From this perspective, gastronomy is more than just the act of cooking and eating; it is a multidisciplinary field that brings together the science, art, and culture of food. This broader perspective emphasizes gastronomy's central role in human life, highlighting the deeper symbolic importance of food within society. Hegarty and O'Mahony (2001) describe gastronomy as both a form of cultural expression and an aesthetic way of living, underscoring its influence in shaping and reflecting social norms and cultural identities. Preparing and consuming food, therefore, goes beyond mere survival—it carries cultural meaning that sets humans apart from other species and reinforces gastronomy's vital role in human civilization.

The multidisciplinary nature of gastronomy is further highlighted by scholars like Maberly and Reid (2014), who stress that the field encompasses natural history, physics, chemistry, cooking, commerce, and political economy. This broad approach demonstrates how gastronomy intersects with various fields of knowledge, each playing a part in deepening our understanding of food's significance within society. Among these, food science plays an increasingly significant role, providing the tools to study the physical, chemical, and biological processes that define food's properties and sensory qualities. By merging gastronomy with food science, researchers and practitioners can preserve cultural heritage while also fostering innovation in the culinary world, enhancing both the enjoyment and functionality of food.

2.2 A Brief History of Gastro and Food Sciences

Ancient Greece and Rome celebrated food not only as a cultural spectacle but also as a cornerstone of health (Dalby, 2003). While banquets and festivals were common, dietary choices were predominantly driven by the humoral theory, which categorized individuals and foods as hot, cold, dry, or moist (Bober, 2001; Manderson, 1987). For instance, Roman physicians regarded bread as the epitome of nutritional balance; a view encapsulated by Aulus Cornelius Celsus's assertion of its superior nutritive content (Flandrin & Montanari, 1999, p. 25). This early blend of culinary practices and health considerations eventually laid the foundation for today's food science.

Although health has long been a significant focus of science, it wasn't until the 1980s that gastronomy and science formally merged, having remained separate fields until then (Guixer, 2019). This divide was aptly highlighted by Oxford physicist Nicholas Kurti's famous 1969 remark: *"I think it is a sad reflection on our civilization that while we can and do measure the temperature in the atmosphere of Venus, we do not know what goes on inside our soufflés*." This somewhat critical observation inspired Kurti and his colleague, physical chemist Hervé This, to establish the field of molecular gastronomy, officially defined in 1988. At the time, the term "molecular and physical gastronomy" was used to describe this emerging field, but after Kurti's death in 1998, the term evolved and continued to be used only as "molecular gastronomy" (Onurlar, 2023; This, 2006). Their work focused on applying scientific techniques—not in kitchens but in laboratories—using advanced tools such as nuclear magnetic resonance spectroscopes and mass spectrometers (This, 2019). This groundbreaking approach revolutionized the culinary landscape, introducing innovative textures and flavor combinations while redefining how we perceive and enjoy food (Barham et al., 2010).

As the intersection of science and gastronomy evolved, the rise of the experience economy emphasized the importance of sensory and emotional aspects in dining (Pine & Gilmore, 1999). Consumers began to value multisensory experiences over functional consumption, with factors like visual presentation, music, and even the weight of a coffee cup playing a pivotal role in shaping perception and enhancing enjoyment (Berčík et al., 2021). This growing focus on sensory dining sparked interdisciplinary research into the mechanisms of taste, aroma, and nutrition, leading to significant advancements in understanding flavor.

Today, fields like sensory science, neurogastronomy, and gastrophysics have revolutionized our relationship with food. Sensory science examines how attributes like sweetness and texture shape preferences, while neurogastronomy explores how the brain integrates multisensory cues to construct flavor and its relevance to human behavior. Closely related, gastrophysics combines psychology, neuroscience, and physics to address fundamental questions about food consumption, focusing on both pleasure and health. Together, these disciplines bridge science and perception, offering deeper insights into how humans experience food (Møller, 2013; Shepherd, 2011, pp. 2-3)

2.3 The Emergence and Framework of Neurogastronomy

Significant progress in understanding the connection between the brain and flavor perception began after 2000, largely thanks to Gordon M. Shepherd, a neurobiology professor at Yale University and the creator of the term "neurogastronomy." In his 2004 paper, *The Human Sense of Smell: Are We Better Than We Think?*, Shepherd introduced an important distinction between "sniffing" and "smelling," explaining how odor molecules interact with the brain. He identified two key pathways for odor detection: ortho-nasal and retronasal olfaction. Ortho-nasal olfaction happens when odors enter the nose during inhalation, while retronasal olfaction occurs as odors travel from the mouth to the nasal cavity during eating or drinking. This retronasal process plays a vital role in how we experience flavor, combining smell, taste, and touch to determine whether foods and beverages are enjoyable or not (Shepherd, 2004).

In 2006, Gordon M. Shepherd introduced the concept of "neurogastronomy," an interdisciplinary field that bridges the biochemistry of food preparation, the molecular biology of olfactory receptors, and the brain's role in flavor perception (Shepherd, 2006). He argued that understanding these connections could lead to innovative strategies for enhancing flavor and promoting healthier diets. Expanding on this idea, Shepherd (2011) positioned neurogastronomy as a modern extension of classical gastronomy. Unlike traditional gastronomy, neurogastronomy shifts the focus to how the brain generates the perception of flavor. By investigating the neural mechanisms behind taste and aroma, this field has redefined our understanding of the interplay between food, the senses, and cognition. In neurogastronomy, the auditory system plays an often overlooked but integral role in shaping the perception of flavor. The auditory pathway, which begins in the ear and processes sound signals through the brain stem and auditory cortex, is primarily designed to interpret environmental sounds. However, in the context of eating and drinking, it becomes relevant for the sounds associated with food consumption. From an evolutionary perspective, these sounds likely helped our ancestors assess the ripeness, freshness, or toughness of food. Today, while we may not consciously associate sound with flavor, auditory cues remain a subconscious yet critical part of the eating experience. For instance, the absence of expected chewing sounds, like the crunch of a crisp apple can diminish the overall enjoyment of the food. Thus, hearing is not merely a passive sense but an active contributor to the perception of flavor (Shepherd, 2011, pp. 143–144).

However, despite the advances in neurogastronomy, Charles Spence, an experimental psychologist and professor at the University of Oxford specializing in multisensory perception and crossmodal correspondences, proposes a more practical approach to studying flavor and dining experiences. While neurogastronomy offers valuable insights into the brain’s mechanisms, Spence (2015) argues that it falls short in addressing real-world dining contexts. The reliance on brain scanners and controlled environments makes it impractical for measuring customer experiences in restaurants.

Spence (2021) further highlights several challenges that have slowed progress in flavor research. First, the complexity of controlling stimulus delivery poses difficulties for psychologists and cognitive neuroscientists; such research cannot be conducted with participants passively seated in front of a computer. Second, subjects adapt quickly to taste and smell stimuli, becoming sated after a few exposures, which often requires multiple testing sessions. Finally, Spence points to a deep-seated bias in cognitive science that perceives taste and smell as “lower” or “common” senses, leading to their neglect compared to other modalities like vision and hearing. Given these limitations, Spence advocates for gastrophysics, a more holistic, real-world approach that focuses on the interaction of multiple sensory inputs in natural dining environments. By moving beyond the laboratory, gastrophysics aims to provide a more comprehensive understanding of the multisensory dining experience (Mouritsen, 2021).

2.4 The Conceptual Foundations of Gastrophysics

Gastrophysics focuses on the full spectrum of the senses, exploring how their interactions generate new perceptual experiences. These interactions are not passive or isolated; rather, they actively shape how individuals perceive, evaluate, and respond to food and drink. Consequently, gastrophysics has moved beyond the laboratory and evolved into a versatile field that informs a wide range of applied domains—from product development and nutrition to hospitality, architecture, and marketing (Spence, 2016;

Spence & Sathian, 2020). Its core strength lies in its capacity to translate complex sensory principles into real-world interventions that affect consumer behavior and shape everyday eating experiences.

A foundational area in applied gastrophysics is the design of food-related objects and environments, particularly in hospitality settings. The choice of materials, shapes, weights, and textures in utensils and packaging can significantly influence taste perception. For example, studies have shown that the weight and material of cutlery affect both the perceived quality of a meal and the intensity of its flavor. Heavier cutlery and menus tend to evoke impressions of higher quality, contributing to a more premium dining experience (Spence & Piqueras-Fiszman, 2012; Michel, Velasco, & Spence, 2015). This is not merely symbolic: even the taste of yogurt has been reported as more enjoyable when eaten with heavier utensils (Piqueras-Fiszman et al., 2011). Such findings underscore how somatosensory cues—often overlooked in traditional food research—play an integral role in modulating hedonic responses.

Equally important is the spatial composition of food, particularly how it is arranged on the plate. Gastrophysics draws attention to the aesthetic principles that govern visual perception and their effects on taste judgments. For instance, consumers tend to favor arrangements that follow horizontal or vertical alignment, a preference that mirrors the "aesthetic oblique effect" known from visual arts (Spence et al., 2019). Upward-oriented or triangular plating designs have been found to enhance visual appeal and even increase willingness to pay (Michel et al., 2015). These insights support the argument that food aesthetics are not merely about visual pleasure; they form part of a cognitive schema through which value and flavor are interpreted.

Beyond the material and visual dimensions, gastrophysics also investigates the sociocultural frameworks that shape multisensory experiences. Cultural studies within this field examine how factors such as gender, tradition, and geography influence food preferences and sensory interpretations. For example, research has shown that men often rely on personal taste histories when choosing food, while women tend to seek novelty, authenticity, and complex sensory experiences (Kim, Xu, & Park, 2024). These findings suggest that sensory interventions—such as sonic seasoning—must be adapted to audience-specific expectations rather than assumed to work universally. The cultural embeddedness of sensory processing is also evident in how different populations interpret sensory cues. Studies comparing Western and non-Western audiences have shown that the same auditory or visual stimulus can elicit entirely different taste associations depending on cultural background (Eitan & Timmers, 2010; Reinoso-Carvalho et al., 2020). This divergence challenges the assumption of universal crossmodal correspondences and highlights the importance of cultural calibration in the design of sensory experiences. Without such sensitivity, gastrophysical strategies risk reinforcing cultural biases or producing ineffective results.

The public health implications of gastrophysics are also becoming increasingly evident, particularly in the domain of nutrition. The field has shown promise in addressing behavioral challenges associated with diet, such as obesity or aversion to certain healthy foods. One of the core insights here is that healthier foods—particularly green vegetables—often lack a favorable sensorial profile and are visually associated with bitterness, a generally disliked taste (Spence, 2020). Visual interventions offer a potential remedy: studies have demonstrated that salads with high color contrast between ingredients are perceived as more attractive and are more likely to be selected (Paakki et al., 2019). This suggests that multisensory design can be leveraged not only for indulgence but also for encouraging healthier choices.

Environmental and architectural factors form yet another layer of multisensory experience that gastrophysics seeks to understand and shape. Elements such as lighting, wall color, table material, ambient temperature, and scent all contribute to the context in which food is consumed—and thereby to the perception of taste and quality. For example, warm colors like red and pink are often linked to sweetness, while ambient scents like cinnamon and vanilla can increase the perceived value of food items (Velasco et al., 2016; Madzharov, Block, & Morrin, 2014). Likewise, thermal comfort plays a role in decision-making: excessively warm environments can impair cognitive control, subtly altering food choices (Huang et al., 2014; Cheema & Patrick, 2012). These findings reinforce the importance of atmosphere in shaping consumer behavior at a subconscious level.

Ultimately, gastrophysics offers more than an applied toolkit; it constitutes a shift in how food and eating are conceptualized. By emphasizing the interdependence of sensory, cultural, and contextual elements, it moves away from reductionist models that isolate variables in favor of holistic, experience-centered paradigms. The field also fosters innovation in areas ranging from sensory marketing to space food design (Campo, Rosato, & Battisti, 2022). Its insights enable practitioners to craft environments and products that not only taste better but resonate emotionally, socially, and psychologically with consumers. When integrated thoughtfully, gastrophysics becomes a powerful instrument for shaping not just what people eat, but how they feel, decide, and connect through food. Finally, music and sound design play a crucial role in gastrophysics, where auditory cues are used to shape flavor perception and elevate sensory experiences. For instance, studies on sonic seasoning systems have shown how pairing specific music with food can influence taste perception and even impact food intake (Spence et al., 2021; Mathiesen, Byrne, & Wang, 2019; Cui et al., 2021). What makes music particularly significant is its practicality—it stands out as one of the easiest and most cost-effective sensory elements to manipulate in any environment (Stevenson, 2014). A simple change in music can dramatically alter perceptions and, in turn, consumer behavior. This makes music an invaluable tool not only for marketers but also for food producers, suppliers, and consumers looking to enhance or adapt sensory experiences.

As a result, gastrophysics stands out as a multidisciplinary field, combining insights from sensory science, psychology, neuroscience, design, behavioral economics, and architecture to explore and enhance flavor perception and consumer behavior. Its applications extend from marketing strategies to promoting healthier eating habits, emphasizing the importance of multisensory elements such as music, lighting, and food presentation. The field also recognizes the influence of cultural and environmental factors on sensory experiences, highlighting the need for tailored approaches like culturally specific sonic seasoning. By uniting science and practical application, gastrophysics offers innovative ways to transform dining into a multisensory experience, fostering engagement and creating meaningful connections with food.

3. THE EFFECTS OF MUSIC AND SOUND ON TASTE PERCEPTION

3.1 Introduction

Sound is often overlooked in food and beverage experiences (Spence, 2015). Surveys among food scientists and regular consumers consistently rank sound as the least significant factor influencing flavor, behind taste, smell, texture, and temperature (Delwiche, 2003; Spence, 2015). These findings highlight a general underestimation of how auditory stimuli, such as music or environmental sounds, can shape our perception of food. The effects of music and sound on taste perception can be grouped into three key areas, as outlined by Spence, Reinoso-Carvalho, Velasco, and Wang (2019). First, general background noise subtly impacts how flavors are perceived. Second, background music influences food perception and consumer behavior, with elements like volume affecting arousal and aligning actions with the music's rhythm. Finally, "sonic seasoning" uses specific sounds to enhance or modify taste experiences in a deliberate way.

3.2 Background Noise

Noise is an auditory stimulus, particularly one that is loud or undesirable, that disrupts people. Noise manifests in various forms, such as the background chatter of children, the roar of car and airplane engines, the sudden clatter of a pan or plate dropped while cooking, or multiple people talking loudly in a shared space (Mehta, Zhu, & Cheema, 2012). Especially after work hours, the blending of music with overlapping conversations creates a particularly chaotic atmosphere. Research shows that background noise can alter the perception of food properties. Woods et al. (2011) found that loud noise reduces the perceived intensity of sweetness and saltiness while enhancing crunchiness. For example, participants consuming various foods, such as crisps and biscuits, under loud noise conditions consistently rated them as crunchier. This suggests that unrelated auditory stimuli can amplify sound-conveyed attributes, like texture, while masking gustatory cues, potentially due to sensory interference or divided attention. These findings highlight the significant impact of environmental noise on how we experience food.

While Woods et al. (2011) demonstrated how noise can suppress gustatory perception, other studies suggest that specific types of auditory stimuli, such as music, may enhance certain taste attributes. Stafford et al. (2012) found that music can increase the perceived sweetness of alcohol compared to quieter or distracting conditions, contrasting with Woods et al.'s (2011) findings on solid foods. This difference may stem from methodological variations and product types, as beverages interact differently with sensory cues. Stafford's study, conducted in a bar environment with socially active drinkers, revealed that participants exposed to music rated alcohol as sweeter than those in quieter or more distracting conditions. However, when music was combined with a cognitively demanding task, such as background television or competing sounds, participants struggled to accurately assess alcohol strength, especially at higher concentrations. This aligns with Stevenson's (2012) view that external stimuli can disrupt attention and supports Schifferstein and Verlegh's (1996) theory, which suggests that cognitive load from competing stimuli compromises detailed sensory processing, making it harder to focus on taste perception.

The disparity between Woods et al.'s and Stafford et al.'s results underscores the impact of varying noise types (white noise vs. music) and stimuli (food vs. drink) on taste perception. This suggests a complex interaction between auditory and gustatory stimuli, where noise can either enhance or diminish sensory perception depending on the context (Caldwell & Hibbert, 1999).

3.2.1 Noise in the Air

Moreover, noise is also a common factor in airplane environments. Commercial aircraft typically generate noise levels between 80-85 dB(A), depending on the passenger's proximity to the engines and the type of aircraft (Ozcan & Nemlioglu, 2006). This constant auditory stimulation creates a challenging environment for sensory perception, which may alter the way passengers experience their in-flight meals. Several factors, including low cabin pressure, lack of humidity, and high levels of background noise, have been shown to impact passengers' ability to taste and smell food and beverages (Spence, 2017). However not all tastes react equally to background noise. Research shows that in-flight noise (80–85 dB) suppresses sweetness and saltiness while leaving umami unaffected, sometimes enhancing other tastes (Spence, 2014; Yan & Dando, 2015). To address this, airlines like British Airways create umami-rich dishes and slightly adjust sweetness and saltiness to improve in-flight meals (Spence, 2017). Additionally, pairing meals with carefully curated music or soundscapes could further enhance the sensory experience and make dining more enjoyable (Spence, 2016).

3.2.2 Noise in the Real-World Setting

Numerous chefs have explored the role of auditory stimuli in dining environments, believing in its potential to enhance the multisensory experience of food. Food preparation sounds are likely to impact food and beverage experiences and ratings through a process of associative learning and expectation setting (Spence, 2012). For instance, chef Per Samuelsson in Sweden records the sounds of food preparation, including peeling, chopping, and stirring, and incorporates them into musical compositions played during meals. This practice enables diners to "hear the food being made," creating a closer emotional connection with the kitchen and enriching their overall sensory experience (Spence, 2015).

Similarly, Heston Blumenthal, the renowned chef at The Fat Duck, has been a pioneer in incorporating sound into the dining experience. In collaboration with Professor Charles Spence, Blumenthal explored how auditory cues influence taste perception. In one experiment, Blumenthal gave diners headphones and exposed them to either farm or beach sounds while they ate the same oysters. Those listening to the beach sounds reported the oysters as saltier and fresher, demonstrating how sound can alter the perception of food (Blumenthal, 2008, as cited in Spence, 2011).

Not all chefs believe that music or noise enhances the dining experience. Ferran Adrià of ElBulli and Grant Achatz of Alinea prohibited music in their kitchens, emphasizing the need for a distraction-free environment for both chefs and diners. Similarly, Daniel Humm of Eleven Madison Park highlighted the importance of natural kitchen sounds, like sizzling and chopping, as essential feedback for cooking, arguing that music would disrupt this process (Spence, 2015).In conclusion, while some chefs and restaurateurs use sound, whether in the form of music, noise, or kitchen sounds, to enhance the emotional and sensory aspects of dining, others prioritize the purity of the culinary experience by maintaining a soundscape free of external auditory stimuli.

3.3 Background Music

While noise often disrupts sensory focus, music has the potential to enrich it, creating a multisensory experience that engages diners on both emotional and perceptual levels. Chefs and restaurateurs have capitalized on this potential in various ways, ranging from the incorporation of kitchen sounds into the dining atmosphere to the curation of specific playlists to enhance particular flavors. The central question then emerges: how does music influence consumers' perceptions and emotions in dining environments? To address this question, it is crucial to first understand the complex nature of music itself.

According to Martineau (2021), music is essentially a sophisticated interplay of numerous elements, including pitch, rhythm, volume, and harmony, all of which are structured in such a way as to elicit a wide range of emotional responses from listeners. The fact that music does not correspond to a single description or experience makes it difficult to define it in a way that encompasses all of its characteristics (Cross, 2003). This complexity makes it difficult to characterize anything. A deeper comprehension of music's harmonic and melodic patterns typically takes substantial training and theoretical knowledge (De Prisco et al., 2017). While some people may experience music only through its fundamental sound aspects, others may be able to acquire this understanding through research. Moving forward, Crisinel and Spence (2010) expanded on these findings by examining how different tastes correspond to musical pitch. Participants matched sweetness and sourness with high-pitched sounds, while bitterness was consistently linked to lower-pitched notes, particularly from brass instruments. This pattern suggests that people associate tastes with sounds based on their perceived pleasantness. The study also proposed that these associations may help simplify sensory processing, aiding in tasks like assessing fruit ripeness or recognizing warning cues in nature.

Fiegel et al. (2014) investigated how different music genres influence food perception, particularly in emotionally associated foods like chocolate compared to non-emotional foods like bell peppers. Participants tasted both foods while listening to classical, jazz, hip-hop, and rock music. The results showed that chocolate was rated as more pleasant when paired with jazz, while hip-hop and rock had less positive effects. However, music had no significant impact on bell peppers, suggesting that emotional associations between food and music play a key role in shaping sensory experiences. Notably, while music influenced overall enjoyment, it did not significantly alter specific taste perceptions like sweetness or bitterness. This connection between emotion and food preference is further supported by Motoki et al. (2022), who found that background music not only shaped consumer choices but also mediated preferences through emotional responses. The results showed classical and jazz music increased preferences for healthy savory foods, while rock/metal and hip-hop favored indulgent savory options. Classical music also enhanced preferences for both healthy and indulgent sweet foods compared to other genres. Emotional responses influenced food preferences, with positive valence enhancing sweet and healthy savory choices, while arousal was linked to indulgent savory options. This connection between music, emotion, and sensory perception is in line with by Kontukoski et al. (2015), who demonstrated that music can also influence the preparation of food and drinks. Their study showed that listening to classical music pieces associated with either sweet or sour tastes biased participants' decisions when balancing sweet-sour flavors in a drink**.** These findings collectively highlight how auditory stimuli can extend beyond consumption, shaping both sensory experiences and decision-making processes.

Moreover, Bravo-Moncayo et al. (2020) found that loud background music diminished key sensory attributes in coffee, particularly bitterness and aroma intensity, while also lowering participants' willingness to pay. In the study, 384 participants sampled the same black coffee—an Ecuadorian medium roast Arabica—under either loud

(85 dB) or quiet (20 dB) conditions. The results suggest that excessive noise can interfere with taste perception, reinforcing why professional tasters often prefer silence for a more accurate evaluation. These findings suggest that background music can be strategically used to shape consumer behavior in retail settings.

3.4 Sonic Seasoning

Sonic seasoning refers to the process of using specific auditory properties, such as tones, frequencies, or even whole musical compositions, to impact and regulate how people perceive food and beverage flavors (Crisinel et al., 2012). Based on the concept of cross-modal correspondences, this interaction between sound and taste allows specific auditory signals to amplify, inhibit, or change various taste components such as sweetness, spiciness, or fruitiness. Sonic seasoning takes advantage of the interaction between the auditory and gustatory senses to produce a multimodal dining experience, proving that eating is a holistic sensory engagement influenced by sound rather than just taste. This method proposes that music or certain noises can be carefully introduced into dining situations to alter the flavor profile of a meal, so increasing the entire sensory experience of eating or drinking (Mathiesen et al., 2019).

While Spence (2016) formally introduced the concept of sonic seasoning by discussing how auditory cues influence taste perception, earlier research like that of Knoeferle et al. (2015) laid the groundwork by identifying consistent sound-taste associations. Their findings demonstrated that auditory properties such as pitch and roughness influence taste perception, highlighting the foundational principles that later studies on sonic seasoning would build upon. They found that sound-taste associations follow consistent patterns, even among non-musicians. Higher-pitched, faster sounds were linked to sweet and sour tastes, while bitter, salty, and sour were associated with rougher sounds. When tested with music compositions designed to reflect these mappings, participants accurately matched them to tastes, suggesting that pitch and roughness shape taste perception. Cultural differences also played a role—while both U.S. and Indian participants performed above chance, U.S. participants were more accurate, particularly for "sweet" sounds, indicating that some associations may be universal, while others are shaped by cultural exposure. These findings suggest that while some crossmodal correspondences are culturally influenced, others may stem from basic sensory processes like statistical learning or embodied cognition (Spence & Deroy, 2012).

Building on this, Wang, Woods, and Spence (2015) investigated whether soundtracks designed to represent basic tastes (sweet, salty, sour, and bitter) could influence taste perception. Unlike previous studies using forced-choice methods (e.g., Knoeferle et al., 2015), this study allowed participants to freely associate sounds with tastes. Across 24 short soundtracks, sweetness was the most consistently matched taste (56.9%), while bitterness had the lowest accuracy (31.4%). These results suggest that sweetness is more easily evoked through auditory cues, possibly due to its strong positive associations (Velasco et al., 2015). Musical expertise had little impact on accuracy, though non-musicians were more likely to associate dissonant sounds with sweetness, while trained musicians focused more on complex musical structures, making these associations less intuitive.

Knoeferle et al. (2015) briefly acknowledged the role of emotion in sound–taste correspondences, yet the specific relationships between sonic seasoning, emotional valence, and hedonic evaluation remained underexplored. Addressing this gap, Guedes et al. (2023a) conducted a series of experiments investigating the bidirectional influence between sound and taste—examining not only how soundtracks affect the perceived sweetness or bitterness of chocolate, but also how taste modulates musical evaluation. In their first experiment, participants tasted semi-dark chocolate while listening to either a "sweet" or "bitter" soundtrack. No significant differences were observed, suggesting that sonic effects may not emerge without direct comparison. A second experiment introduced this comparative element by presenting the same chocolate twice, each time paired with a different soundtrack. Under these conditions, participants rated the chocolate as sweeter with the sweet soundtrack and more bitter with the bitter one—highlighting the importance of relative context in crossmodal modulation (Spence et al., 2019).In a third experiment, the direction of influence was reversed: participants first tasted either sweet or bitter chocolate, then evaluated a bittersweet soundtrack. Those who had consumed sweet chocolate found the soundtrack more pleasant and sweet; those who had the bitter sample perceived it as less pleasant and more bitter.

These results support the concept of sensation transference, wherein sensory input from one modality (taste) shapes perception in another (audition) (Reinoso-Carvalho et al., 2016). Overall, the findings indicate that sonic seasoning effects are context-dependent and that crossmodal correspondences operate dynamically, shaped by comparative, multisensory experiences (Guedes et al., 2023b; 2023c).

3.5 Grass Is Not Always Green

While previous research has demonstrated that music influences taste perception (Hauck & Hecht, 2019; Crisinel & Spence, 2010), the lack of significant differences in flavor intensity observed in this study suggests a more complex and context-dependent interaction. Hence, these findings highlight the nuanced nature of crossmodal correspondences, shaped by both cultural and experiential factors.

For example, cultural influences further complicate this relationship. As Knoeferle, Woods, Käppler, and Spence (2015) note, the extent to which crossmodal correspondences are universal or culturally determined remains uncertain. To point out one possible explanation, sound-taste associations may emerge from culturally specific factors, such as linguistic metaphors and musical traditions. For instance, in Western contexts, the link between high-pitched sounds and sweetness might stem from the shared use of the term "sweet" to describe both music and taste (Knoeferle et al., 2015). On the other hand, some crossmodal correspondences appear to be more universal. Research suggests that associations like the connection between red colors and sweet flavors may result from learned environmental regularities (Spence, Levitan, Shankar, & Zampini, 2010). This implies that our sensory systems internalize patterns through mechanisms such as Hebbian learning, reinforcing associations that provide evolutionary advantages.

Moreover, a deeper understanding of the psychological and neuroscientific foundations of multisensory perception is essential, particularly in terms of how auditory, gustatory, and olfactory interactions unfold (Spence, 2013). To emphasize this point, Spence (2015) highlights the methodological challenges in studying flavor perception, an area historically overlooked in cognitive neuroscience. Since sensory stimuli are difficult to control and processed rapidly, this field has been largely neglected. Nevertheless, while certain multisensory integration principles may be universal, individual culinary experiences likely shape the specific interactions that enhance or diminish crossmodal effects. Therefore, further research is needed to determine the relative contributions of universal mechanisms and cultural factors in shaping taste perception.

4. THEORETICAL AND METHODOLOGICAL PERSPECTIVES ON MUSIC AND TASTE INTERACTION

4.1 Introduction

Music plays a crucial role in shaping our sensory experiences, influencing not only what we hear but also how we perceive flavors and enjoy food. While the precise mechanisms underlying this relationship remain under investigation, research suggests that music can modulate taste perception and overall food experience. To explain these interactions, scholars have proposed various theoretical frameworks. Among them, crossmodal correspondence, the natural tendency to associate specific features across sensory modalities, has gained the most empirical support (Spence, 2011). However, this is not the only relevant framework. Other factors, such as cultural and individual variability, priming effects in multisensory perception, sensation transference, emotional mediation, and sound symbolism with its evolutionary roots, also play a critical role in shaping sensory interactions. While crossmodal theory will serve as the primary framework in this discussion, these additional perspectives provide a more comprehensive understanding of the complex relationship between music and taste.

4.2 Crossmodal Correspondence

Crossmodal correspondences refer to the tendency for a stimulus, attribute, or characteristic in one sensory modality to be systematically associated with a feature in another modality, whether physically present or mentally imagined (Spence & Sathian, 2020). These associations have been shown to facilitate faster responses in various perceptual tasks, such as detection, categorization, and visual search, indicating that they operate at an intuitive and often automatic level. Experimental studies suggest that such correspondences are not solely shaped by cultural or linguistic learning; evidence from primate research points to an underlying biological basis for these associations (Spence, 2011; Knoeferle et al., 2015).

Beyond basic perceptual connections, crossmodal correspondences extend to more complex and symbolic relationships. A well-documented example is the link between auditory pitch and taste perception. High-pitched sounds are frequently associated with sweet or sour flavors, while lower-pitched tones tend to correspond with bitterness or umami (Crisinel & Spence, 2009, 2010; Crisinel et al., 2012). These findings have given rise to the. This practice seasoning, a practice that involves pairing specific types of music or sound with food to amplify or alter perceived flavor attributes (Mathiesen, Byrne, & Wang, 2019). Such findings indicate that auditory cues can systematically shape gustatory experiences without conscious awareness. As this body of research grows, it suggests that insights derived from pitch–taste associations may be extended to other sensory pairings, contributing to a broader understanding of how the brain constructs unified perceptual experiences across modalities (Spence & Sathian, 2020).

4.3 Types of Crossmodal Correspondences

Crossmodal correspondences can be further classified into distinct types based on the associations' nature. Spence identifies these crossmodal correspondences as statistical, structural, semantic (or linguistic), and emotional (Spence, 2011). The previously mentioned association between pitch and elevation can be understood as an instance of what Spence (2022) defines as a statistical correspondence. Statistical correspondences emerge from associative learning, reflecting the brain's ability to internalize consistent patterns in the multisensory environment.

This process of learning extends across sensory modalities and begins early in life. Studies have shown that even at four months of age, infants can internalize statistical relationships, such as the link between the color of a cup and the taste of the drink inside it. Adults, too, can quickly form new associations, such as sound-taste pairings, through brief but repeated exposure. These findings support the idea that the brain continuously updates its priors over the lifespan, dynamically adapting to the crossmodal statistics of the environment (Spence & Levitan, 2022).

Structural correspondences, in contrast, are considered innate and are believed to arise from shared patterns in how the brain processes different sensory information (Wan et al., 2014). For instance, this category includes associations within the magnitude domain, such as linking "big" with "loud" (Ohtake, Tanaka, & Yamamoto, 2023; Spence, 2011). Similarly, certain strong crossmodal correspondences, like associating the color black, cross shapes, or ellipses with bitterness and pink or cloud shapes with sweetness, might also be structural in origin, potentially rooted in common neural pathways. However, it is also possible that such correspondences are statistical, formed through repeated co-exposure to correlated stimuli or dimensions shared across cultures (Wan et al., 2014).

Semantic correspondences rely on shared linguistic terms and are closely tied to high-level mechanisms that connect information across the senses. These mechanisms may develop through experiences with various sensory perceptions encoded into language, influencing multiple levels of human information processing. As a result, crossmodal congruence effects can emerge not only in interpreting perceptual stimuli but also in processing verbal cues (Velasco et al., 2016b). For example, the use of terms,s like “bright” to describe both color and sound, or “high” and low” to refer to both pitch and spatial elevation, highpoints the potential for linguistic associations to drive crossmodal correspondences. However, it remains unclear whether these associations are the cause or the result of such correspondences (Dacremont & Sester, 2019; Spence, 2011)

Finally, emotional correspondences are grounded in affective experiences, with the emotional mediation account proposing that the emotional associations people form with stimuli serve as a fundamental basis for crossmodal connections. For instance, composed music can evoke strong emotional responses, such as certain melodies enhancing the perception of sweetness. These emotional connections often overlap and interact with other correspondences, collectively influencing how individuals perceive and integrate sensory inputs (Spence, 2020; Hanada, 2018; Guedes, Garrido, Lamy, Cavalheiro, & Prada, 2023). Moreover, emotionally mediated correspondences are likely to exhibit more outstanding individual or cultural variation. This is supported by evidence showing cultural differences in affective responses to unisensory stimuli, such as colors and odors, influencing how people perceive and connect sensory inputs (Spence, 2022).

4.4 Limitations of Crossmodal Correspondences

Though extensively studied, cross-modal correspondences face significant limitations rooted in cultural, individual, and structural factors that complicate their universality and application. These correspondences influence how sensory information is processed, often enhancing speed and accuracy when inputs align, such as matching high-pitched sounds with small objects. However, not all sensory tasks benefit uniformly. For instance, the Colavita visual dominance effect demonstrates that, in certain cases, visual stimuli can overshadow auditory inputs, indicating that crossmodal effects are not universally consistent in shaping sensory performance (Spence & Sathian, 2020).

Cultural variations further complicate these correspondences. Patterns of multisensory exposure differ across societies, leading to distinct associations. While Western individuals commonly link angular shapes with bitterness, the Himba people associate bitterness with roundness. This divergence highlights how statistical learning shaped by cultural environments can lead to varying sensory mappings. Such culturally dependent correspondences challenge the assumption of universality, suggesting that exposure and learned associations play a pivotal role in shaping these connections. On an individual level, developmental stages and neurodiversity significantly influence crossmodal correspondences. Robust mappings, such as size-loudness associations, are evident in adults but inconsistently observed in younger children. Moreover, individuals with high autistic traits exhibit weaker and less consensual correspondences, reflecting how neurodevelopmental differences impact the strength and agreement of these sensory associations. Such individual variability underscores the need to consider how innate and acquired factors shape sensory integration.

Structurally, some correspondences, like pitch-size or brightness-loudness mappings, appear universal due to shared neural encoding. However, others depend on semantic and emotional mediations. The language introduces terms like "high" and "low," which link pitch to spatial elevation, creating culturally and linguistically mediated mappings. Similarly, emotionally mediated correspondences connect pleasant shapes, such as roundness, with sweet flavors, further complicating the structural foundation of these associations. These factors reveal the inherent variability and contextual dependency of crossmodal correspondences. While they enrich our understanding of multisensory integration, their cultural, individual, and structural limitations challenge their application as universal principles, necessitating a more nuanced and context-sensitive approach (Spence, 2022).

While crossmodal correspondence provides a foundational framework for understanding sensory interactions, it does not fully account for the diverse mechanisms at play. To address this gap, exploring alternative theories reveals how various cognitive, emotional, and perceptual processes contribute to the phenomenon. Emotional Mediation Theory, for instance, explains how the emotional tone of music can amplify or suppress taste perceptions. At the same time, Sound Symbolism sheds light on the intuitive associations between auditory features and food textures. Similarly, theories such as Priming, Sensation Transference, and Evolutionary Perspectives offer unique insights into the origins and functions of these interactions. By integrating these explanations, this chapter aims to present a multidimensional perspective on how music influences taste, emphasizing the interplay between these theories and their collective contribution to understanding this complex phenomenon (North, 2012; Spence, 2012; Spence & Sathian, 2020; Campinho et al., 2023).

4.5 Priming Effect in Multisensory Perception

While crossmodal correspondences offer one framework for understanding sensory integration, priming theory provides a complementary perspective by emphasizing how prior exposure to one stimulus can shape the perception of another. Priming theory explains how exposure to a particular sensory cue can unconsciously influence subsequent perception or behavior by activating related cognitive schemas (Mast, Frings, & Spence, 2017). In sensory and consumer research, auditory stimuli such as music often act as external primes, subtly guiding sensory interpretation and behavioral responses. Music may influence decision-making processes through these priming effects, even when those decisions appear unrelated to auditory input (Spence et al., 2019). This function positions music as a background element and active modulator of multisensory experiences and consumer behavior.

One of the most widely cited studies in this area was conducted by North, Hargreaves, and McKendrick (1999), who investigated how national music influenced wine sales in a supermarket. Over two weeks, French and German music were alternated as background stimuli. The findings revealed a strong alignment between music and purchase behavior: French wine sales increased during French music, while German wine sales rose during German music. Notably, post-experiment interviews indicated that participants were unaware of the influence, suggesting that the observed effects occurred at a subconscious level.

Subsequent research has expanded upon these findings. North, Shilcock, and Hargreaves (2003) demonstrated that classical music in restaurant settings increased customer spending relative to pop music, which the authors attributed to classical music's associations with luxury and sophistication. Similarly, Yeoh and North (2010) showed that culturally specific background music could shape food selection: participants were more likely to choose Indian cuisine when Indian music was played and Malay cuisine when Malay music was used. These effects suggest that auditory primes activate culturally embedded expectations, guiding behavior.

Building on these earlier studies, North (2012) explored how music might influence not only behavior and qualities attributed to wine. Participants tasted the exact wine under four musical conditions, each designed to evoke a specific emotional quality: "powerful and heavy," "mellow and soft," "zingy and refreshing," and "subtle and refined." The results indicated that participants' descriptions of the wine aligned with the symbolic character of the music they were exposed to. For instance, while listening to Carl Orff's *Carmina Buran, wine tastings were* likelier to be described as "powerful," while wine accompanied by Michael Brook's *Slow Breakdown* was rated as "mellow."

These findings illustrate how music can be a prime, reinforcing behavioral and perceptual responses of familiarity, metaphor, or symbolic meanings. However, several limitations have been noted. First, Spence and Deroy (2013) argue that the descriptors used in studies such as North's may reflect metaphorical associations rather than genuine sensory modulation. Terms like "heavy" or "mellow" originate in the tactile domain and may not correspond directly to gustatory or olfactory features. Second, the absence of a shared semantic field between music and wine raises whether these effects arise from symbolic priming or crossmodal correspondences grounded in perceptual similarity. As such, while priming theory contributes meaningfully to understanding multisensory interactions, it does not fully account for the underlying mechanisms by which sound influences taste perception.

4.6 Emotional Mediation

In addition to cognitive mechanisms such as priming, emotional processes play a significant role in shaping multisensory perception. The relationship between affect and sensory input highlights the brain's ability to integrate emotional meaning across different modalities, forming unified and emotionally charged perceptual experiences (Royet et al., 2000). This interest has led to the development of the modality-general representation of affect, a theoretical framework suggesting that emotions are mentally represented in an abstract form that transcends any sensory modality, including vision, audition, or taste (Park & Kim, 2024).

This framework helps explain how emotional responses can be transferred from one sensory modality to another. For example, Guetta and Loui (2017) argue that the brain identifies shared emotional qualities between music and taste by aligning structural components such as pitch, harmony, and tempo with the chemical composition of sweetness and acidity. As a result, unpleasant auditory stimuli are often associated with unpleasant tastes, while pleasant sounds are linked to flavors perceived as more enjoyable (Liang et al., 2021). Empirical findings support these mappings. Harsh and discordant sounds, such as those produced by brass instruments, are frequently matched with bitter flavors, while soft and melodic tones, like piano music, tend to be associated with sweetness (Guetta & Loui, 2017).

The emotional tone of music can further modulate how flavors are perceived. Campinho et al. (2023) demonstrated that sour music can intensify the perception of sourness in food, particularly when both the auditory and gustatory elements are affectively negative. Similarly, Kantono et al. (2020, as cited in Campinho et al., 2023) found that participants rated ice cream as sweeter or more bitter depending on whether they liked or disliked the background music. Emotional congruency between sound and flavor enhances or diminishes perceived taste characteristics. This effect is not limited to taste. In a study on olfactory perception, Seo and Hummel (2020) showed that the emotional valence of sound could alter how odors were evaluated, even when the sound and smell did not share the same level of pleasantness. In another example, Reinoso-Carvalho et al. (2020) found that beer flavors were rated differently depending on whether the accompanying music elicited positive or negative emotions. Ziv (2020) further reported that biscuits were perceived as more enjoyable when consumed with pleasant background music than unpleasant music.

These findings suggest that music serves not merely as a background stimulus but as an emotional driver that interacts with other sensory inputs. Whether consciously or unconsciously, individuals form affective associations between sound and taste, reinforcing flavor perception through shared emotional meaning. This line of research adds a critical affective dimension to the broader understanding of multisensory integration and further emphasizes the need to account for emotion in the study of cross-modal experiences.

4.7 Sensation Transference

Building on the role of emotion in multisensory perception, the concept of sensation transference offers a valuable framework for understanding how sensory and affective cues interact to shape food-related experiences. Initially introduced by Cheskin (1972), sensation transference describes how perceptions of a product can be influenced by unrelated but co-occurring sensory attributes such as packaging, shape, or design. Recently, this framework has been extended to include auditory stimuli, particularly music, as a source of affective modulation in food perception (Guedes et al., 2024; Reinoso-Carvalho et al., 2020).

Through its capacity to convey emotional meaning, music is a potent modulator of how people perceive what they eat or drink. Hunter and Schellenberg (2010) emphasize that music can evoke emotional states that influence decision-making and perception even when the auditory input is not directly related to the food itself. Guedes et al. (2024) suggest that such emotional responses can mediate how music modifies flavor perception, reinforcing the principles of sensation transference through affective alignment. When music evokes positive emotions, the accompanying food is often perceived as more enjoyable and better tasting. Conversely, music that elicits negative emotions may reduce hedonic evaluations and alter the perceived intensity of specific taste qualities (Reinoso-Carvalho et al., 2023).

A range of empirical studies illustrates this mechanism in action. Seo and Hummel (2011) found that the emotional tone of sounds influences olfactory perception, independent of odor pleasantness, highlighting how crossmodal emotional transfer can occur even without direct sensory similarity. In an experimental study by Wang and Spence (2018), participants tasted fruit juice while being exposed to either upbeat (consonant music or happy faces) or negative (dissonant music or sad faces) stimuli. Positive stimuli led to higher sweetness and enjoyment ratings. However, because there was no baseline tasting condition without external cues, it remained unclear whether the effect was driven by enhancement of positive qualities, suppression of negative ones, or both. Reinoso-Carvalho et al. (2019) investigated similar effects using beer and emotionally contrasting musical excerpts. The same beer was perceived as sweeter and more enjoyable when paired with music associated with positive emotional responses. In contrast, it was rated as more bitter and more pungent in alcohol when accompanied by negatively valenced music. Notably, participants were also willing to pay 7–8% more when listening to the track that was positively associated with it. These results point to the emotional congruency between music and taste as a driver of valuation.

Visual elements can also produce similar effects. Chen, Woods, and Spence (2018) extended the notion of sensation transference to plate ware, demonstrating how color and shape influence taste expectations. Their first experiment applied the Bouba-Kiki effect to food presentation, finding that smooth, rounded plate shapes were associated with sweetness, while angular, pointed shapes were linked to sourness. In a second experiment, white plates enhanced the perceived sweetness of chocolate ice cream, whereas black plates increased bitterness ratings. Additionally, smooth shapes improved hedonic ratings of ice cream, while angular ones amplified the perceived sourness of lemon sorbet.

Further evidence comes from a study by Guedes et al. (2023), which examined how soundtracks associated with different sweetness levels influenced the perception of vegetables and cookies. Participants rated all samples as sweeter when paired with the high-sweetness soundtrack, regardless of the sugar content. Notably, the high-sweetness soundtrack also led to greater liking and higher intention for future consumption, even for sugar-free cookies, suggesting that sound can act as a tool to increase the acceptance of healthier products.

Together, these findings demonstrate the broad applicability of sensation transference to multisensory design. While auditory and visual cues can independently shape perception, their emotional meaning is a key mediator. By aligning the emotional tone of external stimuli with the intended sensory profile of a product, designers, and marketers can enhance both hedonic experience and consumer preference.

However, several questions remain. Spence et al. (2019) caution that sensation transference is not a universal mechanism. Its effects may depend on specific sensory dimensions and emotional congruency combinations and may not generalize across all products or cultural contexts. Additionally, whether sensation transference influences perceptual qualities such as taste intensity or merely alters hedonic judgments remains unclear. Despite these uncertainties, the accumulated research supports the idea that external sensory cues, particularly those with emotional significance, play a central role in shaping flavor perception, food preference, and consumption behavior. Sensation transference thus offers a critical link between the emotional and sensory components of food experience, reinforcing the value of multisensory design strategies in commercial and health-focused contexts.

4.8 Sound Symbolism and Its Evolutionary Roots

Sound symbolism refers to the non-arbitrary association between the acoustic features of sounds and their perceptual or semantic interpretations. It offers compelling support for crossmodal correspondences by highlighting how certain sounds evoke specific sensory expectations. One of the earliest empirical investigations in this area was conducted by Köhler (1929), who demonstrated that participants consistently associated nonwords like "baluma" with rounded shapes and "takete" with angular ones. This phenomenon, later validated by Bankieris and Simner (2015), suggests that humans are predisposed to interpret specific sound structures as representations of physical properties, pointing to a deep-seated perceptual bias.

Although initially observed in visual-auditory mappings, the scope of sound symbolism extends to taste perception. Sakamoto and Watanabe (2016) proved that certain phonetic features can influence expectations about flavor profiles. These correspondences are believed to originate from evolutionary adaptations involving oro-facial reactions to different tastants. For example, sweet flavors, which indicate high-energy, safe-to-consume foods, are typically associated with high-pitched, lighter tones. In contrast, bitter tastes often signal toxicity corresponding to low-pitched, darker sounds.

This mapping reflects basic emotional and behavioral responses that may have assisted early humans in food selection and danger avoidance. From this evolutionary standpoint, humans appear to have developed an intuitive ability to integrate auditory and gustatory signals in assessing food's edibility and safety of low frequencies with aversive tastes and high frequencies with pleasurable ones, which can be traced to oro-facial reflexes and vocal expressions associated with different taste stimuli. These associations are not arbitrary nor culturally bound; instead, they are served across species and societies, suggesting a universal and biologically grounded mechanism for sensory evaluation (Spence, 2012).

Experimental research has further substantiated these claims. Cuisine et al. (2012) showed that exposure to specific sound frequencies could shape the perception of flavor intensity. Participants exposed to low-pitched soundscapes likelier to report bitter tastes, while high-pitched tones enhanced perceived sweetness. These effects occurred even without explicit verbal associations, indicating that auditory cues can set subconscious expectations about taste. Additional studies have extended this research to sourness, showing that high-frequency sounds are linked with more acidic or sour flavor profiles. These findings correspond with shifts in pitch and phonetic features, supporting a systematic auditory-taste mapping (Simner, Cuskley, & Kirby, 2010). Taken together, the literature suggests that sound symbolism contributes to flavor perception not only through cultural learning or semantic priming but also through deeply ingrained, evolutionarily shaped associations. The brain appears to fuse auditory and gustatory inputs into a coherent perceptual experience, allowing external sound cues to influence how taste is interpreted. This framework complements crossmodal correspondence theory and offers a biologically plausible explanation for why sound-based interventions—such as sonic seasoning—can consistently alter flavor experiences in predictable ways.

4.9 General Summary

This chapter positions crossmodal correspondence as the central theoretical framework to explain how auditory stimuli, such as music, interact with taste perception. These correspondences refer to the systematic and often automatic associations people experience between features in different sensory modalities. However, this framework alone cannot fully account for the complexity and variability observed in multisensory experiences. The chapter integrates complementary perspectives—priming, emotional mediation, sensation transference, and sound symbolism to address this. Each offers distinct mechanisms contributing to our understanding of how music shapes taste. These theories highlight that crossmodal effects are neither fixed nor universal but dynamic and context-sensitive. A holistic perspective is, therefore, essential to capture the multidimensional nature of the interaction between music and taste. Table 4.1 presents a comparative summary of the theoretical frameworks discussed in this chapter, detailing the core mechanisms of each theory and their relevance to the interaction between music and taste perception.

Table 4.1 *Crossmodal Correspondence Summary and Comparison Table*

Theory	**What It Proposes**	**Example**
Crossmodal Correspondence	Refers to the systematic, often intuitive associations that people form between features in different sensory modalities. These correspondences may arise from statistical regularities in the environment, shared neural processing structures, linguistic patterns, or emotional associations.	High-pitched sounds are associated with sweetness or sourness, while low-pitched sounds correspond with bitterness or umami (Crisinel & Spence, 2010; Spence & Sathian, 2020).
Priming	Suggests that prior exposure to a sensory stimulus can unconsciously influence subsequent perception or behavior by activating cognitive or associative schemas.	French music increased the purchase of French wine, despite participants being unaware of the influence (North, Hargreaves, & McKendrick, 1999).
Emotional Mediation	Proposes that emotional responses evoked by stimuli in one modality (e.g., music) can influence how stimuli in another modality (e.g., taste) are perceived. Emotional congruence between modalities enhances this effect.	Soft and melodic music enhances the perceived sweetness of food (Guetta & Loui, 2017; Campinho et al., 2023).
Sensation Transference	Refers to the transfer of affective or perceptual impressions from one sensory modality to another. Originally linked to design and packaging, it has been extended to include sound and music.	Beer tasted with positively valenced music is rated as sweeter and more enjoyable (Reinoso-Carvalho et al., 2019).
Sound Symbolism	Describes non-arbitrary associations between sound features (e.g., pitch, timbre) and sensory impressions, grounded in evolutionary or structural mechanisms. These associations are thought to support early decision-making in food selection.	Words like “takete” are associated with bitterness and angularity, while “baluma” is linked to sweetness and roundness (Köhler, 1929; Crisinel et al., 2012).

5. THE INFLUENCE OF BACKGROUND MUSIC ON WINE PERCEPTION

5.1 Literature Review: The Relationship Between Wine and Music

Wine is a product with a well-defined sensory structure. Its evaluation typically relies on key attributes such as acidity, which creates a mouth-watering sensation on the sides of the tongue; alcohol, which adds a sense of heat and body; tannin, responsible for dryness and astringency especially in red wines; and body, which refers to the perceived weight or fullness of the wine in the mouth (Arroyo & Roberts, 2015). Ideally, these elements are balanced, forming the sensory profile that guides professional evaluation and everyday enjoyment (Koone et al., 2014). Suppose music can shift how sweetness or bitterness is perceived in other food and beverage categories. In that case, it raises whether it can modify how these structural wine attributes are experienced. For instance, could a particular musical piece enhance the sensation of the body in a light wine or suppress the perception of tannin in a bold red? Studies exploring music's effect on taste perception are beginning to address these possibilities. Yet, little is known about how such effects manifest specifically in the context of wine.

Recent research provides empirical support for these questions. For example, Burzynska (2018) demonstrated that specific auditory frequencies play a selective role in taste perception: higher-frequency sounds are reliably associated with sweet and sour attributes, whereas lower frequencies tend to evoke bitterness. This finding suggests that auditory cues can be strategically manipulated to accentuate or diminish particular gustatory experiences. Complementing these empirical results, Spence (2020) proposed a conceptual framework that advocates pairing wines with music to capture their intrinsic sensory character. He argues that wine consumption engages extensive neural processes, highlighting the complex interplay between auditory and gustatory systems. This perspective challenges conventional numerical scoring methods by suggesting that musical context may offer a more holistic evaluation of wine quality.

Further, Wang et al. (2019) employed the Temporal Dominance of Sensations (TDS) technique to elucidate the temporal dynamics of taste perception under different auditory conditions. Their study revealed that musical stimuli not only shift the temporal profile of key attributes, such as bitterness and acidity but also alter the overall sensory landscape of the wine. Specifically, acidity was perceived earlier on the palate when music was present, while tannin sensations were reported as more intense. In contrast, the perception of alcohol appeared to diminish. These findings underscore the importance of temporal sequencing in multisensory integration and suggest that music can actively unfold flavor experiences over time.

Expanding on taste modulation, Hauck and Hecht (2019) explored the crossmodal transfer of emotional qualities from music to flavor. Their controlled experiments involving complex beverages and simpler taste solutions showed that harmonious musical pieces enhanced perceptions of floral and delicate notes. At the same time, dissonant compositions tended to evoke bitterness or astringency. Notably, these effects were consistent across participants with varying levels of musical expertise, suggesting a broadly applicable auditory influence on taste evaluation.

In a complementary study, De Luca et al. (2019) examined musical genre's impact on wine tasting within a controlled experimental setting. Their results indicated that classical music heightened perceptions of delicacy and sweetness in Chardonnay, whereas high-volume pop music reduced the perceived alcohol content in Merlot. Although not all anticipated effects were observed, this study provides further empirical support for the nuanced role of auditory context in shaping sensory experiences.

Collectively, these recent studies provide robust evidence that auditory stimuli are integral to the multisensory evaluation of wine. By selectively enhancing or suppressing specific taste attributes and influencing the temporal progression of flavor perception, music emerges as a powerful modulator of sensory experience.

5.2 Experimental Design

In this study, we aim to retest earlier experiments by using the same musical selections tested previously (e.g., Wang et al., 2019), but substituting Kalecik Karası, a Turkish grape variety structurally similar to Pinot Noir, for the original wine. Our objectives are twofold: (1) to determine how background music influences specific wine attributes such as acidity, tannin and body and (2) to assess whether different music genres alter hedonic evaluations, thereby shaping the wine's overall character.

The experiment took place on Thursday, January 12, 2024, in the sensory analysis laboratory at Özyeğin University. Participation was voluntary, and those who joined received an additional three points toward their end-of-semester grades. Ethical approval (Code: 2024/16/18) was obtained from Özyeğin University's ethics committee prior to the study, and all relevant guidelines were strictly followed during the tasting session. Participants were informed of the tasting protocol in advance, including key instructions such as spitting the wine, drinking water between trials, refraining from conversation, and adhering to the structured flow of the experiment.

Data collection was conducted in two separate sessions: from 12:00 to 13:00 for the first group and from 16:00 to 17:00 for the second group. This schedule was necessary due to the sensory analysis class's maximum capacity of 25 participants. First, students tasted the wine under a no-music condition for three minutes and filled out the questionnaire. Then, Tchaikovsky's "Waltz of the Flowers" was played for three minutes while participants continued tasting and completed the survey questions. Throughout these tastings, participants were instructed to spit the wine into the sink in front of them, a precaution to prevent palate fatigue and cognitive impairment. Participants also sip water prior to tasting each wine so that their palate is clear away. Each condition was repeated three times for consistency. Please refer to Figure C.1 and Figure C.2 in Appendix C, for an overview of the figures of the research environment, including the tasting session with participants and the presentation of the wines.

5.2.1 Selection of Music

Two contrasting musical pieces were selected based on tempo, mode, and instrumentation variations. The first was Tchaikovsky's "Waltz of the Flowers" (Hauck & Hecht, 2019; North, 2012), which previous research has associated with making the wine seem softer, more subtle, and refined. This song is typically performed at a moderately lively waltz tempo (around 140–150 BPM), set in a major key (commonly D major), and arranged for a full orchestral ensemble. The instrumentation includes strings, woodwinds, brass, percussion, and a prominent harp passage.

North's (2012) research supports this selection, where a pilot study categorized preselected musical pieces using wine-relevant descriptors. Participants unanimously classified "Waltz of the Flowers" as "subtle and refined." This finding was further validated in a larger experiment involving 250 participants, which revealed that wines tasted while listening to this piece were described in alignment with its symbolic qualities. These consistent results underscore the music's capacity to evoke specific perceptual associations, making it a strong candidate for studies exploring crossmodal influences on sensory experiences.

Similarly, Hauck and Hecht (2019) conducted a follow-up investigation into how classical music evokes sensory associations, further validating the selection of *Waltz of the Flowers*. In their pilot study, *Waltz of the Flowers* was compared against contemporary musical pieces by Berg, Ligeti, and Stravinsky using multivariate analyses of variance (MANOVA). The results showed that *Waltz of the Flowers* scored highest on *global liking* (M = 7.72, SD = 1.78), and was therefore chosen for the main experiment. In the subsequent study involving 115 participants, those exposed to *Waltz of the Flowers* while tasting wine reported significantly higher *global liking* for the beverages (M = 4.45, SD = 1.39). Furthermore, this group described the wine as more *'harmonic,' 'mellow and soft'* compared to the control group.

The second selected piece, Mussorgsky's *"A Night on Bald Mountain"*, has also been utilized in wine and music studies exploring sound and taste interactions (Wang et al., 2019). This piece is typically performed at a faster tempo (around 121 beats per minute), set in a minor key, and features a large orchestral arrangement with a prominent emphasis on brass and percussion. Its dynamic shifts in orchestration, register, and loudness, coupled with the interplay of consonant and dissonant harmonies, create a darker, more intense auditory experience (Wang et al., 2019).

In their study, Wang et al. conducted a pre-test with 19 participants to examine the impact of Mussorgsky's composition on the perception of a light red wine (*Georges du Boeuf's Beaujolais-Village, 2014*). Results revealed that the music heightened perceptions of bitterness and intensified the tannin profile of the wine. A subsequent main experiment involving 39 participants confirmed these effects, demonstrating that the composition consistently influenced sensory perceptions, aligning with its intense auditory characteristics. Finally, a no-music condition served as a control group, allowing for a comparison of participants' sensory evaluations of the wine in the absence of auditory stimuli.

5.2.2 Wines

For this study, a DLC Kalecik Karası from Doluca Winery was used, generously provided by the producer. Kalecik Karası was chosen because it shares key structural similarities with Pinot Noir, a variety commonly used in previous research (Burzynska, 2018). Characterized by low-to-medium tannins, medium acidity, moderate alcohol, and a medium body, this was the sole wine employed during the tasting sessions. Participants were not informed about the grape variety or brand or told that the same wine would be served throughout. They were only advised that the study focused on exploring interactions between wine and music.

5.2.3 Participants

A total of 41 second-year Gastronomy and Culinary Arts/Hospitality students, enrolled in the Wine and Beverage course were initially recruited for the study. Two participants were excluded due to incomplete data, resulting in a final sample of 39 students (19 male, 20 female) ranging in age from 18 to 24 (M = 20.5). These students were selected because they possess prior experience with wine tasting and are familiar with evaluating attributes such as acidity, tannins, and body, a skill set deemed critical given that wine knowledge remains relatively limited in Turkey. Their familiarity with these wine attributes was expected to reduce the likelihood of random or uninformed responses.

5.2.4 Questionnaire

To assess the impact of background music on wine perception, participants completed a structured questionnaire. First, they provided demographic information, including age and gender. Following this, they rated the wine's acidity, tannin, and body on a 5-point Likert scale under both music and no-music conditions. Additionally, to examine whether music appreciation influenced wine perception, a hedonic evaluation was conducted. Participants rated their liking of the wine on a 10-point scale and similarly evaluated their enjoyment of the background music. To further explore the interaction between music and wine characteristics, they were also asked to assess how well the music matched the wine. A full version of the questionnaire can be found in the Appendix.

5.2.5 Procedure

Prior to the experiment, participants were thoroughly briefed on the procedure, and informed consent was obtained. The overall protocol and questionnaire items were explained step by step. Although students already possessed basic wine-tasting knowledge, fundamental terms such as tannin, acidity, and body were revisited. They were also reassured that any queries they had would be addressed. At the start of each tasting session, participants received a pour of the wine and then completed a questionnaire assessing both the wine and the music played during that segment. To evaluate wine attributes (e.g., acidity, tannin, body), a five-point Likert scale was employed—ranging from 1 (Low) to 5 (Full/High)—aligning with the WSET tasting assessment approach the students were already familiar with (i.e., 1 = Low, 2 = Medium−, 3 = Medium, 4 = Medium+, 5 = Full/High). This method was chosen to leverage the students' prior training in standardized wine evaluation.

Three tasting conditions were included: (1) no music, (2) Waltz of the Flowers, and (3) A Night on Bald Mountain. To ensure consistent audio quality throughout the experiment, all musical excerpts were played via a JBL Flip 6 Bluetooth speaker. Music was streamed from Spotify, and playback volume was set to a medium level. The volume for both musical pieces was matched as closely as possible. Although no precision sound-level meter was available to calibrate volume numerically, efforts were made to minimize discrepancies in loudness between tracks. This speaker was selected to deliver balanced sound reproduction in a classroom setting, ensuring that all participants could clearly hear the music during the tasting sessions. In accordance with established guidelines for a more accurate sensory analysis (Meilgaard, Carr, & Civille, 1999), each condition was repeated three times within a single session, leading participants to taste the same wine nine times overall—though they were not informed that the wine was the same throughout.

All statistical analyses were conducted using Stata 16. Descriptive statistics were computed to summarize participants' ratings. For ease of interpretation and comparability across attributes, all scores were rescaled to a 0–100 scale, following standard normalization procedures.

To evaluate the internal consistency of responses across repeated tastings, a repeated measures pairwise comparasion was performed. The analysis yielded no statistically significant differences between sessions, suggesting that participants' evaluations remained stable over time and were not systematically affected by order effects or fatigue. Please refer to Appendix C for the results. This stability enhances the reliability of the perceptual judgments obtained during the tasting sessions.

Two additional questions addressing the music were incorporated, each rated on a 0–10 scale: (a) “How much do you like the music you are listening to now?” (0 = Not at all, 10 = Like it very much), and (b) “How well does the music match the wine?” (0 = Not at all, 10 = Like it very much). These measures aimed to capture participants’ hedonic responses to the music and to assess potential interactions between the auditory components and the wine’s perceived attributes.

5.3 Results

Background music influences wine perception through both direct and indirect mechanisms. The direct effect occurs independently of individual music preference, shaping wine perception in real-time as the music is played. In contrast, the indirect effect is more closely linked to hedonic evaluation, meaning that as participants’ appreciation of the background music increases, their perception of specific wine characteristics may shift accordingly.

5.3.1 Direct Effects of Music on Wine Perception

In the first stage of the analysis, we focused on the direct effect of music on wine perception. Participants tasted the same wine under three conditions: silence (control group), Waltz of the Flowers, and A Night on Bald Mountain. The aim was to assess whether background music alone—without any comparative tasting or pairing—could alter the way wine characteristics were perceived. The Table 5.1 below shows the percentage change in sensory ratings (acidity, tannin, and body) compared to the control group. In other words, it illustrates how each musical condition shifted participants’ evaluations relative to the no-music baseline. Although the original data were collected on a 5-point Likert scale, results are expressed as percentage differences to provide clearer interpretation of the musical impact. These values were derived from the ordinary least squares (OLS) regression results, allowing for a clearer visualization of how background music affected specific sensory attributes of the wine.

Table 5.1 *Percentage Change in Perceived Wine Attributes across Music Conditions*

	Acidity	**Tannin**	**Body**
Waltz of the Flowers	1.709	7.265	7.051
	(4.346)	(3.845)	(0.163)
A Night on Bald Mountain	2.564	**8.974***	(4.087)
	(4.346)	(3.845)	(0.163)
Control Group	37.82***	44.23***	37.50***
	(3.073)	(2.719)	(2.890)
N	117	117	117
adj. R^2	-0.014	0.034	0.010
Standard errors in parentheses * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$			

According to Table 5.1, acidity among participants who listened to *Waltz of the Flowers* rose by about 1.7%, but this difference is not statistically significant. Similarly, when looking at *A Night on Bald Mountain*, we see a 2.56% increase in acidity, which also does not reach statistical significance. Hence, neither piece of music appears to affect acidity perception meaningfully. Turning to body, Waltz of the Flowers yielded around a 7% rise, while A Night on Bald Mountain showed a 5.02% increase, both of which did not achieve statistical significance.

Participants who listened to Waltz of the Flowers gave wines a 7.26% higher acidity rating, which was not statistically significant. In contrast, those who listened to A Night on Bald Mountain perceived roughly a 9% increase in tannin, a difference that proved significant. Taken together, these findings suggest that only the tannin dimension is significantly influenced by *A Night on Bald Mountain*, while acidity and body remain unaffected under both music conditions.

5.3.2 Indirect Effects and Mediating Factors

Moreover, our findings suggest that listeners' enjoyment of background music can influence how they perceive wine. Table 5.2 presents the indirect effects, showing how the degree of liking for the music affected the perceived characteristics of the wine. When participants liked *Waltz of the Flowers* more, there was no meaningful change in acidity, tannin, or body. However, higher appreciation for *A Night on Bald Mountain* did not affect acidity but was linked to a 7.36% increase in perceived tannin and an 8% increase in body. These results suggest that musical enjoyment, depending on the piece, may subtly shape how certain wine attributes are experienced—particularly those related to structure, such as tannin and body.

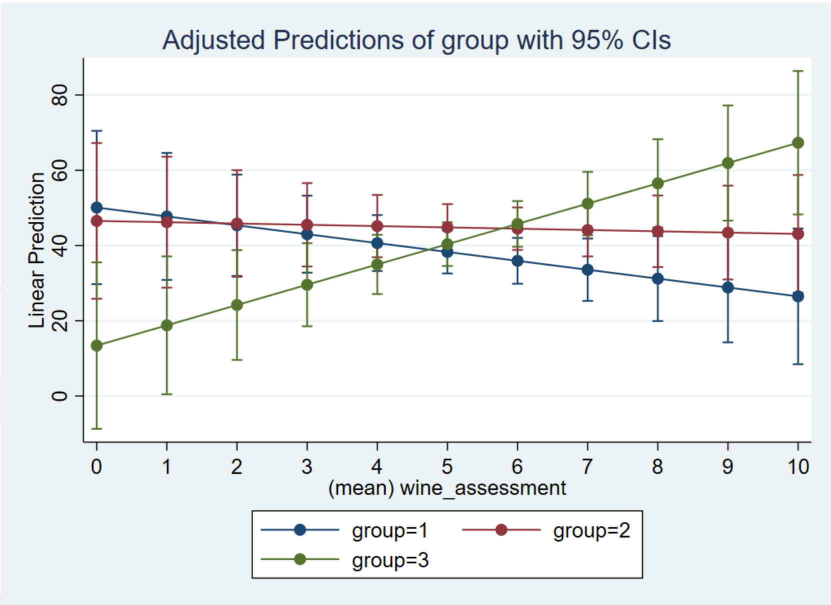
Table 5.2 *Indirect Effects of Music on Wine Attribute Ratings (%)*

	Mean Acidity	**Mean Tannin**	**Mean Body**
Waltz of the Flowers	3.350	1.799	2.016
	(2.780)	(2.396)	(2.546)
A Night on Bald Mountain	4.147	**7.360****	**7.753****
	(2.979)	(2.568)	(2.728)
Control Group	46.87***	59.37***	50.09***
	(11)	(9.682)	(10)
N	117	117	117
adj. R^2	-0.017	0.081	0.059

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Figure 5.1 below represents the adjusted predictions of wine body ratings across three groups: Control intervals. The x-axis represents participants' ratings of how much they liked the wine (hedonic liking, from 0 to 10), while the y-axis shows the predicted body ratings.

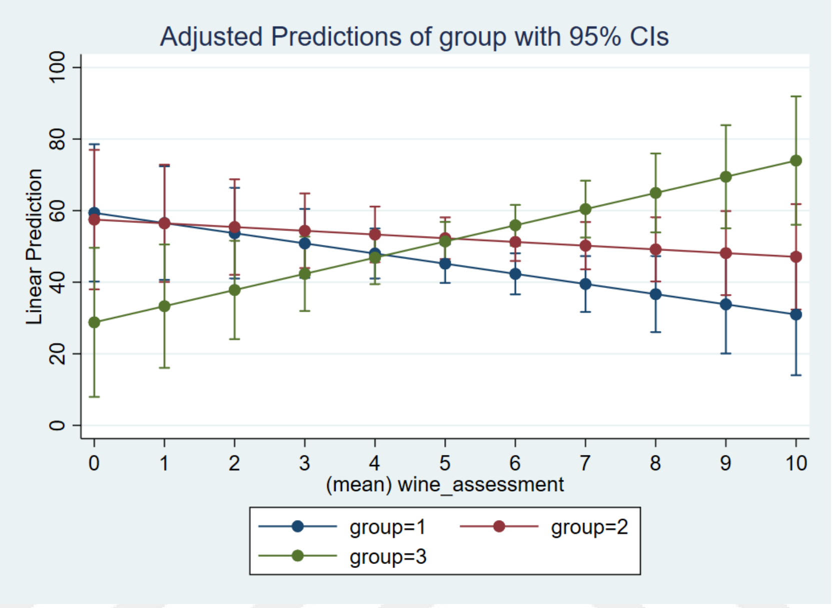
Figure 5.1 *Adjusted Prediction of Wine Body Ratings across Three Groups*



For all groups, there is a general relationship between how much participants like the wine (x-axis) and the perceived body (y-axis). As wine liking increases, the predicted body rating tends to increase, particularly for *A Night on Bald Mountain*. The Waltz of the Flowers group also shows a fairly stable trend, with only a slight upward slope. While body ratings increase slightly as wine liking increases, the change does not significantly differ from the control group. This implies that Tchaikovsky's music does not strongly enhance the perceived body of the wine, even for participants who liked the wine more.

The A Night on Bald Mountain group displays the steepest upward trend, indicating a stronger relationship between wine liking and body perception. The steep slope and larger separation from the control group reflect the statistical results (interaction term 0.310, p < .01) and demonstrate that this effect is not due to chance. As a result, for participants who liked the wine more the predicted body ratings increased sharply compared to the control and *Waltz of the Flowers* groups. Moreover, Figure 5.2 visualizes the adjusted predictions of tannin ratings across three groups.

Figure 5.2 *Adjusted Predictions of Tannin Ratings across Three Groups*



The A Night on Bald Mountain group (green line) exhibits the steepest slope, indicating that higher enjoyment of the wine corresponds to a significant increase in perceived tannins. In contrast, the Waltz of the Flowers group (red line) shows only a slight upward trend, suggesting that while some participants rated tannins slightly higher when enjoying the wine, the effect was minimal. The control group (blue line) remains stable, reinforcing the idea that musical influence varies based on its emotional and sensory association.

In conclusion, in terms of direct effects, the results show that *A Night on Bald Mountain* significantly increased the perceived level of tannin by approximately 9%, while it did not produce a statistically significant change in body or acidity. *Waltz of the Flowers*, on the other hand, did not lead to any significant shifts in the wine's structural attributes. Regarding indirect effects, participants who liked *A Night on Bald Mountain* more tended to rate the wine as fuller in body and higher in tannin. Specifically, hedonic appreciation of this music corresponded to a 7.36% increase in perceived tannin and an 8% increase in body—both statistically significant. No such indirect effect was observed for *Waltz of the Flowers*, as higher liking for this piece did not lead to any significant change in the evaluation of wine characteristics.

5.4 Discussion

The primary goal of this study was to examine how background music influences consumers' wine evaluations. In the experiment, participants tasted the same wine under three conditions: without music and with two different music tracks that had been used in prior studies. Each condition was repeated three times, and the results consistently showed similar patterns across all repetitions. This consistency indicates that the findings are statistically congruent and unlikely to be random.

The selected music tracks were cross-modally congruent with specific wine characteristics and simultaneously influenced the hedonic ratings of the music, which in turn shaped participants' perceptions of the wine. These findings confirm both research questions: that background music influences specific wine attributes, particularly tannins (RQ1) and that different music genres alter hedonic evaluations, thereby shaping the wine's body and tannin (RQ2). However, neither music exposure nor hedonic ratings of music produced significant changes in the perceived acidity of the wine.

We conducted descriptive analyses, tested for significant differences across the three tasting rounds, and performed regression analyses that included interaction effects and average marginal effects (AME). To the best of our knowledge, this study is the first to investigate these effects among Turkish consumers.

When examining the crossmodal effects between music and wine, we first consolidated the data from three tasting repetitions to ensure consistency and reliability. Following this, we analyzed the differences among the experimental groups. Participants who listened to "*Waltz of the Flowers"* and *sh*owed no significant *differences in their ratings for acidity, body and tannins.* In previous studies, "*Waltz of the Flowers"* was associated with making wines seem "subtle and refined," "harmonic," "mellow," and "soft" (North, 2012; Hauck and Hecht, 2019). However, to the best of our knowledge, no prior research has examined whether these effects influence the actual sensory profile of the wine. In our study, while "*Waltz of the Flowers"* did not significantly impact the acidity, body, or tannins of Kalecik Karası.

Furthermore, participants who listened to *"A Night on Bald Mountain"* consistently rated the wine as having higher tannin levels compared to the control group across all three trials, with no significant differences in acidity or body. This finding aligns with previous studies (Burzynska, 2018; Wang et al., 2019), which also reported that *"A Night on Bald Mountain"* increased perceived tannin levels in light red wine. Furthermore, our findings demonstrate that background music can shape wine perception. While the light and uplifting tones of *Waltz of the Flowers* did not significantly alter the wine's characteristics, listeners who enjoyed the darker, more intense composition of *A Night on Bald Mountain* appeared to transfer this preference onto the wine itself, leading to an 8% increase in perceived body and a 7% rise in tannin. These results align with Charles et al. (2013), who suggested that red wines pair more effectively with music in a minor key or emotionally darker compositions, as they do not harmonize well with more upbeat pieces like *Waltz of the Flowers*.

6. CONCLUDING REMARKS AND FUTURE DIRECTIONS

6.1 Conclusion

This study highlights the transformative role of music in shaping multisensory gastronomic experiences, demonstrating how auditory stimuli can influence taste perception without altering the physical properties of food. At its core, this is what gastrophysics is concerned with is how the senses interact, and how these interactions can be directed to enhance what we eat and drink. While taste has often been studied in isolation, it rarely occurs alone. It is shaped by what we see, hear, smell, and feel, sometimes in ways we are not fully aware of.

Music, among all sensory inputs, offers a unique opportunity: it is inexpensive, easy to modify, and highly accessible. Unlike changing a plate's texture, lighting in a room, or packaging material, adjusting music requires no physical contact with the product. This makes it one of the most pragmatic entry points for exploring crossmodal interactions in real-world settings.

Within this framework, the study explored whether background music influences how wine is perceived, using Kalecik Karası as a representative Turkish varietal. Although similar studies have been conducted in other cultural contexts, this research marks the first attempt to replicate such effects with Turkish consumers and a locally produced wine. The findings suggest that musical stimuli can selectively amplify specific wine attributes. A Night on Bald Mountain, for instance, led to a measurable increase in perceived tannin and body. These shifts occurred despite the wine remaining unchanged, indicating that auditory cues alone can modulate structural taste characteristics. In contrast, Waltz of the Flowers had no significant impact on the same parameters, highlighting the selective and stimulus-dependent nature of such effects.

Beyond direct sensory shifts, the results also confirmed the influence of hedonic responses. Participants who reported higher enjoyment of the music were more likely to evaluate the wine as fuller-bodied and richer in tannin. This supports the idea that affective engagement can mediate crossmodal interactions, reinforcing findings from previous literature on emotion-taste transfer.

By extending earlier research into a new cultural and sensory setting, this study offers two key contributions. First, it demonstrates that the modulation of taste by music is not limited to Western European samples or internationally distributed wines. The same principles apply in Turkey, with a local grape and a local participant group. Second, it affirms the relevance of music as a practical sensory input for shaping consumer experience. These results are particularly relevant for practitioners in hospitality and food and beverage sectors, where contextual elements such as sound may influence how products are evaluated and remembered.

While this study focused on auditory cues, the broader implications point to a more integrated understanding of multisensory dining. Future research could examine how auditory stimuli interact with other sensory modalities such as lighting, texture, or olfaction, and how these combined effects might enhance the overall dining experience or reveal latent dimensions of a wine's sensory profile. Ultimately, the research findings demonstrate that gastrophysics' core principle is correct because tastes emerge dynamically from sensorial interactions with the environmental conditions at each present moment.

6.2 Multisensory Insights for the Wine Industry

Consumer experiences with products are increasingly understood as multisensory in nature, shaped not only by visual appearance but also by a complex interplay of sounds, textures, aromas, and flavors. These sensory inputs are integrated through direct bodily engagement, producing emotionally salient experiences that influence how products are evaluated, remembered, and re-engaged with (Brochado, Stoleriu, & Lupu, 2021; Heide & Grønhaug, 2006). Emotional connection and pleasure are critical to consumer satisfaction, particularly in the context of food and beverage consumption (Joo, Kim, & Hwang, 2023). As a result, hospitality professionals must consider the full sensory environment in which products are delivered, including ambient sound. In this context, the contribution of music as a sensory cue has become especially salient. Over the past decade, the intersection of sound and taste has been investigated with growing empirical and conceptual depth, shedding light on how auditory stimuli modulate the perception of food and beverages (Reinoso-Carvalho et al., 2020). In particular, wine has emerged as a focal product in this line of inquiry, due to its rich complexity and sensitivity to contextual variation (Campo, Reinoso-Carvalho, & Rosato, 2021).

Applied to the wine industry, findings open several concrete opportunities. First, wineries may curate auditory environments or playlists that reinforce the structural properties of their wines, thereby enriching the overall tasting experience. Second, these insights can be integrated into training and education programs for sommeliers and staff, who can learn to identify how inappropriate music may obscure key sensory elements of a wine. Third, when consumers evaluate a wine negatively, repositioning that product within a different sensory context—particularly one with emotionally congruent music—may reframe their impression and strengthen their long-term connection with the brand.

From a theoretical perspective, these observations support previous research by Reinoso-Carvalho et al. (2020), who emphasized the emotional mediating role of music in crossmodal correspondences. The results of this study further suggest that emotions may represent a distinct subclass of crossmodal interaction, not merely an additive layer but a structural component shaping how music and taste are integrated. Accordingly, designing multisensory experiences in wine contexts requires both perceptual alignment and emotional congruency to achieve a coherent and satisfying result. These insights contribute to an expanded understanding of the gastro-psychological and atmospheric factors shaping wine consumption. They also offer an actionable path for professionals aiming to translate sensory science into practice, reaffirming the value of a multisensory design approach in premium and everyday consumption experiences.

6.3 Limitations and Future Work

It is worth stressing that the present study has several limitations. This study has several limitations that should be addressed in future research. First, the relatively small sample size (n = 39, including the control group) may have influenced the results due to individual differences in taste perception. Although the experiment was repeated three times to improve reliability, all repetitions were conducted on the same day. A more robust approach would involve tastings on different days while maintaining the same conditions. Future studies should expand the sample size and introduce repeated testing across multiple sessions to account for variations in sensory perception over time.

Second, participants were university students (18–24) with wine education but limited exposure to various wines. Less experienced tasters tend to provide less consistent ratings than experts (Tempere et al., 2016), which could have contributed to variability in the results. Additionally, analyzing only overall averages may overlook essential differences between subgroups, highlighting the need for segmentation in future research (Köster & Mojet, 2015). Future research should include a more diverse sample of age, experience, and cultural background to examine whether wine expertise influences cross-modal interactions.

Third, cultural differences may have played a role in auditory-taste associations. While Western listeners often link high-pitched sounds with sweetness due to linguistic and musical traditions, individuals from other backgrounds may not share the same associations (Knoeferle et al., 2015). This is particularly relevant in studies using Western classical music, such as *A Night on Bald Mountain* or *Waltz of the Flowers*, which may evoke different emotional and sensory responses depending on familiarity. Variations in musical exposure, food preferences, and dining traditions could explain inconsistencies in crossmodal effects (Spence et al., 2010). Future studies should test these effects across different cultural groups and incorporate a broader range of musical styles to determine whether these associations are universal or culturally specific.

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APPENDICES

APPENDIX A. SURVEY QUESTIONS

1. Rate the following wine characteristics on a scale of 1 (Low) to 5 (High):

	1 (Low)	2	3	4	5 (High)
Acidity	☐	☐	☐	☐	☐
Tannin	☐	☐	☐	☐	☐
Body	☐	☐	☐	☐	☐

2. How much do you like the wine? ***(0 = Not at all, 10 = Like it very much)***

0	1	2	3	4	5	6	7	8	9	10
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

3. How much do you like the music you are listening to now? ***(0 = Not at all, 10 = Like it very much)***

0	1	2	3	4	5	6	7	8	9	10
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

4. How well does the music match the wine? ***(0 = Not at all, 10 = Like it very much)***

0	1	2	3	4	5	6	7	8	9	10
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

APPENDIX B. DESCRIPTIVE STATISTICS AND RELIABILITY TESTS

Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Acidity	117	39,25	19,06	0,00	75
Tannin	117	49,64	17,28	16,67	100
Body	117	41,52	18,14	0,00	87,5
Wine like	117	5,50	1,54	1,33	9

Reliability Tests / Pairwise Comparisons - Tukey HSD Results

Acidity

Round	Contrast	Std. Err.	t	p-value
2 vs 1	-0,02	0,15	-0,11	0,99
3 vs 1	0,02	0,15	0,11	0,99
3 vs 2	0,03	0,15	0,21	0,98

Tannin

Round	Contrast	Std. Err.	t	p-value
2 vs 1	0,03	0,14	0,24	0,97
3 vs 1	0,15	0,14	1,04	0,55
3 vs 2	0,11	0,14	0,80	0,70

Body

Round	Contrast	Std. Err.	t	p-value
2 vs 1	-0,05	0,14	-0,33	0,94
3 vs 1	0,16	0,14	1,10	0,51
3 vs 2	0,20	0,14	1,43	0,33

Wine Like

Round	Contrast	Std. Err.	t	p-value
2 vs 1	-0,21	0,28	-0,74	0,74
3 vs 1	-0,10	0,28	-0,36	0,93
3 vs 2	0,11	0,28	0,38	0,92

APPENDIX C. FIGURES

Figure C.1 *Experimental Setup: JBL Speaker and Wine Samples Covered with Foil to Prevent Visual Bias During Tasting*

Figure C.2 *Participant Engaged in Sensory Evaluation of the Wine Sample under Auditory Conditions*