# Acoustic Influences on Consumer Behavior

## Empirical Studies on the Effects of In-Store Music and Product Sound

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# Summary

Sound forms an essential part of consumers' daily interaction with companies, brands, and products, often influencing their cognitive processes, their emotions, and their behavior. However, while marketing-relevant sounds are ubiquitous, studies examining their impact on consumers are rare. In order to contribute to a broader understanding of auditory influences on consumer behavior, the present dissertation examines the effects of product-related sounds and of music at the point of sale. The findings are summarized in five articles.

In the first article, a field experiment is reported in which two structural properties of in-store music (tempo and mode) are manipulated in a department store, and the interactive effect of these variables on actual sales volume is measured. Qualifying previous research that suggests a positive influence of slow tempo, a significant interaction between tempo and mode indicates that slow music only results in increased sales when paired with minor mode.

The second article deals with crossmodal influences of product sounds on consumers' taste perceptions. Results of two experiments suggest that a systematic pleasantness manipulation of a product sound biases subsequent taste evaluations. Specifically, participants perceive the taste quality of coffee to be higher after being exposed to a pleasant (versus unpleasant) sounding coffee machine. The effect is strongest for consumers who express greater enjoyment for product sounds.

Switching from a consumer- to a management-oriented perspective, the third article proposes a novel approach that enables marketers to effectively employ customer insights to guide product sound design. The new multi-step approach is introduced and discussed by describing a research collaboration with a coffee machine manufacturer.

The fourth article examines consumers' differential reactions to acoustic product design. Based upon the notion that consumers differentially evaluate and appreciate, as well as diagnostically utilize product-related sounds, a new construct and a corresponding scale are developed and validated in a series of four studies.

The fifth article is a reduced version of the first article. It is based on the same dataset and has been published in conference proceedings.

# Zusammenfassung

Klang ist ein wichtiger Bestandteil der täglichen Interaktion von Konsumenten mit Unternehmen, Marken und Produkten, und beeinflusst häufig kognitive Prozesse, Emotionen und Verhalten. Trotz der Allgegenwart von marketingrelevanten Klängen sind Studien zu ihrer Wirkung auf Konsumenten allerdings selten. Um zu einem besseren Verständnis von akustischen Einflüssen auf das Konsumentenverhalten beizutragen, untersucht die vorliegende Dissertation die Wirkung von In-Store-Musik und von Produktgeräuschen. Die Ergebnisse sind in fünf Artikeln zusammengefasst.

Der erste Artikel beschreibt ein Feldexperiment, in dem der Effekt zweier struktureller Eigenschaften von In-Store-Musik (Tempo und Tongeschlecht) auf den Umsatz untersucht wird. Während frühere Studien einen positiven Einfluss von langsamem Tempo auf den Umsatz berichten, relativieren die vorliegenden Ergebnisse diese Annahme: Ein signifikanter Interaktionseffekt zwischen Tempo und Tongeschlecht zeigt, dass langsames Tempo nur in Moll-Tonarten zu höheren Umsätzen führt.

Der zweite Artikel beschäftigt sich mit sinnesübergreifenden Einflüssen von Produktgeräuschen auf die Geschmackswahrnehmung. Die Ergebnisse zweier Experimente zeigen, dass Individuen die wahrgenommene Geschmacksqualität von Kaffee höher bewerten, wenn die zur Zubereitung genutzte Kaffeemaschine angenehm (versus unangenehm) klingt. Der Effekt ist am stärksten ausgeprägt bei Konsumenten, denen das Hören von Produktgeräuschen Vergnügen bereitet.

Der dritte Artikel präsentiert einen neuartigen Ansatz, der es Marketingmanagern erlaubt, durch Kundenwissen zur Optimierung des Produktsounddesigns beizutragen. Zur Veranschaulichung und Diskussion der mehrstufigen Herangehensweise wird eine Forschungskooperation mit einem Kaffeemaschinenhersteller beschrieben.

Der vierte Artikel beschäftigt sich mit interindividuellen Unterschieden in der Reaktion auf akustisches Produktdesign. Basierend auf der Annahme, dass Konsumenten Produktgeräusche in unterschiedlicher Weise beurteilen, wertschätzen und zur Produktbewertung nutzen, werden ein neues Konstrukt und eine dazugehörige Skala in einer Reihe von vier Studien entwickelt und validiert.

Der fünfte Artikel ist eine reduzierte Version des ersten Artikels. Er basiert auf demselben Datensatz und wurde in einem Konferenzband veröffentlicht.

## Article I

Knöferle, K. M., Herrmann, A., Landwehr, J. R., & Spangenberg, E. R. (second round, minor revisions needed). It Is All in the Mix: The Interactive Effect of Music Tempo and Mode on In-Store Sales. *Marketing Letters*.

# It Is All in the Mix: The Interactive Effect of Music Tempo and Mode on In-Store Sales


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## Abstract

Though practitioners have relied on *tempo* as a criterion to design in-store music, scant attention has been devoted to the *mode* of musical selections, and no consideration has been given to the potential for the interactive effects of low-level structural elements of music on actual retail sales. The current research reports a field experiment wherein the positive main effect of slow tempo on actual sales reported by Milliman (1982, 1986) is qualified by musical mode. A significant interaction between tempo and mode was evidenced, such that music in a major mode did not vary in effectiveness by tempo, while music in a minor mode was significantly more effective when accompanied by a slow tempo. That is, the Milliman effect was eliminated for music in a major mode. Implications of our findings and directions for further research are presented.

# Introduction

Recognizing the potential for music to influence individual affect, cognition, and behavior which in turn impacts consumer behavior and decision making, marketers invest substantial resources in an effort to effectively incorporate music into the design of retail environments (e.g., Morrison & Beverland, 2003). Considerable research in the field of atmospherics has examined the effects of high level, global properties of music including music versus no-music comparisons (Park & Young, 1986), background versus foreground conditions (Morrison, Gan, Dubelaar, & Oppewal, 2011; Yalch & Spangenberg, 1993), and comparisons of the effects of differing musical genre (Areni & Kim, 1993; North, Hargreaves, & McKendrick, 2000; North, Shilcock, & Hargreaves, 2003). Related research has focused on properties not inherent to music itself, but to variables arising either from the interplay between music and the environment (e.g., interaction between music and scent; Spangenberg, Grohmann, & Sprott, 2005; fit of music and store image; Vida, Obadia, & Kunz, 2007), or the interplay between music and participant (e.g., musical preferences; Caldwell & Hibbert, 2002; subjective liking; Vida et al., 2007; shopper's familiarity with the music; Yalch & Spangenberg, 2000). For comprehensive reviews of previously identified effects of music in a marketing context, see Kellaris et al. (2008), Garlin and Owen (2006), Hargreaves and North (1997), as well as Turley and Milliman (2000).

Little research, however, has studied the direct relationship between low-level, structural properties of in-store music and outcome variables. Milliman's (1982) seminal work examining the effects of a structural property – tempo – of musical selections on supermarket shoppers' behaviors, including spending, unfortunately did not stimulate a large stream of follow-up research. In fact, to our knowledge, there is no published work to date examining the combined impact of more than one structural property of music on consumer responses in a realistic field setting. This dearth of research represents a gap in our understanding, often leaving those designing and selecting environmental music reliant on little more than partially-informed guesswork with regard to music's structural properties. It can be argued that knowledge regarding the effects of low-level musical properties – which are considered the building blocks used by composers and musicians, as well as prerequisites to higher-level musical properties like genre, fit, or liking – is critical to the systematic design of effective in-store music.

The current research begins to address this gap in our knowledge by examining how the mode and tempo of environmental music affects sales in a retail context. Although in-store music has attracted much “applied” research activity over the past 30 years, the experiment reported herein is the first to demonstrate both main and interactive effects for the two low-level structural properties of music, tempo and mode. Further, we extend laboratory findings regarding structural properties of music to real-world consumer decision making with actual financial implications. Knowledge about the impact of the structural properties of music can facilitate scientific selection of effective in-store music, thereby enabling practitioners to move beyond guessing or relying on intuition.

Below, we summarize previous research regarding how selected structural properties of in-store music may impact consumer behavior. Following that, a field experiment wherein tempo and mode of musical selections are manipulated and effects upon actual retail sales are measured is reported. Finally, implications of our findings as well as avenues for future research are discussed.

## Background and Research Questions

### Structural Properties of Music

Music is categorized by the objective structural properties of time, pitch, and texture (Bruner, 1990). Examples of properties along the time dimension are tempo, meter, rhythm, and phrasing, while the pitch dimension includes the properties of mode, harmony, melodic contour, and ambitus. The dimension of texture includes timbre – a complex function of log attack time, spectral centroid, and spectral flux (McAdams, Winsberg, Donnadieu, De Soete, & Krimphoff, 1995) – as well as instrumentation, volume, and dynamics. To the composer, musician, or sound designer, these properties provide the means to systematically change the overall nature of the music. On the listener’s side, relative property configuration not only determines cognitive and affective responses to music, but also influences physiological responses such as respiration, skin conductance, and heart rate (Gomez & Danuser, 2007).

Although empirical evidence is sparse, tempo and mode may be particularly important determinants of listeners’ responses to music with regard to consumer behavior (Kellaris & Kent, 1991). Tempo refers to the speed or pacing of a musical piece measured in beats per minute (BPM), whereas mode is a musical variable that defines the specific configuration of musical intervals used within a scale, a chord, or a piece of music (Sadie & Tyrrell, 2001). The ability to perceive and process these characteristics is often considered universal or *hard-wired* in human beings. In light of recent research, these two properties appear to be distinctive attributes of virtually all music, operating independently of geographic or other cultural contextual variance (Bowling, Gill, Choi, Prinz, & Purves, 2009; Fritz et al., 2009; Harwood, 1976). In fact, virtually every piece of music consists of a series of musical events in time, which – like any other event occurring in time – follow each other in a particular tempo. Similarly, virtually every piece of music exhibits a kind of underlying tonal system comprising its tonal structure (i.e., mode). We now turn to a discussion of the potential effects of each of these musical elements on customer response.

## Effects of Tempo

Research from the fields of musicology, psychology and consumer behavior suggests that tempo is one of the most important determinants of human response to music. The high impact of tempo (i.e., the rate of events in time) may stem from the fact that tempo is applicable not only to music but to a wide range of experiential contexts and that the ability to process music tempo is acquired early in life (Dalla Bella, Peretz, Rousseau, & Gosselin, 2001).

Tempo is strongly correlated with arousal. Fast (slow) music has been shown to raise (lower) listeners' self-reported arousal levels (Balch & Lewis, 1996; Chebat, Chebat, & Vaillant, 2001; Husain, Thompson, & Schellenberg, 2002; Kellaris & Kent, 1993). Further, the effect of tempo on self-reported arousal is reflected in bodily responses to tempo; fast music can increase physiological variables such as heart rate, blood pressure, and breathing rate (Lundin, 1985).

Tempo of music can also affect time perception. Oakes (2003) showed that time spans filled with slower music are perceived to be shorter than those filled with faster music. Theoretically, these findings can be explained with recourse to a memory-based "storage size" model of temporal perception. This model postulates that an increase in tempo (i.e. an accelerated frequency of musical events) corresponds to an increase in cognitive data load. The larger the data load to be processed, the larger the allocated memory space and the longer the perceived duration associated therewith (Oakes, 2003).

Importantly, a now classic pair of field studies by Milliman (1982, 1986) examined the effects of music varying in tempo on actual customer behavior. Milliman's (1982) first study found slower music to decrease pace of in-store traffic flow in a supermarket, thereby leading to greater sales, whereas fast music accelerated pace of in-store traffic flow corresponding to lower sales. Milliman's (1986) second published study similarly found that patrons spent more time in a restaurant and consumed more alcoholic beverages under conditions of slow (relative to fast) tempo environmental music.

Thus, existing research raises obvious research questions regarding effects of tempo on customer perceptions and behavior. Can we replicate the Milliman effect, and if so, what structural element(s) of music might interact with tempo? We turn now to one such structural element – musical mode – which may also impact consumer behavior.

## Effects of Mode

Although many different tonal systems are known and have been used by musicians across different times and cultures (e.g., pentatonic or atonal scales), the major and minor modes (featuring a major versus a minor third, respectively) have been the predominant tonal systems for several centuries in Western music (Meyer, 1956). [Hereinafter the term "mode" refers to the major and minor modes.] Previous research regarding mode gives rise to several lines of argument resulting in potentially conflicting predictions when considered in the context of retail atmospherics and consumer behavior.

In Western music, the major and minor modes are known to be strong indicators of positive and negative affective valence (i.e., perceived sadness or happiness) (Gagnon & Peretz, 2003; Hevner, 1935; Peretz, Gagnon, & Bouchard, 1998). From a developmental perspective, mode appears to be mastered later than tempo as a cue to music valence: At the age of six years, children begin to use both tempo and mode to infer the valence of a piece of music, whereas younger children rely solely on tempo in their valence ratings, or they are simply unable to distinguish happy from sad music (Dalla Bella et al., 2001). In addition to being a cue to certain affective states, mode has also been shown to induce mood in listeners (Webster & Weir, 2005). In a laboratory experiment conducted by Husain et al. (2002), listening to a piece of music in major mode changed participants' moods in a positive direction, whereas listening to the same piece of music in minor mode had a negative effect on participants' moods. Given prior research on atmospherics showing a positive correlation between mood and customer behavior (Donovan & Rossiter, 1982), these findings suggest that music in a major mode (i.e., positively valenced) could lead to greater sales than music in a minor mode (i.e., negatively valenced).

While recent limited evidence suggests that mode may not impact temporal perceptions (Droit-Volet, Bigand, Ramos, & Bueno, 2010), work in consumer psychology supports the idea that mode influences listeners' temporal perceptions. Kellaris and Kent (1992) found that time spans filled with music in minor mode are perceived as shorter than spans filled with music in major mode. Thus, shoppers exposed to music in minor mode may underestimate actual time spent in a store while those exposed to music in major mode may overestimate perceived time spent. Subjective under- and over-estimations of time can affect actual time spent in a store (Yalch & Spangenberg, 2000), thereby leading to respectively prolonged or shortened shopping trips. Important to retailers of course is the fact that customers spending more time in a store are more likely to interact with sales personnel, make a greater number of unplanned purchases, and spend more money (Donovan & Rossiter, 1982; Inman, Winer, & Ferraro, 2009).

In summary, there is not an overwhelming amount of evidence or theory to suggest specific effects of musical mode on consumer behavior. However, some evidence for an effect of mode exists, and research in atmospherics research has shown positive correlations between customer mood, store evaluation, actual time spent in the store and spending (Donovan & Rossiter, 1982). Thus, a further research question we explore herein regards what might be the effect of mode on consumer behavior.

## Interactive Effects of Mode and Tempo

Shoppers are assailed by a host of sensory impressions in retail environments and, although theoretically interesting and normatively important, interaction of various atmospheric variables has received little research attention. Receiving even less research consideration has been the interaction of specific characteristics (or structural elements) of a single environmental cue such as music.

Past theoretical discussion (Bruner, 1990) as well as empirical research across the disciplines of marketing (Kellaris & Kent, 1991), psychology (Webster & Weir, 2005), and music (Husain et al., 2002) suggests that there may well be normatively significant interaction effects between characteristics of music on customer responses. The work of these several scholars suggests that mode and tempo specifically may have an interactive effect on listener response variables. In the shopping environment, combinations of musical features which can be easily processed should logically put customers at ease, affect their perceptions of the environment, and perceptions of both perceived and actual shopping times, thereby increasing approach behaviors (e.g., sales). In many instances, people seem to prefer certain combinations of tempo and mode (e.g., *minor-slow* or *major-fast*) to others (e.g., *minor-fast*). For example, Husain et al. (2002) found fast tempo music led to greater enjoyment ratings in a major mode, whereas slow tempo music led to greater enjoyment in a minor mode. The authors speculate that this may be due either to learned associations of certain typical combinations of mode and tempo, or to mode-specific critical speeds. These findings suggest a research question regarding the interactive effect of musical tempo and mode on consumer response. That is, the typical combinations of slow tempo and minor mode, as well as fast tempo and major mode could increase sales volume, while less typical combinations of tempo and mode would correspondingly decrease sales volume.

Our research questions were examined in a field experiment that was conducted in an actual retail setting wherein the structural elements of musical mode and tempo were manipulated and measured while controlling or accounting for exogenous variables.

## Experiment

Music was experimentally manipulated through synchronous playback in three urban locations of a large Swiss department store chain offering a broad range of premium products involving fine foods, wine, clothing, house wares, and accessories. Actual gross sales constituted the dependent measure of consumer response in the field experiment. The three stores had each been open for several decades, and thus had relatively stable customer bases. A 2 (mode: minor vs. major) × 2 (tempo: slow vs. fast) full factorial, repeated-measures design was implemented.

## Procedure

The main experiment took place over four weeks between May 14 and June 10, 2010, a period selected to avoid spring and summer holiday periods as store locations were potentially impacted by nearby university populations. Managerial constraints limited treatments to being implemented three days per week with each condition assigned to one randomly selected Thursday, one randomly selected Friday, and one randomly selected Saturday to insure a counterbalanced design. Identical experimental conditions were never administered on directly succeeding days to avoid boredom and/or negative reactance to the musical selections by the staff. Experimental treatments were administered without interruption from open to close; playlists for each condition were played in two alternating a priori randomized orders.

Volume was adjusted such that the music was clearly audible throughout each of the stores (determined by pretesting), while at the same time soft enough to be perceived as a background (as opposed to foreground) stimulus. After initial calibration, volume remained constant across all conditions. Also, other environmental factors such as ambient scent or visual advertising remained unchanged during the experiment.

## Stimulus Materials

Experimental stimuli were selected from an initial set of 330 songs made available by a commercial retail-business music provider. It is important to note that the 330 songs formed a single music program ("Sophisticated") from this provider, and were relatively homogeneous in terms of global style and genre (original pop/rock songs from the years 1999 to 2009). Moreover, this initial set was representative of a music program that would normally be played in this department store chain. The 330 songs were analyzed using the online music listening algorithm EchoNest API (Jehan, 2005). This analysis provided estimates of the mode (i.e., minor vs. major) and tempo (in BPM) for each song, as well as confidence values for the reliability of each of these estimations. Results of this objective analysis were reviewed by a musicologist and errors were corrected.

Based on the corrected results, songs were classified as minor or major with regard to mode; for tempo, songs slower than 95 BPM or faster than 135 BPM were assigned to slow and fast conditions respectively. Thus, four stimulus subsets, varying by number of titles they contained (number in parentheses), were created: *minor-slow* (25), *minor-fast* (27), *major-slow* (62), and *major-fast* (67). The subsets were further reduced to four sets of 24 songs each, including those with the highest overall confidence values ($confidence_{total} = 0.5 \times confidence_{mode} + confidence_{temp}$), resulting in four playlists of equal song number and approximately equal duration (i.e., 90 minutes). The average BPM values of the four playlists closely approximate the 60 vs. 140 BPM used by Balch and Lewis (1996) and the 60 vs. 165 BPM used by Husain et al. (2002); they are, however, more widely separated than the 114.2 vs. 145.3 BPM used by Oakes (2003). The former is arguably a stronger manipulation than the latter due to greater distance between fast and slow conditions. The 90 minute run time was selected because it clearly exceeded the maximum shopping duration of individual customers as reported by store management, thereby minimizing the probability of repeated exposure of any customer to the same song. In order to avoid a potential confound of experimental condition and music familiarity, we compared song familiarity across experiment groups. To this end, we obtained the amount of Google hits for every song as an objective measure of song familiarity (Stenberg, Hellman, & Johansson, 2008). Since the data were non-normally distributed, a logarithmic transformation was applied. There was no significant effect of experiment condition on logarithmized familiarity (all $p$ values > .3). Table 1 summarizes playlist subset properties.

**Table 1**
**Playlist properties**

| | **Playlist** | | | |
|---|---|---|---|---|
| | 1 | 2 | 3 | 4 |
| **Mode** | minor | minor | major | major |
| **Average Tempo [BPM]** | 85.0 | 161.9 | 82.5 | 157.1 |
| **Number of songs** | 24 | 24 | 24 | 24 |
| **Duration [min]** | 92.8 | 92.5 | 93.3 | 90.4 |
| **Average song familiarity [logarithmized Google hits]** | 11.9 | 12.2 | 11.6 | 12.0 |

## Dependent Variables

Gross sales data for all checkouts ($N$ = 60) across the three stores were collected hourly for each of the 12 days of the field experiment. Thus, individual checkouts served as observational units. If no purchases were recorded for a specific checkout during a given hour the timeframe was coded as missing. As the sales variable was non-normally distributed, a logarithmic transformation was used to achieve a normal distribution (Fox, 2008).

## Covariates

In order to avoid a possible confounding of music condition and week of the experiment, we included week of the experiment as a covariate with every three subsequent treatment days constituting one of four experimental weeks. As turnover and customer shopping patterns (i.e., visits) varied across the three possible treatment days, day of the week was controlled for by recognizing gross sales as lowest on Thursdays, higher on Fridays and highest on Saturdays. Also, in order to control for known influences of weather on gross sales, meteorological data were obtained from weather stations close to each of the three stores (distances < 6 miles, source: Swiss Federal Office of Meteorology and Climatology). Following the results of Murray et al. (2010), these data were comprised of sunshine duration, humidity, and mean temperature (with temporal resolution of 1 hour).

## Results

As measurements of gross sales for individual checkouts were likely to lead to correlated error terms, a linear mixed-model was used to appropriately model the data (Fitzmaurice, Laird, & Ware, 2004). Such a model explicitly accounts for unobserved, but constant, heterogeneity between individual checkouts by adding a random intercept to the model. Three models were estimated, differing with regard to included predictors, and with regard to hierarchical structure using the lme()-function of the nlme package of the statistical software R (Pinheiro, Bates, DebRoy, Sarkar, & the R core team 2011).

The first model used a *loaded mean structure* containing the objective musical properties and their interaction (main model). This model yielded significant coefficients for mode, tempo, and the interaction term. The second model contained additional fixed effects accounting for the influences of week, day of the week, and weather variables. This model yielded significant coefficients for mode, tempo, the interaction term, the dummy variable for Saturday, humidity, sunshine duration, and temperature. In the third model, additional random intercepts were specified to model the three-level hierarchical structure resultant to checkouts being nested inside store departments, and store departments nested inside stores. Again, this model yielded significant coefficients for mode, tempo, the interaction term, the dummy variable for Saturday, and weather covariates. This third model yielded a significant increase in fit compared to the second, non-hierarchical model (Likelihood ratio ($LR$) = 29.145, $df = 2$, $p < .001$). Table 2 summarizes results and properties associated with each of the three models.

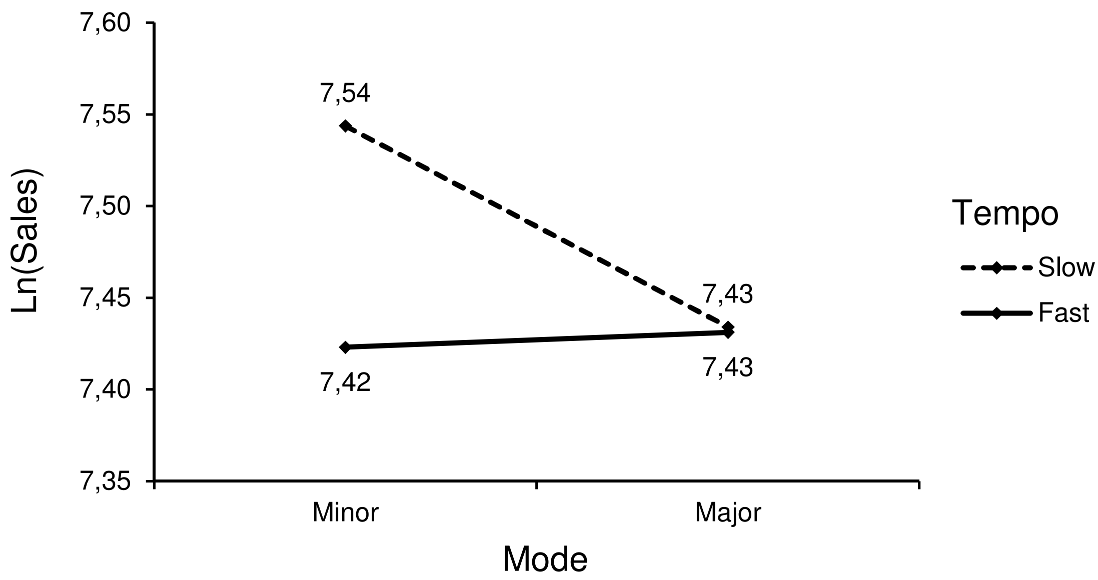
## Table 2
## Comparison of linear mixed models

| | Model 1 (main model) | | | | Model 2 (covariates included) | | | | Model 3 (hierarchical structure) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Log-Likelihood*** | –2047.868 | | | | –1748.893 | | | | –1734.320 | | | |
| ***AIC*** | 4107.736 | | | | 3523.786 | | | | 3498.641 | | | |
| ***BIC*** | 4148.556 | | | | 3612.217 | | | | 3600.676 | | | |
| **McFadden's Adjusted $R^2$** | .018 | | | | .159 | | | | .159 | | | |
| | *b* | *SE* | *t* | *p* | *b* | *SE* | *t* | *p* | *b* | *SE* | *t* | *p* |
| **Constant** | 7.275 | .037 | 198.018 | .000 | 7.605 | .051 | 150.024 | .000 | 7.544 | .083 | 91.165 | .000 |
| **Mode (major)** | –.066 | .011 | –5.910 | .000 | –.110 | .015 | –7.409 | .000 | –.110 | .015 | –7.408 | .000 |
| **Tempo (fast)** | –.076 | .011 | –6.821 | .000 | –.121 | .012 | –9.989 | .000 | –.121 | .012 | -9.948 | .000 |
| **Mode × Tempo** | .032 | .016 | 2.024 | .043 | .118 | .017 | 6.852 | .000 | .118 | .017 | 6.836 | .000 |
| **Week 2** | | | | | –.124 | .018 | –7.053 | .000 | –.124 | .018 | –7.022 | .000 |
| **Week 3** | | | | | –.165 | .013 | –12.971 | .000 | –.165 | .013 | –12.923 | .000 |
| **Week 4** | | | | | –.278 | .020 | –13.948 | .000 | –.277 | .020 | –13.873 | .000 |
| **Friday** | | | | | .062 | .010 | 6.470 | .000 | .061 | .010 | 6.442 | .000 |
| **Saturday** | | | | | .134 | .010 | 12.906 | .000 | .134 | .010 | 12.872 | .000 |
| **Humidity** | | | | | –.004 | .000 | –9.150 | .000 | –.004 | .000 | –9.041 | .000 |
| **Sunshine** | | | | | .001 | .000 | 3.074 | .002 | .001 | .000 | 3.094 | .002 |

Figure 1 graphically depicts the ordinal interaction of mode and tempo on log-transformed sales indicated by the three-level hierarchical structure. Interestingly, while initial examination shows fixed main effects of minor mode and slow tempo on sales, a significant interaction between tempo and mode qualifies these main effects: music in a major mode varied imperceptibly with regard to effectiveness by tempo while music in a minor mode was significantly more effective when accompanied by a slow tempo.

**Figure 1**

**Fixed effects of tempo and mode on (log)sales from hierarchical structure (from table 2: model 3:)**




## Discussion

Although compelled by Bruner's (1990) work, little research to date has examined the general research questions we proposed regarding the effects of the structural elements of musical mode and tempo. The current research presents empirical evidence from a field experiment regarding an interaction effect between these musical elements. We have therefore made progress regarding these research questions by extending previous research on the effects of structural properties of music on retail sales. Qualifying the positive main effect of slow tempo on sales reported by Milliman (Milliman, 1982, 1986), our results show that the positive effect of slow tempo strongly depends on the mode of the musical selection. That is, only for music in a minor mode slow tempo favorably affects sales volume.

One explanation for our pattern of results may be related to the simple fact that specific, typical combinations of tempo and mode are preferred over others. Relatedly, Husain et al. (2002) found that combinations of slow tempo and minor mode, as well as fast tempo and major mode, led to greater enjoyment ratings than other less typical combinations of tempo and mode. This effect likely stems from several hundred years of Western music tradition using the slow-minor combination to express sad affective states, while the fast-major combination has most frequently been applied to convey feelings of elation or joy. By way of explanation, both the slow-major and fast-minor conditions contain inconsistent emotional cues (Hunter, Schellenberg, & Schimmack, 2008) and are perceived (by Western listeners anyway) as less typical than the slow-minor or fast-major combinations. Resultant increased levels of enjoyment associated with typical tempo-mode combinations may therefore lead to more positive evaluations of store environments resulting in increased spending consistent with traditional valence-based models of consumption (Donovan & Rossiter, 1982). In the fast-major condition, however, this positive interaction is neutralized by the counteractive effect of fast tempo (Milliman, 1982, 1986); a customer's pace is accelerated as they move through the store resulting in reduced time spent in the store, and therefore reduced spending.

Our results may also be interpreted in the context of recent research regarding affective consumption. Two distinct streams of literature have shown feelings of sadness to lead to increased spending either consciously (as a means of mood repair) or unconsciously (as a carry-over effect). For example, sad mood inductions have been shown to result in increased food intake (Garg, Wansink, & Inman, 2007), increased price of product choice (Lerner, Small, & Loewenstein, 2004) and increased spending (Cryder, Lerner, Gross, & Dahl, 2008).Given that both slow tempo and minor mode are associated with negative affect (i.e., sadness), music-induced sadness may well explain increased spending behavior in a shopping environment. Consistently, this explanation is supported by Alpert and Alpert (1990), who report consumers' buying intentions increased (decreased) after exposure to sad (happy) music.

It is worth noting that our results, while statistically and normatively significant, are more modest (from an effect size perspective) than those of Milliman's (1982). While Milliman reported an average gross sales increase of 38.2% between fast and slow conditions, our model suggests that the minor-slow condition yielded 12.1% greater sales than the minor-fast condition. We believe, however, that our results are likely a more realistic estimate of the effect of music tempo on sales due to our control for external influences (e.g., weather), as well as our application of statistical methods that account for the hierarchical structure and repeated measurements in such data. Milliman did not report accounting for these potential influences on his results.

Though practitioners have relied on tempo as a criterion to design in-store music, little of their attention has been devoted to the mode of musical selections and much less (if any) consideration to the interaction between musical mode and tempo. The findings herein increase awareness regarding these variables, their interaction, and the potential benefits of deliberate application thereof. Specifically, increased sophistication in designing more effective in-store music is suggested by the mode × tempo interaction found in our work. From a practitioner's perspective, our findings suggest that retailers can improve effectiveness of in-store music by using slow music in a minor mode rather than other combinations of tempo and mode. Practitioners should consider the structural elements of mode and tempo in conjunction or the desired effect (i.e., increased sales) of atmospheric music could be under realized or, taken to the extreme, may have a detrimental effect on the bottom line. These improvements can easily be implemented for virtually any kind of music, irrespective of genre or most other musical variables. To efficiently design appropriate playlists for future research or application, researchers and practitioners can adopt the software-based analysis method we used to identify and manipulate mode and tempo (described in the *Stimulus Materials* section).

From an epistemological perspective, the current research should be interpreted in light of an on-going debate in psychology. In their recent publications, Cialdini and colleagues (Cialdini, 2009; Goldstein, Cialdini, & Griskevicius, 2008) have made a strong argument for studying naturally occurring behavior in real-life environments and to reassign more value to field research. This call for a revitalization of field research is further supported by empirical findings from Anderson et al. (1999) demonstrating that effect directions and effect sizes correlate highly across laboratory and field experiments. The findings also suggest that both the external validity of laboratory experiments and the internal validity of field experiments are higher than previously assumed by many researchers. Thus, studying the effects of music on sales in a field setting may yield results not only high in external, but also internal validity.

The current work, while providing evidence of an important interaction between two structural properties of music, certainly raises issues motivating further research. It would be compelling to examine the influence of mode and tempo as a function of time of day. It may be that time of day affects preferred stimulation levels of shoppers, and musical variables could thus be tailored to provide optimal levels of stimulation. Further, the question arises from our work as to whether the influence of different levels of mode and tempo vary across specific store departments and/or product categories. For example, musical treatments may have differential effects for low- versus high-involvement products. Perhaps most compelling, future research should examine the processes underlying our findings. We particularly encourage looking at factors driving behavior – examining the main and interactive effects of musical mode and tempo on customers' affective and cognitive responses including variables like mood as well as real versus perceived shopping times.

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## Article II

Knöferle, K. M., Sprott, D. E., Landwehr, J. R., & Herrmann, A. (in preparation for submission). It's the Sizzle that Sells: Crossmodal Influences of Acoustic Product Cues Varying in Auditory Pleasantness on Taste Perceptions. *Journal of Consumer Psychology*.

# It's the Sizzle that Sells: Crossmodal Influences of Acoustic Product Cues Varying in Auditory Pleasantness on Taste Perceptions

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## Abstract

Previous research suggests that acoustic cues inherent to a product itself (e.g., engine sounds) can influence perceptions of the product. In contrast to prior work, the current research focuses on crossmodal influences of extrinsic product sounds that are not inherent, but still causally related, to the product being evaluated. In particular, we propose that a systematic pleasantness manipulation of extrinsic sounds can bias secondary product evaluations of taste, and that this effect is moderated by people's general enjoyment for product sounds. These hypotheses are confirmed across two experiments. Experiment 1 finds that sounds of a coffee machine (manipulated in terms of auditory pleasantness) influence subsequent coffee taste evaluations, such that the perceived taste of the coffee was more favorable after being exposed to a pleasant sounding machine. Experiment 2 replicates this finding in a more ecologically valid setting. In addition, this study explores boundary conditions by showing that the effect of sound on taste only applies to those consumers with a high enjoyment for product sounds. Implications of these findings for theory and practice as well as avenues for future research are discussed.

# Introduction

Consumers are surrounded by a variety of product-related sounds ranging from automobiles, electronic equipment, appliances to name a few. There has been a dearth of research on how these sounds might influence consumers' responses to products associated with the sounds. While prior research suggests that intrinsic product sounds can influence perceptions of the product itself (Lageat, Czellar, & Laurent, 2003), there is no research that has examined how sounds might influence perceptions of related products. For example, might the sound of an electric shaver affect a person's perception of how smooth his or her skin feels after shaving? In the current research, this issue is investigated in the context of product machine sounds, and the influence of those sounds on taste perceptions of an associated product is examined.

Recently, there has been a growing interest by researchers to understand various crossmodal effects in consumer behavior; that is, the phenomenon whereby information available in one sensory modality influences evaluations in another sensory modality (Krishna, 2006; Krishna, Elder, & Caldara, 2010; Krishna & Morrin, 2008; Spence, Levitan, Shankar, & Zampini, 2010; Spence & Shankar, 2010). To our knowledge relatively few studies in the consumer behavior literature have focused on acoustic cues as antecedents of crossmodal effects. In this article, two experiments are reported that provide evidence of a novel category of auditory crossmodal influences in product perception. More specifically, we show that an experimental manipulation of acoustic product cues (in terms of auditory pleasantness of sounds extrinsic to the evaluated product) affects subsequent taste perceptions of a related product. The robustness of our results is confirmed across the two experiments. In addition, a boundary condition is identified.

Our findings carry theoretical as well as managerial implications. First, we show that complex acoustic stimuli can affect sensory perceptions in a subsequent product experience even if the two sensory events do not originate from the same source and are separated in time. Second, our work introduces a set of psychoacoustic metrics as a means for consumer researchers to objectively quantify acoustic manipulations. Third, our findings imply that product managers and designers would be well advised to pay increased attention to crossmodal biases in product perception.

In what follows, existing research is reviewed regarding the role of sound in product experience in order to develop hypotheses regarding the effect of extrinsic product sounds on taste perceptions. Next, we present an empirical validation of the pleasantness manipulation and report two experiments that support our hypotheses. The paper concludes with a discussion of the theoretical, as well as managerial, implications of the findings and avenues for further research.

# Literature Review and Hypotheses

The primary purpose of this research is to demonstrate crossmodal effects of acoustic product cues on taste perceptions. For purposes of this research, sound is considered to take on the role of either an intrinsic or an extrinsic cue in product perception. The following literature review begins with a short summary of the effects of sound as an intrinsic cue, that is, acoustic cues occurring during product usage or consumption which are caused either by the product itself (e.g., car engine sounds) or by an interaction with the product (e.g., biting and chewing sounds of food). Then, research on extrinsic acoustic cues – the main focus of this research – is reviewed. Such acoustic stimuli are not caused by the product itself, but accompany product usage or consumption more or less incidentally (e.g., background music, environmental noises). Finally, the role of individual sound enjoyment is discussed as a moderator of the effect of extrinsic diagnostic sounds on taste perception.

## Intrinsic Acoustic Cues

In many instances, intrinsic sounds that occur during product usage or consumption can provide value to consumers when making evaluations of the product's quality, condition, or performance. Since the sounds of a product (e.g., the sound of a car's engine) are oftentimes directly related to physical properties of the associated product (e.g., the number of cylinders), such sounds can act as diagnostic cues in the product evaluation process. Real-life evidence for the use of intrinsic product sound as a diagnostic cue can be found in many consumer settings. For instance, when potential car buyers repeatedly tap a car's dashboard while listening for auditory cues, they are normally looking for indicators of build quality (Montignies, Nosulenko, & Parizet, 2010). Similarly, when consumers judge the cleaning capacity of a vacuum cleaner, the loudness of the motor is often considered.

Crossmodal influences of intrinsic (diagnostic) product sounds have been confirmed in a small number of recent experimental studies reported in the sensory literature. For example, Zampini and Spence (2004) demonstrated that the perceived crispness of potato chips is influenced by manipulating the volume and spectral composition of the sound produced during the biting action. Similarly, the volume and spectral composition of electric toothbrush operating sounds have been shown to influence vibrotactile pleasantness ratings (Zampini, Guest, & Spence, 2003). Another example finds that the perceived carbonation of beverages could be manipulated by increasing the volume and spectral content of the sound and frequency at which the soda bubbles popped (Zampini & Spence, 2005). Due to the strong causal linkages between intrinsic product sounds and their sources, researchers have argued that the integration of intrinsic auditory information is often automatic and obligatory during product evaluation (Spence & Zampini, 2006). This is consistent with fundamental research into multisensory integration, which suggests that multiple unimodal sensory events are integrated if they exhibit a temporal, spatial, and semantic proximity (Fort & Giard, 2004).

## Extrinsic Acoustic Cues

In contrast to sounds that are inherent to a product, extrinsic auditory cues do not emanate from the product itself, but rather come from external sources. These sources can either be causally unrelated to the product (e.g., background music; Gorn, 1982; Groenland & Schoormans, 1994) or causally related to the product to be evaluated (the focus of the present research).

There is growing evidence in the sensory literature that extrinsic, non-diagnostic auditory cues can have a crossmodal influence on product evaluation. For example, it has been demonstrated that non-diagnostic background sounds such as random white noise can significantly bias simultaneous taste evaluations. Woods et al. (2011) report significantly higher (lower) perceptions of sweetness and saltiness in quiet (loud) sound conditions. Although they did not find an effect of sound on liking, the researchers did find a correlation between liking of the noise and preference for the food consumed in the presence of that noise. In another recent study examining the impact of pleasant versus unpleasant background sounds on odor perceptions, Seo and Hummel discovered a halo effect that resulted in odors being perceived to be more pleasant under pleasant background sound conditions (Seo & Hummel, 2011).

Moreover, research finds that packaging sounds (such as the opening sound of a chips bag) impacts crossmodal product evaluations. In particular, Spence et al. (2009) showed that consumers rated the crispness of potato crisps higher when listening to the rattling sound of a Kettle's or a Walker's crisp packet, than when listening to the popping sound of a Pringles package being opened. Researchers have proposed that effects of such environmental acoustic cues may reflect a process of conditioning or associative learning. That is, the sound of a packaging may activate certain associations in the listener which then influence product perception (Spence & Shankar, 2010).

At a general level, research supports the notion that extrinsic information may play a diagnostic role in consumers' evaluation of a product. For example, information about sensory properties (Elder & Krishna, 2010), brand, price (Dodds, Monroe, & Grewal, 1991; Jacoby, Olson, & Haddock, 1971), and country of origin (Li & Wyer Jr, 1994) have been shown to influence consumer perceived quality judgments about products. The case of sounds serving as extrinsic diagnostic cues, however, has not been examined until now. An example of such a cue is the sound originating from a product that is perceived to be related to the quality of the product being evaluated.

In the current research, we examine for these effects within the home coffee machine category given the relationship between the machine and the cup of coffee produced by the machine. While the taste of a cup of coffee is primarily driven by the inherent quality of the bean and water, along with marketing cues (such as brand and price of the coffee), consumers may reasonably perceive that a causal relationship exists between the coffee machine itself and the cup of coffee it produces. In particular, since the quality and functionality of the coffee machine is likely determined (at least in part) by the sound of the machine (e.g., the motors, steamer, etc.), the sound of the machine may also influence perceptions of the quality of the output product. In this case, the sound of the coffee machine is an *intrinsic* cue for the quality of the coffee machine, but an *extrinsic* (nonetheless *diagnostic*) cue for the taste quality of the coffee. Accordingly, we hypothesize that consumer perceptions of the taste quality of the coffee will be influenced by the pleasantness of the machine sound preceding the taste evaluation.

**H1:** Acoustic product cues with more (vs. less) pleasant sounds will lead to more (vs. less) favorable taste evaluations of a related product.

### The Moderating Role of Individual Sound Enjoyment

Recent findings reported by Krishna and Morrin (2008) suggest that the crossmodal influence of *non-diagnostic* sensory cues is moderated by consumers' preference for the sensory domain of the cue. Specifically, these authors argue that those with a higher preference for haptic input have an increased awareness for the irrelevance of a non-diagnostic haptic cue, and hence discount its influence. In contrast, we propose that the crossmodal influence of *diagnostic* extrinsic sounds should be more pronounced for those with a high preference for the auditory modality. That is, consumers with higher enjoyment of product sound should rate the taste of coffee more (vs. less) favorably after being exposed to pleasant (vs. unpleasant) coffee machine sounds. In contrast, taste perceptions of individuals with low enjoyment of product sound should not be affected by coffee machine sounds.

**H2:** The effect of auditory pleasantness on perceptions of taste quality will be more pronounced the higher the individual preference for product sounds.

## Overview of Studies

In three studies, we investigate the effects of coffee machine sounds on taste perceptions of the associated product. In a pretest, a series of psychoacoustic properties of coffee machine sounds – in particular, auditory sharpness – are tested to determine their role in terms of auditory pleasantness. In the first experiment, coffee machine sounds are orthogonally manipulated in terms of auditory pleasantness and the influence of those sounds on subsequent taste experience is examined (hypothesis 1). The second experiment replicates the results of experiment 1 in an ecologically valid setting involving real products that have been technically modified to manipulate acoustic properties. Further, the effect of extrinsic diagnostic sound on taste is shown to be moderated by the enjoyment consumers' have regarding product sounds (hypothesis 2).

# Pretest: What Dimensions of Sound Influence Sound Pleasantness?

A pretest was conducted in order to validate the sound pleasantness manipulation used in the primary experiments. Psychoacoustic research suggests that the sensory pleasantness of a sound can be modeled as a linear combination of basic psychoacoustic sensations of loudness, sharpness, tonality, roughness, and fluctuation strength (Aures, 1985; Fastl, 1997; Fastl & Zwicker, 2007). Among these basic psychoacoustic sensations, sharpness is commonly considered to be the most influential factor with regard to sensory pleasantness (Fastl & Zwicker, 2007; Zimmer, Ellermeier, & Schmid, 2004), although any of these metrics may dominate sensory pleasantness depending upon the context.

Auditory sharpness, which correlates negatively with auditory pleasantness, is closely related to the proportion of high- and low-frequency energy in the sound spectrum (von Bismarck, 1974). The main determinants of sharpness are center frequency and bandwidth. The higher the center frequency of a sound, the higher its perceived sharpness. Also, raising the upper cut-off frequency of a sound increases sharpness, while reducing its lower cut-off value decreases it (Fastl & Zwicker, 2007). That means that the sharpness of a sound can be increased both by amplifying high frequencies or by attenuating low frequencies (Fastl, 1997).

## Method

*Stimuli.* Operating sounds of ten commercially available consumer coffee machines were recorded in a professional sound studio (using a pair of Schoeps MSTC 64 U small-diaphragm condenser microphones spread to a 110° angle at a distance of 40 cm from the coffee machine). In order to equalize the run time for the sounds, only the first 10 seconds of each recording (plus a 2-second fade-out segment) were used as stimuli in the pretest.

*Procedure.* Customers of a coffee shop ($N$ = 178) were approached individually after having made their purchases and invited to take part in the study. Participants completed the questionnaire on a Dell Laptop at their own pace. The ten stimuli were played to participants in randomized order via headphones (using a Terratec Aureon 5.1 USB MKII soundcard with closed Sennheiser HD 25-1 II stereo headphones). The experimenter calibrated playback volume by subjectively contrasting one of the prerecorded sounds to the operating noise of the corresponding coffee machine in the store. After listing to a sound, participants indicated their overall liking of the sound on a 7-point scale.

Commercially available sound analysis software (Head Acoustics ArtemiS, version 11.00.200) was used to compute aggregated values for psychoacoustic metrics for each sound, including: loudness, sharpness, tonality, fluctuation strength, and roughness.

## Results and Discussion

As repeated measurements are likely to be correlated, linear mixed models were used with a random intercept for participants to model the data (Fitzmaurice, Laird, & Ware, 2004). The analysis was conducted using the lme()-function of the nlme package within the statistical software R (Pinheiro, Bates, DebRoy, Sarkar, & the R core team 2011).

Sound liking was regressed on z-standardized psychoacoustic metrics sharpness, loudness, tonality, roughness, and fluctuation strength. As expected, there were significant negative effects of sharpness ($b = -.484$, $SE = .048$, $t = -9.974$, $p < .001$), roughness ($b = -.448$, $SE = .074$, $t = -6.046$, $p < .001$), and fluctuation strength ($b = -.219$, $SE = .044$, $t = -5.042$, $p < .001$), as well as a positive significant effect of tonality ($b = .466$, $SE = .145$, $t = 3.212$, $p = .001$). The loudness variable did not reach significance ($p > .8$). Closer examination revealed that loudness was correlated with roughness and tonality (both $r > .5$). Excluding loudness from the model did not change the significance or the pattern of effects.

Consistent with our predictions and psychoacoustic theory, auditory sharpness had a significant negative influence on sound liking. Indeed, this dimension of sound had the largest impact of all psychoacoustic metrics in the model. This finding suggests that auditory sharpness is an appropriate auditory dimension to manipulate the pleasantness of a product sound in subsequent experiments.

# Experiment 1: Does Product Sound Affect Taste?

In experiment 1, the sensory pleasantness of coffee machine sounds was varied by manipulating auditory sharpness. Consumers' coffee taste evaluations were assessed after experiencing a cup of coffee being made by a coffee machine in the presence of the manipulated sounds, with the expectation that pleasant (vs. unpleasant) machine sounds would result in increased (vs. decreased) taste evaluations (hypothesis 1). In addition, the subjective salience of the operating sounds was also manipulated, as we assumed the positive (negative) effect of low sharpness (high sharpness) sound on taste to be discountable.

## Method

*Design.* Experiment 1 employed a 2 (sound sharpness: low vs. high) × 2 (sound salience: low vs. high) between-subjects design. As a starting point for the sharpness manipulation, the operating sound of a commercially available capsule espresso machine (i.e., the Nespresso Lattissima) was selected that had achieved mid-range values for liking in the pretest. From this recording, two target sounds were created that differed in terms of auditory sharpness. Following the standard definitions of sharpness, the manipulation of sharpness was accomplished by applying systematic frequency filtering to the recorded operating sound. Specifically, the pleasant (unpleasant) sounds were created by attenuating (amplifying) the spectral contents between 2.5 kHz and 6.5 kHz by 20 decibels.

In order to compensate for resulting changes in overall loudness, the pleasant sound was amplified by 3 decibels, while the unpleasant sound was attenuated by 10 decibels. Both sounds had a total runtime of 24 seconds, consisting of 11 seconds of machine sound and 13 seconds of dripping sound (the dripping sound remained unchanged across experimental conditions). As table 1 illustrates, this manipulation resulted in a quasi-orthogonal manipulation of auditory sharpness with nearly identical values for other psychoacoustic metrics.

**Table 1**
**Psychoacoustic properties of the machine sounds for experiment 1**

| | Original | Sharpness reduced | Sharpness increased |
|---|---|---|---|
| Sharpness [acum] | 3.23 | 2.47 | 4.39 |
| Loudness [soneGF] | 29.15 | 27.55 | 28.50 |
| Roughness [asper] | 4.88 | 4.57 | 4.82 |
| Fluctuation Strength [vacil] | 0.03 | 0.03 | 0.02 |
| Tonality [tu] | 0.27 | 0.30 | 0.24 |

Sound salience was manipulated by including a sound evaluation task, in which half of the participants were randomly asked to focus on the operating sound of the machine while the coffee was prepared and to rate it with regard to perceived pleasantness. The remaining participants were not asked to focus on the sound.

*Procedure.* A total of 75 participants were recruited at a university cafeteria to take part in a coffee tasting study. Participants were not aware of the study's purpose. One at a time, participants were led into a room, seated at a table behind a room divider and asked to neutralize any pre-existing taste by drinking some water and eating a cracker. The experimenter provided participants with an information sheet summarizing the cover story. Participants in the high salience conditions were additionally provided with a sound evaluation sheet.

The experimenter left the room under the pretext of getting a fresh cup to prepare the coffee. In an adjacent, soundproof room, the experimenter prepared a cup of espresso (40 ml) using a commercially available, single button operated capsule coffee machine (Nespresso Essenza). Per the coffee manufacturer, the focal capsule (Nespresso Volluto) has medium intensity. Returning to the first room with the cup of coffee, the experimenter moved behind another room divider, stating: "I'm now going to prepare your coffee." Immediately, the experimenter played back the randomized coffee machine sound over a MacBook Pro connected to a Logitech Z523 speaker system behind the room divider. As soon as the sound had finished playing, the experimenter served the coffee and sat down at the table face to face with the participant. The experimenter asked the participant to first taste the coffee in small sips and then to rate the perceived taste quality as well as the overall liking for the coffee. Taste quality was measured on a scale anchored at 1 ("extremely unpleasant") and 9 ("extremely pleasant”), overall liking was measured on a continuous labeled affective magnitude scale ranging from −10 to 10 (Cardello & Schutz, 2004; Green, Shaffer, & Gilmore, 1993).

## Results and Discussion

*Results.* When asked whether they had noticed anything special during the study, 13 participants referred to the machine sound. As a precaution against response bias, these participants were excluded from subsequent analyses.

As a manipulation check, we examined differences in perceived sound pleasantness across the two groups in the increased salience conditions. A one-way ANOVA revealed a marginally significant difference, $F(1, 28) = 9.14$, $p = .069$, with the low sharpness sound being perceived as more pleasant ($M_{low} = 4.71$, $SD = 1.64$) than the high sharpness sound ($M_{high} = 3.57$, $SD = 1.56$).

Taste scores were subjected to a two-way ANOVA having two levels of machine sound sharpness (low, high) and two levels of sound salience (low, high). As hypothesized, there was a significant main effect of sound sharpness on taste, $F(1, 62) = 4.12$, $p = .047$, indicating that taste quality was perceived to be lower after exposure to a high-sharpness machine sound ($M_{high} = 5.87$, $SD = 1.53$), than after exposure to a low-sharpness machine sound ($M_{low} = 6.59$, $SD = 1.41$). A significant main effect of sound salience on taste also emerged, $F(1, 62) = 5.05$, $p = .029$, suggesting that under conditions of high sound salience, participants gave more favorable taste evaluations ($M_{high} = 6.68$, $SD = 1.25$) than under conditions of low sound salience ($M_{low} = 5.88$, $SD = 1.61$). The interaction between machine sound sharpness and salience was not significant ($p > .70$).

A similar pattern emerged for overall liking of the coffee: Exposure to the low-sharpness machine sound resulted in significantly higher subsequent liking judgments ($M_{low} = 3.27$, $SD = 2.68$) than exposure to the high-sharpness machine sound ($M_{high} = 1.66$, $SD = 2.80$), $F(1, 62) = 5.26$, $p = .025$. Neither sound salience nor the interaction between sound sharpness and salience reached statistical significance ($p$ values $> .10$).

*Discussion.* The results of experiment 1 suggest that coffee machine operating sounds can influence the perceived taste quality and the global liking of the coffee produced by the machine, supporting hypothesis 1. However, the employed experimental procedure is not a realistic product usage situation, as the coffee machine sounds were presented as background stimuli. Although the machine was hidden from the participants' view, the lack of realism may have impacted results. Thus, we present a more realistic test of hypothesis 1 in experiment 2, as well as testing a possible boundary condition.

## Experiment 2: Product Sound, Taste, and Individual Sound Enjoyment

In this experiment, the effects found in study 1 were replicated in a more ecologically valid setting, that is, in a realistic product usage situation. Since previous research has shown that simultaneously presented visual cues can impair the perception of sounds (Colavita, 1974), the experimental stimuli (i.e., the electronically manipulated coffee machine sounds) were replaced with physically modified coffee machines specifically engineered to differ in terms of auditory sharpness. Thus, experiment 2 is likely to be a more conservative test of hypothesis 1. In addition to this experimental change, individual differences in terms of product sound enjoyment were also measured, with the expectation that this construct would moderate observed effects of sound pleasantness (hypothesis 2).

### Method

*Design.* As in experiment 1, auditory sharpness of coffee machine sounds was manipulated (sharpness: low, high). A sound engineering company physically modified the operating sound of a commercially available, single button operated espresso machine (Nespresso CitiZ). The operating sound was permanently changed by installing a hardware noise generator and miniature speakers. The noise generator was linked to the water pump of the machine so that the activation of the pump triggered the noise generator. Once activated, the noise generator emitted a constant random noise sound with strong frequency components between 2.5 kHz and 10 kHz via the speakers, which could be perceived as a hissing sound. This manipulation resulted in a considerable increase in sharpness while inevitably, but only slightly, increasing loudness. Table 2 summarizes the psychoacoustic properties of both the original and the modified machine sounds. Importantly, the modification left no visible traces, and after reassembling the machine, it was indistinguishable from its original condition. In order to minimize brand effects, all brand information (brand name, type designation etc.) was removed from the machines.

**Table 2**

**Psychoacoustic properties of the espresso machines for experiment 2**

| | Original | Modified |
|---|---|---|
| Sharpness [acum] | 3.19 | 4.31 |
| Loudness [soneGF] | 20.50 | 24.10 |
| Roughness [asper] | 2.35 | 2.45 |
| Fluctuation Strength [vacil] | 0.02 | 0.02 |
| Tonality [tu] | 0.27 | 0.18 |

*Pretest.* An online pretest was conducted to determine whether the sounds of the two espresso machines significantly differed with regard to perceived pleasantness. A total of 18 participants listened to recordings of the two coffee machine sounds, which were presented in randomized order, and evaluated the pleasantness of each of the sounds. A repeated-measures ANOVA showed that the low sharpness sound was perceived to be significantly more pleasant ($M_{low}$ = 2.33, $SD$ = 1.37) that the high sharpness sound ($M_{high}$ = 1.39, $SD$ = .61), $F(1, 18) = 8.82$, $p = .009$.

*Procedure.* A sample of consumers ($N$ = 161, 61.8% female, mean age 27) were recruited for the product test, which was conducted in the premises of a market research company. One at a time, participants entered the room, sat down in front of a table, and were offered water for neutralizing any preexisting taste. Both coffee machines were positioned on the table equidistant from the participant, with only one of the machines being visible at a time (the other one was covered with a cloth). The experimenter advised participants to inspect the coffee machine for a few seconds, and then pay close attention to the performance of the machine while coffee was prepared. After preparing the coffee, the experimenter asked participants to taste the espresso in small sips and to complete a short questionnaire on a laptop at their own pace. The questionnaire contained a series of questions about the perceived taste of the coffee (on a 7-point scale anchored at “very unpleasant” and “very pleasant”) and whether participants had recognized the coffee machine brand or model. Finally, participants completed a short scale measuring individual product sound enjoyment. The scale consisted of three items in 7-point likert format: “It can be pleasant to listen to product sounds”, “I enjoy hearing the sound a product makes”, and “Listening to the sounds of a product can be fun” ($\alpha$ = .82).

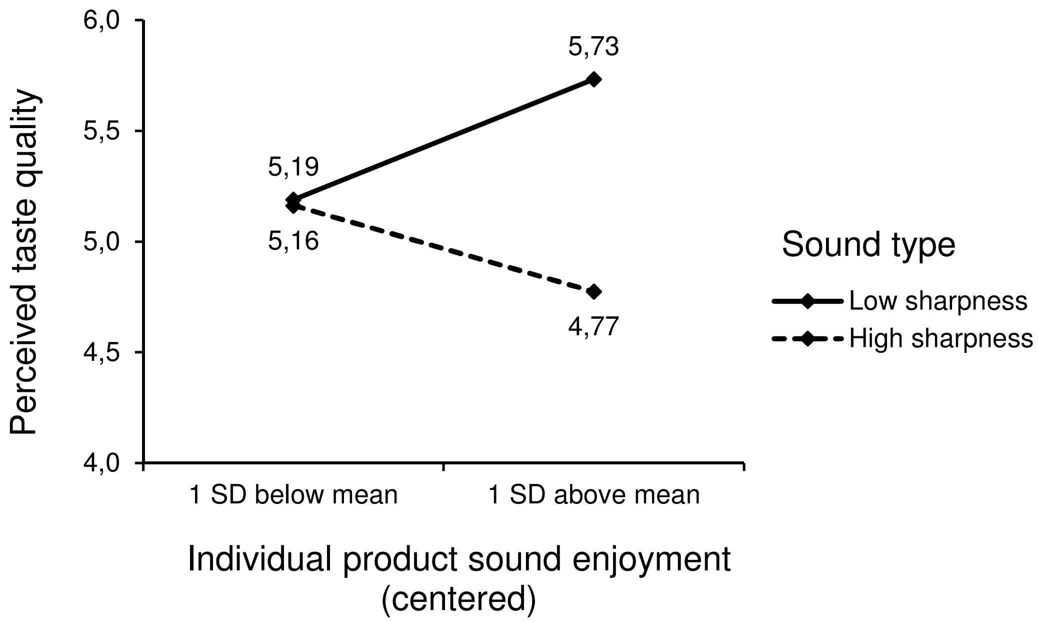
## Results and Discussion

*Results.* In order to minimize the influence of brand name information (Dodds et al., 1991), 29 respondents who had indicated awareness of the machine/coffee brand were excluded from the following analyses. None of the participants correctly identified the sound focus of the study.

To examine the robustness of the effect of sound sharpness on taste, we tested for the interactive effect of sound sharpness and product sound enjoyment on taste perceptions. Following the regression-based approach suggested by Irwin and McClelland (2001) for analyzing interactions with both categorical and continuous independent variables, taste quality was regressed on sound sharpness (low vs. high) and the centered product sound enjoyment score. There was a significant main effect of sound sharpness ($b = -.49$, $SE = .24$, $t = -2.10$, $p = .038$), but no significant effect for the product sound enjoyment scale ($p > .01$). A significant two-way interaction ($b = -.34$, $SE = .17$, $t = -1.98$, $p = .050$) between sound sharpness and product sound enjoyment qualified the main effect.

To explore the nature of the interaction, spotlight analyses were performed one standard deviation below and above the mean of the product sound enjoyment scale (Fitzsimons, 2008; Irwin & McClelland, 2001). The spotlight analysis one standard deviation below the mean of the centered sound enjoyment scale showed no significant difference between low and high sharpness conditions ($p > .9$). A similar spotlight analysis one standard deviation above the mean of the centered sound enjoyment scale revealed a significant difference such that high sound enjoyment participants gave higher taste ratings in the low sharpness condition than in the high sharpness condition ($b = -.959$, $SE = .333$, $t = -2.880$, $p < .01$). Additional spotlight analyses two standard deviations below and above the mean of the centered sound enjoyment scale confirmed this pattern of results. Thus, sound sharpness did not affect taste evaluations for those scoring low on the product sound enjoyment scale. In contrast, consumers scoring high on the scale rated the taste of the coffee higher after being exposed to a low-sharpness sound, but lower after being exposed to a high-sharpness sound. Figure 1 illustrates the pattern of results.

**Figure 1**
**Interaction between sound sharpness and product sound enjoyment in experiment 2**




*Discussion.* In study 2, the effect of machine sound sharpness was shown to influence taste evaluations robustly a) in an ecologically valid setting and b) for a different set of stimulus sounds. These findings add further support to hypothesis 1. Moreover, the results suggest that the effect of sound on taste is moderated by a person's preference for product sounds, lending support to hypothesis 2.

## General Discussion

The key objective of this article is to contribute to the growing literature on sensory perception in marketing by demonstrating that a previously neglected category of acoustic cues – extrinsic diagnostic sounds – can affect subsequent product evaluations. To this end, two experiments were conducted in which we examined whether coffee machine sounds varying in auditory sharpness influence the perceived taste quality of coffee produced by the machine.

In a pretest study, auditory sharpness was shown to negatively influence auditory pleasantness. Building on this relationship as a means to systematically manipulate coffee machine sounds, study 1 showed that sounds varying in auditory sharpness influenced coffee taste perceptions. More specifically, a low sharpness sound resulted in higher taste perceptions than a high sharpness sound. In study 2, this finding was extended and found to hold in a realistic product usage setting – that is, by using actual coffee machines that were technically modified in terms of operating sounds. Together, experiments 1 and 2 support our hypothesis that extrinsic, but diagnostic, acoustic cues can influence subsequent taste perceptions.

This finding extends our knowledge about multimodal interactions in product perception. In previous research, both diagnostic intrinsic (e.g., biting sounds of chips; Zampini & Spence, 2004) and non-diagnostic extrinsic sounds (e.g., white noise; Woods et al., 2011) have been shown to influence taste perceptions when directly accompanying the gustation process. According to the results of the current work, diagnostic extrinsic acoustic cues are also able to affect taste, even if they do not temporally coincide with the taste sensation, but precede the consumption process by a time lag in the order of several seconds.

In experiment 2, a boundary condition of this effect was identified, such that individual product sound enjoyment moderated the effect of auditory sharpness on taste perceptions. The pattern of findings suggests that individuals scoring higher on the product sound enjoyment scale were most affected by auditory cues in their taste perceptions, with taste ratings increased (decreased) after exposure to low (high) sharpness sounds.

This pattern of results may be explained with reference to recent research on the crossmodal influence of haptic stimuli. Krishna and Morrin (2008) showed that a crossmodal effect of non-diagnostic haptic cues on taste perception was eliminated for those with a high autotelic need for touch, suggesting that high haptic expertise made consumers aware of the non-diagnostic nature of the haptic cue. In a similar way, product sound enjoyment is likely to reflect an individual aptitude in processing and tendency to utilize acoustic cues. High product sound enjoyment, and thus product sound expertise, enables consumers to recognize the diagnostic nature of the operating sound (Alba & Hutchinson, 1987) and to accordingly attribute higher or lower taste quality to the coffee.

The sound enjoyment score might reflect (at least to a certain degree) an individual-level auditory sensory dominance. Thus, a high score of sound enjoyment may indicate a higher probability for the auditory modality to dominate a person's experience in a sensory evaluation task. This may promote a shift in sensory dominance from the gustatory to the auditory modality, resulting in a stronger bias of the taste experience.

From a practitioner's perspective, the findings of this research support an increased attention to multisensory biases. In many industries, marketers are still oblivious to the multisensory nature of product experience. Instead, they mistake the various sensory properties of their products to be independent of each other, often focusing on a single dominant modality (e.g., taste). Challenging this traditional approach, the present research highlights the importance of the interplay between different sensory modalities. Specifically, the reported findings suggest that coffee machine sounds can affect secondary product evaluations such as coffee taste. In the light of these results, marketers would be well advised to test for potential crossmodal interactions early in the new product design process in order to avoid undesired and obtain advantageous crossmodal effects.

The current work provides an interesting point of departure for future research. In this article, only one type of coffee was used in the taste evaluation task. Future research could usefully examine how food or beverages varying in gustatory properties (e.g., gustatory pleasantness, intensity) are affected by pleasant and unpleasant auditory cues. Also, it would be interesting to study other classes of product sounds and their influence on consumers. In some cases, intrinsic sounds can also be non-diagnostic. Consider for example keyboard feedback sounds of electronic devices, or the synthesized turn signal sounds in a car. The properties of these sounds do not have a causal relationship to the material, function or quality of the product they are associated with. Probably the most promising avenue for future research would be to disentangle the processes underlying the crossmodal effect identified in this work. The temporal difference between the acoustic cue and the taste evaluation in the experiments reported here seems to rule out a perceptual explanation in the sense of Spence and Shankar (2010), since perceptual effects appear to occur in the millisecond range (Slutsky & Recanzone, 2001; Spence & Squire, 2003). Rather, it points to cognitive or affective processes as mediators of the effect. Indeed, coffee machine sounds may carry information about the effectiveness of the coffee preparation process, which in turn may be used in an inferential way when evaluating the taste of the coffee. Alternatively, coffee machine sounds varying in auditory pleasantness may induce positive or negative affect, which biases subsequent taste evaluations (Herr, Page, Pfeiffer, & Davis, forthcoming).

To summarize, the current research demonstrates that the study of crossmodal effects in general, and of auditory influences on multisensory product perception in particular, merits further scholarly attention. Identifying and explaining the complex, often unconscious, interactions between the various senses will greatly contribute to our understanding of product experience and preference formation.

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## Article III

Knöferle, K. M. (submitted). Using Customer Insights to Optimize Product Sound Design. *Marketing Review St. Gallen*.

# Using Customer Insights to Optimize Product Sound Design

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# Abstract

Sound plays an essential role in customers' daily interaction with products, often influencing their cognitive processes, their emotions, and more generally their behavior. As this realization takes hold, more and more companies begin to take an active interest in the acoustic design of their products. This article demonstrates how marketers can effectively use customer insights to guide product sound design. We illustrate the proposed approach by describing a research collaboration with a coffee machine manufacturer.

# Introduction

The sounds that emanate from a product while it is used or consumed are an integral part of consumers' multisensory product experience. For many product categories such as vehicles, domestic durables, and high-tech products, consumers perceive auditory cues to be just as important as visual cues (Schifferstein, 2006). Therefore, it seems only natural that over the past few years, many industries have witnessed a growing interest in product sound design (Zips, 2004), culminating in the recent discussion about electric car sound design (Wilms & Görmann, 2010). Following the sound example of the automotive industry with its long history of acoustic engineering, companies in the food and electronics industries have begun to also invest considerable sums into the acoustic design of their products. Despite this overall trend, only little research has been conducted in both marketing science and practice to better understand the factors underlying consumer perceptions of, and preferences for, specific product sounds (for an exeption, see Lageat, Czellar, & Laurent, 2003). This is somewhat surprising given that on a general level, awareness has increased for topics at the interface of marketing and product design (Herrmann, Landwehr, & Labonte, 2011; Landwehr, Labroo, & Herrmann, 2011; Landwehr, Mcgill, & Herrmann, 2011).

As a first step to fill this gap, this article shows how marketers can use customer insights to strategically guide new product sound design. It describes a novel approach of integrating customer insights into the process of product sound design and its successful application in a research collaboration with a leading coffee machine manufacturer. The main objective of the collaboration was to obtain insights into how customers perceive the product sound of the company's coffee machines. These insights could then guide and contribute to future product development. More specifically, the objective was to identify the main dimensions in perceiving coffee machine sounds, and to map coffee machines of both the company and its competitors into the resulting perceptual space. In addition, we aimed at identifying robust relationships between customer preferences for certain acoustic designs on the one hand and objective sound properties as well as subjective sound evaluations on the other hand.

The proposed approach combines both quantitative and qualitative methods and integrates several data sources, including software-based psychoacoustic measurements, a regular customer sample, and an expert customer sample. It should be noted that each of these data sources may be useful for sensory evaluation and has been applied in both academic and applied research individually. However, as the article will show, a comprehensive, customer-oriented view that uses statistical methods to combine these data sources can have substantial advantages over isolated analyses.

It is also important to recognize the generalizability of our methodology to different product categories. While we illustrate our approach using the example of a coffee machine manufacturer, it can be applied to a wide variety of industries (e.g., household appliances, consumer electronics, automotive, food and beverages), making it a valuable tool for marketers in many domains.

# A Multi-Step Approach to Guide Product Sound Design

## Overview

The proposed approach consists of five consecutive and interrelated steps. To start with, operating sounds of coffee machines were recorded as a basis for subsequent studies and analyses (step 1). For each of these sounds, basic psychoacoustic metrics (e.g., loudness, sharpness) were computed using sound analysis software (step 2). Next, regular customers evaluated the sounds in terms of liking and perceived similarity (step 3). In order to capture semantic properties of the sounds, another group of customers developed a set of sound-describing terms and used these terms to evaluate the sounds (step 4). Finally, data obtained in steps 2 to 4 were combined using a set of statistical methods (step 5). Specifically, multidimensional scaling was employed to obtain a perceptual map of coffee machine sounds based on customer similarity ratings collected in step 3; both psychoacoustic metric scores computed in step 2 and semantic property ratings obtained in step 4 were regressed into the perceptual map to explain the underlying perceptual dimensions, and preference modeling based on customer preference ratings obtained in step 3 was used to identify preferred and non-preferred regions of the perceptual map. The resulting integrated perceptual map illustrated how customers perceive the machine sounds in relation to each other, the psychoacoustic and semantic dimensions underlying these perceptions, as well as relationships between psychoacoustic and semantic dimensions on the one hand and customers' preferences on the other hand.

## Step 1: Recording a Corpus of Coffee Machine Sounds

Operating sounds of ten consumer coffee machines from both the coffee machine manufacturer and its most important competitors were recorded in a professional sound studio. Since all of the included machines were capsule-based, their sounds were roughly comparable in terms of auditory events; for example, none of the sounds contained a grinding noise. The calibrated recording setting included a pair of small-diaphragm condenser microphones, which were spread to a 110° angle and positioned at a "realistic usage" distance of 40 cm from the coffee machine. In order to standardize run time across sounds, only the first 10 seconds of each recording plus a 2-second fade-out time were used. This runtime was selected as a compromise between capturing as much of the character of each sound as possible, and not exceeding the capacity of the auditory sensory memory of 11-15 seconds (Winkler & Cowan, 2005). Within this time window, participants of the studies reported below should be able to draw on detailed sound representations from their auditory memory for sound evaluation.

## Step 2: Computing Psychoacoustic Metrics

In a second step, psychoacoustic metrics of the recorded sounds were calculated. Psychoacoustic metrics model human perception of sound, i.e., they link physical properties of sound to basic auditory sensations. Importantly, psychoacoustic research suggests that the sensory pleasantness of a sound correlates highly with consumers' preference for that sound, and that it can be modeled as a linear combination of basic psychoacoustic metrics (loudness, sharpness, tonality, fluctuation strength, and roughness; see Fastl & Zwicker, 2007).

Consider briefly these five psychoacoustic metrics: *Loudness* is the perceptual correlate of physical sound intensity that accommodates the human ear's frequency selectivity, that is, its differential sensitivity with regard to specific frequency ranges. *Sharpness* is a psychoacoustic sensation that is closely related to the proportion of high- and low-frequency energy in the sound spectrum. The main determinants of sharpness are center frequency and bandwidth. The higher the center frequency of a sound, the higher its perceived sharpness. Also, raising the upper cut-off frequency of a sound increases sharpness, while reducing its lower cut-off value decreases it. *Tonality* is an auditory sensation depending on whether a sound consists mainly of tonal or noise components. Both auditory roughness and fluctuation strength are auditory sensations caused by temporal fluctuations in a sound. *Fluctuation strength*, the sensation of an audible pulse or "beating", results from slow temporal fluctuations below 20 Hz with a perceptual maximum at frequencies of around 4 Hz. *Roughness* results from faster variations in amplitude or frequency in the range between 20 Hz and 300 Hz with a perceptual maximum at around 70 Hz. Simply put, an increase in any one of these five metrics results in a decrease of auditory pleasantness.

Commercially available sound analysis software was used for the psychoacoustic analysis. For each machine sound, the analysis resulted in a single value for the metrics loudness, sharpness, tonality, roughness, and fluctuation strength.

## Step 3: Collecting Preference and Similarity Ratings from Customers

In order to obtain customer preference ratings for all recorded machine sounds, we conducted a quantitative study. Customers of the coffee machine manufacturer ($N$ = 178) took part in a sound evaluation study, during which they completed two different tasks: First, they listened to five randomized pairs of coffee machine sounds and rated the perceived similarity of each pair. After that, they listened to the ten sounds one by one and indicated their liking for each of the sounds on a 7-point scale. The acoustic stimuli were presented via closed headphones; playback volume was calibrated by comparison of one of the recorded sounds with its real-world counterpart. After filtering participants for hearing disabilities and minimal completion time (resulting in the exclusion of data points with a completion time lesser than the combined playback duration of the sounds), evaluations from 148 participants remained in the data set.

## Step 4: Identifying Semantic Descriptors via Quantitative Descriptive Analysis

Quantitative Descriptive Analysis (QDA) was used to develop a perceptual profile for each sound. QDA is a technique that has frequently been employed in sensory evaluation (Lageat et al., 2003; Stone, Sidel, Oliver, Woolsey, & Singleton, 1974; Stone & Sidel, 2004). The basic idea of QDA is to train a panel of "sensory experts" through a series of laboratory sessions. The training involves developing a custom set of descriptor terms and enables panel members to carry out sensory evaluation with a higher acuity and reliability than regular consumers.

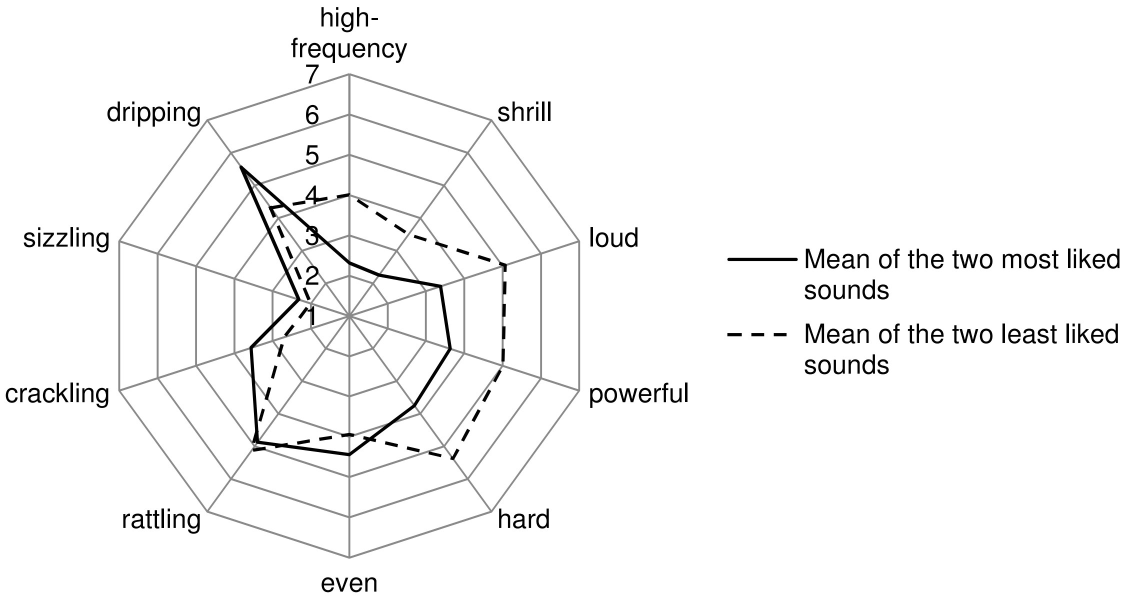
Eight regular users of capsule coffee machines were invited to listen to the ten machine recordings presented in random order (repeated playback was possible). While listening, each participant generated a list of sound descriptor terms that in his or her opinion was suitable for characterizing the sounds. In a subsequent focus group session, a total of 58 identified descriptors were clustered and refined by the participants. Based on general agreement, synonymous terms were eliminated, and antonyms and exact definitions were elaborated for each descriptor, resulting in a generally agreed-upon list of ten descriptors (table 1). This process aimed at establishing a common understanding of the descriptor terms, which is vital for obtaining inter-individually reliable evaluations. Finally, every participant re-evaluated all sounds on the final set of ten descriptors using a 7-point semantic differential response format. The resulting rating scores were aggregated across sounds so that a distinct value for each of the descriptors could be assigned to each sound.

**Table 1**
**List of coffee machine sound descriptors developed in QDA**

| | **Descriptor** | | **Definition** |
|---|---|---|---|
| **Machine sound descriptors** | Low-frequency | High-frequency | Global frequency |
| | Muffled | Shrill | |
| | Soft | Hard | Perceived hardness |
| | Quiet | Loud | Global loudness |
| | Weak | Powerful | Perceived pressure |
| | Uneven | Even | Continuity in volume and pitch |
| | Not rattling | Rattling | Rattling, rumbling, and vibrating sounds |
| | Not crackling | Crackling | Crackling or clicking sounds |
| **Coffee sound descriptors** | Not sizzling | Sizzling | Sizzling, fizzy sounds |
| | Not dripping | Dripping | Sound of coffee dripping into the cup |

By averaging descriptor scores across the two sounds that had received the highest (vs. lowest) liking ratings in the customer study, a sensory profile for a preferred (vs. non-preferred) sound was obtained. As figure 1 shows, there are several clear-cut differences between these sounds: Preferred sounds tend to feature more prominent dripping, sizzling, and crackling components and a more even temporal structure, while non-preferred sounds are more high-frequent, shrill, loud, powerful, and hard.

**Figure 1**
**Comparison of the most liked versus least liked rated machine sounds**

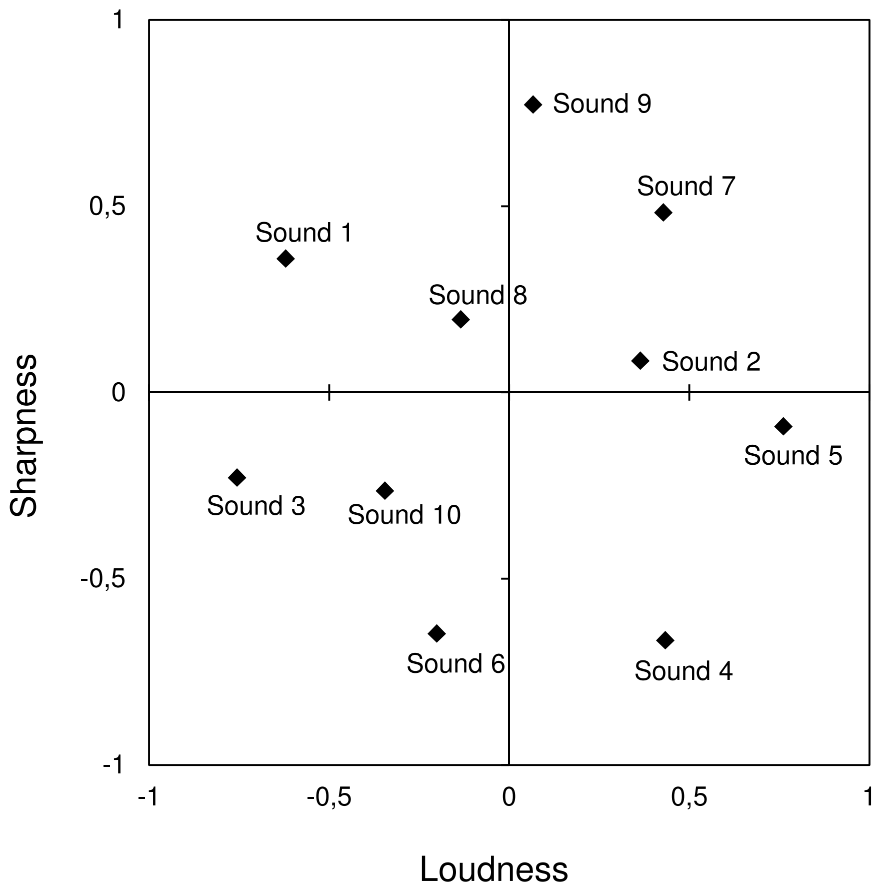



## Step 5: Multidimensional Scaling and Modeling of Customers' Sound Preferences

Based on the aggregated similarity ratings of all possible pairs of machine sounds (obtained in the customer study, step 3), a two-dimensional multidimensional scaling (MDS, see Kruskal & Wish, 1978) model was estimated using the SMACOF package of the statistical software R (De Leeuw & Mair, 2009). MDS is a multivariate method that allows visualizing a set of objects (e.g., coffee machine sounds) in a perceptual map. The position of the machine sounds relative to each other is calculated from averaged (dis-)similarity ratings for these sounds. Consequently, distances between two sounds within the perceptual map represent the perceived (dis-)similarities between these sounds, such that increased proximity correlate with increased similarity. At the same time, the orthogonal axes of the MDS map represent the most salient perceptual features of the sounds contained in the map. Note that a priori knowledge about the relevant properties of the sounds is not necessary in MDS. Rather, the researcher has to label the axes post-hoc based either on salient patterns in the configuration, or based on additional data sources.

Since there were no immediately apparent patterns in the perceptual map, we regressed psychoacoustic metric scores (loudness, sharpness, roughness, tonality, fluctuation strength, step 2) of all sounds on the MDS coordinates of the machine sounds in order to facilitate the interpretation of the two axes of the perceptual map. In the resulting plot, psychoacoustic metrics loudness and sharpness provided the best explanation of the configuration, as their regression slopes were almost orthogonal. Thus, loudness and sharpness were used as axis labels. Figure 2 shows the configuration of the sounds.

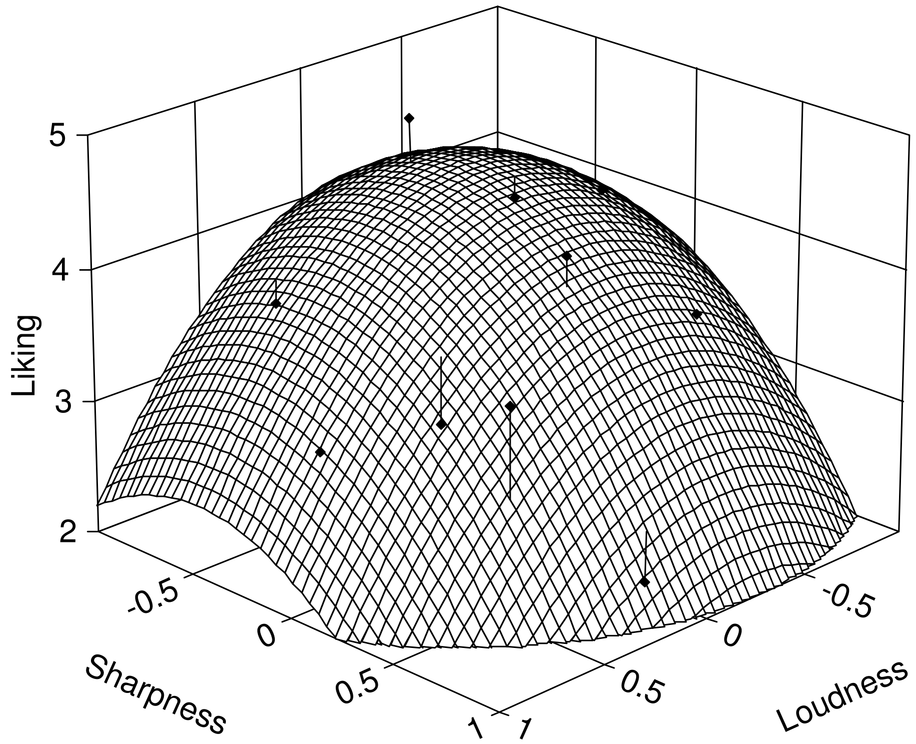
**Figure 2**
**Perceptual map of coffee machine sounds with psychoacoustic metrics loudness and sharpness as perceptual dimensions**



Next, customers' preference ratings obtained in step 3 were integrated into the perceptual map in order to identify preferred and less-preferred regions of the perceptual map. To this end, an averaged "ideal point" preference function was estimated based on customers' preference ratings and MDS coordinates of the machines, and then fitted to the machine sound configuration. The result of this estimation is illustrated in figure 3. In addition, preference functions for individual customer clusters were also estimated in order to check for cluster-specific sound preferences.

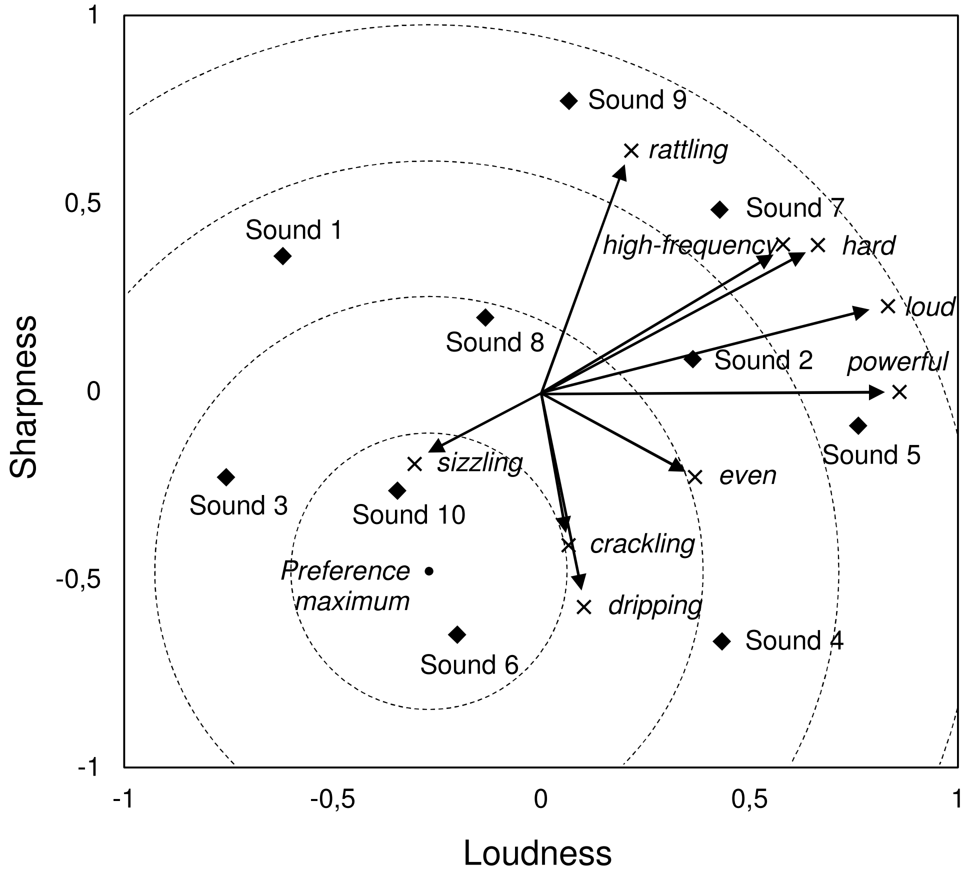
**Figure 3**

**Ideal point preference function based on MDS coordinates and preference ratings of machine sounds**




Finally, the sound descriptor ratings obtained in the QDA (step 4) were regressed into the MDS space. The attributes "sizzling", "dripping", "crackling", and "even" fall close to the extremum of the preference function, which suggests that these attributes best describe the preferred machines. In contrast, the "rattling", "high-frequency", "hard", "loud", and "powerful" attributes best describe the non-preferred machines. Figure 4 summarizes the integrated findings of all previous analyses.

**Figure 4**
**Perceptual map of coffee machine sounds with integrated preference function and sound descriptors**




## Discussion

The analyses described in this article provided marketers at the collaborating firm with information about which product sounds are preferred by its customers, and which psychoacoustic and perceptual features are most likely to drive these preferences. The integrated map resulting from the various analyses can serve as a strategic tool for new product development: According to the map, reducing machine sound loudness and sharpness, as well as increasing the “sizzling”, “crackling”, “dripping”, and “even” components in new product sounds should lead to an increased liking for these sounds. Importantly, since the map includes product sounds of competitors’ products, it enables marketers to compare how customers differentially perceive the firm’s own and competing products. Hereby, managers are enabled to develop improved acoustic designs both in terms of meeting customer expectations as well as in achieving differential competitive positions.

While such knowledge is neither sufficient nor intended to substitute the individual creativity and expertise of product sound designers and acoustical engineers, it can be used by product managers to guide and inform the acoustic design of new products. In contrast to approaches that predominantly rely on the subjective evaluation of few sound design professionals, the approach presented in this article allows to identify and ultimately better meet customers' auditory expectations. Taking into account such sensory expectations can be essential, as evidenced by the example of chips manufacturer Frito-Lay, which was forced to withdraw a new packaging from the market after customer complaints about it being too noisy (Russo, 2010).

Compared to conventional, separate analyses, the approach presented here has several advantages: Note that the spatial configuration of product sounds resulting from the MDS is based upon ratings of similarity. This ensures that the configuration of sounds represents a good approximation of customers' true auditory perceptions, since customers will use their own criteria to assess similarities. In contrast, many other methods that can output multidimensional representations of a set of objects (e.g., principal components analysis) require the manager to a priori specify the attributes on which the objects should be rated. In doing so, the manager potentially introduces a bias and obscures participants' true evaluation criteria.

Also, the integrated view appears to exhibit a superior sensitivity to detect relationships between sound descriptors and customers' preferences. For example, while the profile plots resulting from QDA failed to recognize "rattling" as a negative attribute, the integrated map clearly indicates that the "rattling" attribute, in accordance with everyday experience, is far away from the maximum of the preference function and should thus be avoided in future coffee machine sounds. Similarly, the QDA did not detect "sizzling" to be a positive attribute, whereas the integrated map shows it near the preference maximum.

Of course, it is important to note that the results of the integrated analysis are strongly dependent on product category. While auditory loudness and sharpness appear to be the most salient perceptual dimensions with regard to the specific stimulus set examined in this article, these findings will most likely not apply to other types of product sounds. However, the methodology presented here can be applied to a wide variety of product categories (e.g., household appliances, consumer electronics, cars, foods and beverages), enabling marketers to generate category-specific results.

To conclude, integrating customer insights into the sound design process is likely to result in acoustic product designs that better reflect customers' expectations. As the acoustic design of a product is oftentimes not noticed until after the purchase has been made, an improved acoustic design may ultimately lead to increased customer satisfaction, word-of-mouth referrals, and repurchase intentions.

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## Article IV

Knöferle, K. M., Sprott, D. E., Landwehr, J. R., & Herrmann, A. (in preparation for submission). "I Like the Sound of That": Individual Differences in Responses to Product Sounds. *Journal of Consumer Psychology*.

# "I Like the Sound of That":

# Individual Differences in Responses to Product Sounds

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# Abstract

While a considerable amount of research has investigated how music influences consumer behavior, only minimal research has been conducted in marketing to understand the effects of non-musical sounds, especially regarding the sounds of the products that we consume and use. As a first step in addressing this gap, the present research explores consumers' differential responses to product sounds. We propose that consumers differentially evaluate product-inherent sounds, appreciate product-related acoustic cues, and utilize the sound of products as means to evaluate products. In order to measure these individual differences, we develop a new construct referred to as the *Importance of Product Sound* (IPS). We consider IPS to be a multi-dimensional measure comprising three subdimensions (*product sound expertise, product sound enjoyment, product sound diagnosticity)*. Based on this theorizing, we develop and validate an 11-item scale in a series of four studies, in which dimensionality, reliability, discriminant, and construct validity of the scale are assessed.

# Introduction

*I like to listen. I have learned a great deal from listening carefully. Most people never listen. – Ernest Hemingway*

Whether it be background noise in consumption settings, marketer manipulated sounds (e.g., background music in an advertisement), or the sounds of products we use (e.g., cars, appliances), there is little doubt that acoustic cues play a role in many dimensions of consumer behavior. This has been no more clearly demonstrated than with marketing research that has investigated the effects of music on consumers. Research in this well-established field has shown that basic dimensions of music – such as tempo (Milliman, 1982, 1986) or mode (Kellaris & Kent, 1991) – can strongly influence consumer attitudes and behavior. Previous research also suggests that music can interact with key marketing variables such as the products offered in a store (North, Hargreaves, & McKendrick, 1997), department (Yalch & Spangenberg, 1993), or retail crowding (Eroglu, Machleit, & Chebat, 2005) to influence product selection and choice.

While a considerable amount of research has investigated how music influences consumer behavior, minimal research has been conducted to understand the effects of other sounds in a consumption setting, especially regarding the sounds of the products that we consume and use. Indeed, there is only one known marketing study that has examined how product sounds influence consumers. In that article, Lageat and colleagues (2003) identified acoustic properties of lighter sounds (the item used to light cigarettes and cigars) which influence consumers' perceptions of luxury. While there exists some research on designing the sounds of products from an engineering perspective (Bowen & Lyon, 2001), there is clearly a dearth of research on how consumers respond to the sounds of products. This is somewhat surprising given that firms have recognized the importance of product sound, as witnessed by their investments in designing such acoustical cues for consumers as part of the product development process.

To begin to address this gap, the current research explores consumers' differential responses to product sounds. Building on basic research finding that humans differ in terms of their abilities to perceive sounds (Fastl & Zwicker, 2007), we propose that consumers, in a similar fashion, differentially evaluate product-inherent sounds, appreciate product-related acoustic cues, and utilize the sound of products as means to evaluate products. Similar to the Centrality of Visual Product Aesthetics (CVPA; Bloch, Brunel, & Arnold, 2003) and the Need for Touch (NFT; Peck & Childers, 2003), we develop a new construct referred to as the Importance of Product Sound (IPS) that captures individual differences in consumers' auditory sensory modality regarding sounds made by products. Like the constructs and scales by Bloch et al. (2003) and Peck and Childers (2003), we consider IPS to be multi-dimensional.

In the present research, we begin by conceptualizing the Importance of Product Sound construct. Next, details about our scale development efforts are presented. A series of empirical studies are then reported to provide initial evidence regarding the validity of the construct. Finally, implications of the new construct and its measure are discussed in terms of marketing theory and practice.

## The Importance of Product Sound

We define the Importance of Product Sound to represent the differential value that consumers place on product sounds (i.e., product-inherent acoustic cues occurring during product usage or consumption). Based on our theorizing and the development of similar constructs (Bloch et al., 2003; Peck & Childers, 2003), we conceptualize IPS as a multidimensional, individual difference variable that features three dimensions: *product sound expertise* (the degree to which individuals are able to perceive and process auditory stimuli), *product sound enjoyment* (the hedonic value provided by product sounds), and *product sound diagnosticity* (the extent to which product sound is used as an evaluation criterion for products).

As an individual difference variable, IPS is expected to be relatively stable over time, but can develop or evolve through experience. Also, it is not limited to specific product categories or usage contexts, but rather is predicted to be influential across a variety of products and situations. IPS is a continuous difference variable. Lower levels of IPS in a consumer indicate that a person's responses to products are largely unaffected by acoustic cues. In contrast, higher levels of IPS suggest that the acoustic modality dominates the consumer's product preferences, purchase decisions, as well as usage and consumption experiences.

Some might argue that the auditory sense is less important in shaping consumers' product experience than the visual modality. While we admit that the two systems operate differently (vision allows consumers to perceive a greater amount of information simultaneously, whereas audition provides information in a consecutive manner with less data perceived simultaneously; Schifferstein & Cleiren, 2005), we hold that both systems are important sources of information regarding product consumption. Indeed, there is a considerable range of product categories (such as vehicles, high-tech products, and domestic durables) in which consumers attach considerable importance to the auditory modality (Schifferstein, 2006). Due to multisensory integration (Driver & Noesselt, 2008), unconscious multimodal effects of acoustic cues on subsequent product experience are likely to occur in an even wider range of products (e.g., the rustle of clothing, or the crunch of certain foods; Zampini & Spence, 2004).

## Product Sound Expertise

The product sound expertise dimension of IPS represents the ability to perceive, process, and memorize auditory stimuli associated with products. While anatomic capabilities of people vary (e.g., discrimination threshold, diminished sensitivity to certain frequencies), we also expect consumers to differ with regard to their perceptual expertise due to social and experiential factors (Chartrand, Peretz, & Belin, 2008). Specifically, von Hippel and colleagues demonstrated that expertise emerges because of perceptual experience in a certain domain (Vonhippel, Hawkins, & Narayan, 1994). This dimension of the IPS represents known examples of auditory specialists with especially high sound expertise, such as musicians, sound engineers, car mechanics, cardiologists, speech therapists, or ornithologists (Chartrand et al., 2008).

While low-level processes like stream segregation or perceptual attribute discriminations are hard-wired, higher-level properties such as attentional flexibility and hierarchical organization are developed throughout life (Steven McAdams & Drake, 2004). Sound expertise can be similarly developed, both by formal training and by informal listening experiences (Bigand & Poulin-Charronnat, 2006). An example for the effects of systematic training is given by Lageat et al. (2003), who describe how initially naïve listeners can become capable of complex product sound evaluations through a series of training sessions.

More specifically, individuals with higher levels of sound expertise should be better able to extract subtle acoustical dimensions of product sounds (e.g., spatial, temporal, pitch, and timbre characteristics) than individuals with lower levels of sound expertise

(Stephen McAdams, Winsberg, Donnadieu, De Soete, & Krimphoff, 1995; Micheyl, Delhommeau, Perrot, & Oxenham, 2006; Rammsayer & Altenmuller, 2006). This conclusion is supported by recent research showing that naïve and expert listeners use different listening strategies when categorizing environmental sounds. In particular, naïve listeners group auditory stimuli based on the assumed physical cause, while expert listeners tend to rely on acoustical properties (Lemaitre, Houix, Misdariis, & Susini, 2010).

## Product Sound Enjoyment

Prior research suggests that acoustic stimuli can activate appetitive and aversive processes in ways similar to visual stimuli (Bradley & Lang, 2000). Accordingly, the product sound enjoyment dimension reflects the hedonic value provided by product sounds. In particular, it represents a general tendency regarding consumers' enjoyment derived from perceiving product-related auditory cues. This dimension is built upon the notion that consumers may differentially derive pleasure from listening to the sound of a product as an end in itself. In this regard, this dimension bears resemblance to the autotelic dimension of the NFT scale (Peck & Childers, 2003), or the value dimension of the CVPA scale (Bloch et al., 2003). The assumption that individuals differ in terms of sound enjoyment is backed by recent findings that demonstrate the existence of intercultural differences in emotional reactions to acoustic stimuli (Redondo, Fraga, Padrón, & Pineiro, 2008).

While not all products provide sounds that consumers enjoy, there are a number of product categories where the sound of the item can be affectively pleasing to consumers, such as the powerful sound of a high performance sports car's engine (Bisping, 1997), or the cozy feeling one gets in a coffee shop as an espresso machine makes a cup of coffee.

Whereas consumers with lower appreciation of product sounds are likely to feel indifferent or even averse towards acoustical cues of products, individuals with a greater appreciation for product sounds should react favorably when interacting with or consuming products that provide auditory stimulation. This also suggests that consumers scoring high on this evaluative dimension should (at a general level) be more likely to evaluate specific product sounds in a favorable manner. More generally, consumers higher on this IPS dimension may believe in supra-individual value of product sounds and how such sounds can impact the quality of one's acoustic surroundings. In other words, such consumers may hold that aesthetically appealing acoustic surroundings (e.g., pleasant car engine sounds, acoustically optimized living spaces or retail stores) can exert a positive influence on the consumer's environment.

## Product Sound Diagnosticity

The sound diagnosticity dimension captures the extent to which product sounds are used as an evaluative criterion for products. As such, this dimension of the IPS is expected to influence product preferences, purchase decisions, and purchase satisfaction for consumers. Product sound diagnosticity can be compared to the instrumental dimension of the NFT scale (Peck & Childers, 2003) and to the determinancy dimension of the CVPA scale (Bloch et al., 2003).

In many instances, sounds that occur during product usage or consumption can have a diagnostic value in terms of the product's function or abilities (Montignies, Nosulenko, & Parizet, 2010). Just like other product attributes, such as brand, price, or country of origin (Dodds, Monroe, & Grewal, 1991; Jacoby, Olson, & Haddock, 1971), the acoustic design of a product can consciously or unconsciously be used to make a judgment about a product. Since acoustic cues are oftentimes directly related to physical properties of a product (e.g., the sound of a car's engine), they are likely to act as intrinsic cues in the product evaluation process (Jacoby et al., 1971). In particular, given that product sounds are most often accessible to consumers, such cues are likely to be used to draw conclusions about a product's quality, condition, or performance.

Real-life evidence for this kind of behavior can be found in many consumer settings, for instance when potential car buyers repeatedly slam car doors while listening for auditory cues that may indicate particularly low or high build quality, or when consumers judge the cleaning capacity of a vacuum cleaner by the loudness of the motor. Zampini and Spence presented empirical evidence that the perceived crispness of potato chips can be influenced by manipulating the sound that is produced during the biting action (Zampini & Spence, 2004). Similarly, the operating sound of electric toothbrushes has been shown to moderate vibrotactile pleasantness ratings (Zampini, Guest, & Spence, 2003).

In terms of this IPS dimension, we expect consumers with higher levels of product sound diagnosticity to rely more on acoustic cues during product evaluation and selection. For these consumers, the possibility to obtain product information via sound may result in a higher confidence in their overall product evaluation compared to no-sound situations. For consumers scoring high on this dimensions, obtaining acoustic product information may even justify compromising on other product attributes (e.g., by paying a higher price), and may result in increased post-purchase satisfaction. In contrast, consumers who place less value on this dimension will be largely unaffected by the presence or absence of product sounds when forming product-related attitudes and making product choices.

# Scale Development

## Item Generation and Expert Review

On the basis of a literature review, consideration of related measures, and our own item generation efforts, an initial set of 58 items was developed. This set contained items that were developed to represent the hypothesized IPS sub-dimensions of expertise ($N$ = 17), enjoyment ($N$ = 21), and diagnosticity ($N$ = 20). Following prior research (Bearden, Hardesty, & Rose, 2001; Bearden, Netemeyer, & Teel, 1989), we conducted an initial pretest in which the content validity of the items was evaluated by a group of experts. After having been provided with definitions of the IPS construct and its sub-dimensions, a group of five PhD students assigned each item to the sub-dimension, which, in their opinion, best captured its content (if any). This pretest resulted in dropping 14 of the initial items that were not consistently assigned to a single sub-dimension (by at least four out of the five judges). In addition, another five items were reassigned to other dimensions due to consistent reassignments of at least four of five judges. In a second pretest following Bearden et al. (1989) and Zaichkowsky (1985), definitions of each sub-dimension and corresponding items were presented to a separate group of eight PhD students and faculty judges. The judges rated how well each item represented the sub-dimension on a 9-point likert scale. Then, we computed means for all items and removed 21 items with a mean equal to or lower than the median ($M$ = 6.25) of the item means.

## Studies 1 and 2: Scale Refinement

The remaining 23 scale items were administered to an undergraduate student sample (*N* = 312) in order to examine the underlying factor structure. All items were presented in a 7-point likert scale format with higher values signifying increased agreement. Four cases in which responses had obviously been carelessly given (values being equal across all items) were removed from further analyses.

As a first step in scale purification, the correlation of each item with the score for the total set of all 23 items was examined. Items with an item-total correlation < .40 were deleted. This led to the elimination of two items. The Kaiser-Meyer-Olkin test (KMO) and Bartlett's test of sphericity were used for determining the adequacy of using factor analysis on the data set (Kaiser & Rice, 1974). With a KMO value of .89 and Bartlett's test being significant ($\chi^2$ = 3072.19, df = 210, $p \leq .001$), an exploratory principal components analysis with varimax rotation was conducted for the remaining 21 items. As suggested by Hayton, Allen, and Scarpello (2004), parallel analysis was used for determining the number of factors to retain. The factor analysis resulted in a four-factor solution; this is one factor more than expected with regard to the postulated three IPS dimensions. The amount of variance explained was high (60.53%). While the factor analysis results were clear for the product sound expertise and enjoyment sub-dimensions, two factors emerged that were related to the postulated diagnosticity sub-dimension. Based on the results of this initial principal components analysis, another nine items were removed because they did not exhibit simple structure on any factor. Item-total correlations were computed again with the remaining 12 items, this time yielding acceptable results for all items.

Maximum-likelihood exploratory factor analysis (varimax rotation) was then conducted on the remaining 12 items (KMO value =.81; significant Bartlett's test, $\chi^2$ = 1502.08, df = 66, $p \leq .001$). Three factors were extracted (as determined by parallel analysis) with an explained variance of 53.36%. Based on the results, one item from the diagnosticity sub-dimension was removed due to weak factor loadings. Two items from this dimension, however, showed cross-loadings on the enjoyment dimension. This problem persisted in a subsequent factor analysis on the remaining 11 items. The scale items and associated factor loadings for the 11 items appear in table 1, with associated explained variance and alphas for each sub-dimension.

## Table 1
## Study 1 results of initial scale purification

| Scale items | Factor | | |
|---|---|---|---|
| I'm able to identify products based on their characteristic sounds. | **.63** | | |
| I have a well-trained sense of hearing. | **.65** | | |
| I'm able to differentiate even between sounds that are very similar to each other. | **.77** | | |
| I'm often able to tell apart products from the noises that they are making. | **.77** | | |
| It can be pleasant to listen to product sounds. | | **.73** | |
| I enjoy hearing the sound a product makes. | | **.83** | |
| Listening to the sounds of a product can be fun. | | **.72** | |
| If I realize that a product I just bought sounds bad, I'm dissatisfied. | | | **.73** |
| The sound of product influences my evaluation of the product. | | | **.83** |
| I rely upon the sound of a product to make a choice. | | .32 | **.51** |
| When I have to choose between several products, the sounds they make are an important factor for my decision-making. | | .31 | **.56** |
| **Extracted variance in percent** | 19.81 | 18.49 | 18.04 |
| **Cronbach's alpha** | .82 | .83 | .78 |

*Note.* Loadings < .30 are omitted.

In order to provide additional insights into the scale items, we conducted a second purification study ($N$ = 97) with a sample of customers in a retail store. Again, exploratory PCA and ML-FA were used on the 11 items determined in study 1. Identical to the results of the first study, a three-factor solution emerged for the 11 final items that represents the postulated three dimensions of IPS: The first factor reflects sound expertise, the second factor product sound enjoyment, and the third factor sound diagnosticity.

# Construct Validation

## Study 3a: Scale Dimensionality and Reliability

We administered the scale items to an undergraduate student sample ($N$ = 378) in order to verify the factor structure of the IPS scale using confirmatory factor analysis in Mplus (Muthén and Muthén 2010). Listwise deletion of missing values led to a usable sample of 355 cases. For the analysis, we compared various confirmatory factor analysis models, including: (1) a null model in which all items were uncorrelated with all other items in the model; (2) a one-factor unidimensional model; (3) a three-factor uncorrelated model; (4) a three-factor correlated model; and (5) a one-factor second-order model with three subdimensions. Results appear in table 2.

**Table 2**
**Study 3 results for various CFA models**

| Model | *Chi-square* | *df* | *Chi-square* diff | *CFI* | *TLI* | *RMSEA* | *RMSR* |
|---|---|---|---|---|---|---|---|
| **Null** | 2568.62 | 55 | | .00 | .00 | .36 | .42 |
| **1-factor** | 1032.12 | 44 | 1536.50[a] | .61 | .51 | .25 | .14 |
| **3-factor uncorrelated** | 450.38 | 44 | 581.74[a] | .84 | .80 | .16 | .29 |
| **3-factor correlated** | 230.25 | 41 | 220.13[a] | .93 | .90 | .11 | .07 |
| **1-factor second-order** | 230.25 | 41 | 0 | .93 | .90 | .11 | .07 |

[a] Chi-square difference to preceding model significant at .001-level.

As noted in table 2, confirmatory factor analysis yielded acceptable fit indices for the three-factor correlated model and the one-factor second-order model. Both the CFI and the TLI exceeded or approximated, respectively, the .90 recommendation (Hu & Bentler, 1999). The RMSR indicated good fit with a value < .08 (Hu & Bentler, 1999). The RSMEA failed to meet the cut-off value of .08, but can reasonably be considered an outlier in the face of the other fit indices. While these two CFA models are similar, we contend that the three-factor correlated model best represents the conceptual nature of our construct and therefore focus on this model regarding the following additional analyses.

For the three-factor correlated model of IPS, all factor loadings were equal to or greater than .60, and the $z$-values of all items exceeded 11.99 ($p < .001$). An examination of the indicator reliabilities for the three-factor correlated model showed good results. The average variance extracted (AVE) exceeded the recommended cut-off value of .50 for all three dimensions (Fornell & Larcker, 1981). Similarly, both Cronbach's coefficients (all > .84) and composite reliabilities (all > .85) for the three dimensions were high. The correlations between the various sub-dimensions are positive and strong: expertise and enjoyment ($\Phi = .52$), expertise and diagnosticity ($\Phi = .46$), and enjoyment and diagnosticity ($\Phi = .59$).

In summary, the IPS construct is confirmed by study 3a to have three inter-correlated dimensions. This leads to the question whether the IPS scale should be analyzed at the composite level or at a dimensional level. Both strategies may have unique advantages and disadvantages (for a detailed discussion, see Carver, 1989). Given that each of the three IPS dimensions is likely to have a predictive value of its own in a product evaluation context, we choose to analyze the IPS scale at the dimensional level in the remainder of this research.

## Study 3b: Discriminant Validity

Next, we examined the discriminant validity of the IPS dimensions among each other and in relationship to related measures. The survey that was administered in study 3a included additional measures, including the CVPA scale (Bloch et al., 2003), and the Need for Uniqueness (NFU) scale (Tian, Bearden, & Hunter, 2001). The IPS and CVPA scales both measure the role that a specific sensory modality plays within the context of product perception and both constructs fall within the realm of aesthetic evaluation. Thus, we expect that consumers who score high on the CVPA scale will also score high on the three dimensions of IPS. In terms of the NFU scale, consumers with a high need for uniqueness in products may try to maximize overall uniqueness by distinguishing themselves via all available product attributes. Since acoustic product design may serve as a means of setting oneself apart from others in terms of consumption behavior, we anticipate that consumers high in NFU would be similarly high on the expertise, enjoyment, and diagnosticity sub-dimensions of IPS.

Results of our analysis provide support for the preceding expectations. Table 3 shows paired phi correlation estimates between IPS dimensions and related measures. Considering the relatively high correlations between the scales, we assessed the discriminant validity between the constructs using the approach outlined by Fornell and Larcker (1981). This approach consists of pairwise comparisons between all constructs, whereby the average variance extracted of two constructs must exceed their squared phi correlation. For all combinations of IPS dimensions and related constructs, extracted variances exceeded the squared phi estimations, indicating discriminant validity.

**Table 3**

**Paired phi correlation coefficients between IPS dimensions and related measures**

| | **IPS dimensions** | | | **NFU** | **CVPA** |
|---|---|---|---|---|---|
| | Expertise | Enjoyment | Diagnosticity | | |
| **IPS dimensions** | | | | | |
| Expertise | … | .52[a] | .52[a] | .26[a] | .38[a] |
| Enjoyment | | … | .50[a] | .23[a] | .41[a] |
| Diagnosticity | | | … | .31[a] | .41[a] |
| **Cronbach's alpha** | | | | .85 | .90 |

[a] Correlation is significant at the .001 level (2-tailed).

As an additional assessment of discriminant validity, for each factor combination, we examined whether a two-factor model fit significantly better than a one-factor model (Anderson & Gerbing, 1988). The two-factor model exhibited a better fit in all instances ($p < .001$), with the smallest chi square difference ($\chi^2 = 490.82$) occurring between the IPS expertise dimension and the CVPA scale. Based on these results, all three IPS dimensions have good discriminant validity, that is, they do not overlap with one another, nor with the other scales.

## Study 4: Product Sound Enjoyment and the IPS Scale

Given that the IPS scale is conceptualized to contain three interdependent sub-dimensions that are expected to have differential effects on consumers, we assessed the performance of one of the scale's sub-dimensions (vis a vis the other two dimensions) when consumers are presented with actual product sounds. More specifically, we designed an experimental context whereby consumers' responses to products sounds (that vary in terms of sensory pleasantness) should be predicted by the product sound enjoyment sub-dimension of the IPS. Based on our theorizing of the IPS construct, we hypothesized that: (1) pleasant product sounds will lead to more favorable consumer responses, than unpleasant product sounds; (2) individuals scoring higher on the sound enjoyment sub-dimension of the IPS will evaluate sounds more favorably independent of their sensory pleasantness; and (3) neither consumers' sound expertise nor sound diagnosticity will significantly affect consumer evaluations.

Sound pleasantness was experimentally manipulated by selecting two product operating sounds from the same product category (consumer coffee machines) that varied in sensory pleasantness (low vs. high). The stimuli were obtained by recording the sounds of ten coffee machines (duration: 12 seconds) in a professional recording studio. Next, a pretest was conducted, in which ten PhD students rated the pleasantness of the sounds. The highest (lowest) rated machine sound was selected to represent the high (low) pleasantness condition.

Customers of a coffee shop ($N$ = 97) were invited to take part in the experiment. Both stimuli were played to participants in randomized order over closed Sennheiser HD 25-1 II stereo headphones. After listing to a sound, participants indicated their overall liking of the sound on a 7-point scale. Finally, they completed the IPS scale.

As these repeated measurements from participants are likely to be correlated, we used linear mixed models with a random intercept for participants to model the data (Fitzmaurice, Laird, & Ware, 2004). All analyses were conducted using the lme()-function of the nlme package within the statistical software R (Pinheiro, Bates, DebRoy, Sarkar, & the R core team 2011). After centering the IPS sub-dimension scores, we estimated four models: In each one, liking was regressed on the sound pleasantness variable, and on one of the three IPS subdimensions or the IPS composite score, respectively.

First, we regressed liking on stimulus pleasantness and sound expertise. As expected, there was only a positive effect of sound pleasantness ($b = 2.21$, $t = 9.07$, $p < .001$), but no effect of sound expertise ($p = .38$), and no interaction ($p = .21$). In the second model, we regressed liking on stimulus pleasantness and sound enjoyment. We found a positive effect of sound pleasantness ($b = 2.18$, $t = 8.96$, $p < .001$), a marginally significant positive effect of sound enjoyment ($b = .25$, $t = 1.97$, $p = .05$), but no interaction ($p = .69$). Next, we regressed liking on stimulus pleasantness and sound diagnosticity. There was an effect for pleasantness ($b = 2.19$, $t = 8.93$, $p < .001$), but not for diagnosticity ($p = .39$), and no interaction ($p = .72$). Finally, we regressed liking on stimulus pleasantness and the composite IPS score. The analysis yielded a significant coefficient for sound pleasantness ($b = 2.20$, $t = 8.96$, $p < .001$), but not for IPS score ($p = .50$) or the interaction term ($p = .58$).

Consistent with our predictions, sound enjoyment was the only IPS dimension that significantly influenced liking judgments of product sounds. In addition, the results suggest that IPS scores should be analyzed on a dimensional rather than on a composite level only.

## General Discussion

In the present research, we propose that consumers differ in the extent to which product sound influences their reaction to and evaluation of products. The multi-dimensional IPS construct features three dimensions, including: the degree to which individuals are able to perceive and process auditory stimuli (product sound expertise), the hedonic value of product sound (product sound enjoyment), and the extent to which product sound is used as an evaluation criterion for products (product sound diagnosticity).

Following generally accepted procedures, an 11-item scale was developed (studies 1 and 2) and evaluated with regard to its psychometric properties (studies 3 and 4). The four studies reported in this research provide strong evidence for the dimensionality, reliability and validity of the IPS scale. In terms of construct validity, IPS is distinct but positively correlated with the CVPA (Bloch et al., 2003) and the NFU (Tian et al., 2001) scales. These results suggest that IPS captures unique, auditory-based differences in consumers' responses to products. Construct validity is further demonstrated in study 4 by showing that the sound enjoyment sub-dimension of the

IPS (but not the other dimensions) predicts reactions to product sounds. These findings indicate that treating IPS as a multi-dimensional (i.e., not single, composite) measure is most appropriate.

There are a variety of directions for future research. One avenue is to extend the design of study 4 to test for differential effects of the expertise and diagnosticity sub-dimensions of IPS. For example, in a product evaluation task, consumers who score higher on the diagnosticity dimension should indicate higher (lower) confidence in their product evaluations if product sound is present (vs. not present). In contrast, consumers scoring lower on diagnosticity should be unaffected by the availability of acoustic product cues. Prior research indicates that product cues are differentially used in the evaluation process based on diagnosticity and accessibility of the cues. Studies that explore the interactive effects of product cues (e.g., auditory and tactile cues) and the ISP scale could be particularly insightful.

Further validation of the new measure would also be useful. For example, tests for known groups validity could be instructive and conducted by comparing IPS scores between naïve and expert listeners (e.g., such as musicians or sound engineers). Finally, applying the IPS in different auditory contexts would be another useful direction of future research. One of the most compelling areas would be to investigate how consumers differentially react to negative product sounds. Such contexts are particularly important for consumers who can react unfavorably to unpleasant product sounds, as witnessed by the recent decision by Frito-Lay to replace its noisy (but environmentally friendly) bag from the market due to consumer complaints (Russo, 2010).

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## Article V

Knöferle, K. M., Herrmann, A., Landwehr, J. R., & Spangenberg, E. R. (2011). The Interactive Effect of Music Tempo and Mode on In-Store Sales. *Proceedings of the 40th European Marketing Academy Conference (EMAC) 2011*.

# The Interactive Effect of Music Tempo and Mode on In-Store Sales

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# Abstract

This article extends previous research regarding the effects of in-store music on consumer behavior. It is the first article to show the effect of music varying in multiple low-level properties (musical mode and tempo) on sales in a real-life retail environment. In addition to confirming previous findings on the effects of tempo, we show that mode can affect sales and that an interaction between tempo and mode qualifies these main effects: Slow music resulted in higher sales than fast music, and music in minor mode resulted in higher sales than music in major mode. The tempo manipulation was more influential in minor mode.

# Introduction

Music is a complex, multidimensional stimulus with the potential to influence individual affect, cognition, and behavior (Bruner, 1990). Recognizing this potential, which in turn can impact consumers' behaviors and decision making, marketers invest substantial resources in trying to effectively incorporate music into design of retail environments (e.g., Morrison & Beverland, 2003). A considerable amount of research in the field of musical atmospherics has examined the effects of high-level or global properties of music. These studies include music versus no-music conditions (Park & Young, 1986), background versus foreground conditions (Morrison, Gan, Dubelaar, & Oppewal, 2011), and musical genre (Areni & Kim, 1993). Another branch of research has focused on properties not inherent to the music itself, but variables arising from either the interplay between music and the environment (e.g., interaction between music and scent; Spangenberg, Grohmann, & Sprott, 2005; fit of music and store image; Vida, Obadia, & Kunz, 2007), or from the interplay between music and participant (e.g., musical preferences; Caldwell & Hibbert, 2002; shopper's familiarity with the music; Yalch & Spangenberg, 2000).

Milliman (1982) published a seminal paper studying the effects of a structural property of musical selections (i.e., tempo) on supermarket shoppers' behaviors, including spending. This work unfortunately did not stimulate a large stream of follow-up research; only a few studies since Milliman have focused on the direct relationship between low-level, structural properties of in-store music and financial outcomes. In fact, to our knowledge, there is no published work to date examining the combined impact of more than one structural property of music on financial measures in a realistic field setting. This dearth of research represents a serious gap in our understanding, leaving those designing and selecting in-store music reliant on little more than guesswork. It can be argued that only an acute knowledge regarding the effects of low-level musical properties – the "building blocks" of music – allows for the systematic design of effective in-store music.

The current research begins to address this gap in our knowledge by examining how the mode and tempo of environmental music affects sales in a retail context. Our work makes at least three important contributions to the literature. It is the first to extend laboratory findings regarding structural properties of music to real-world consumer decision making with actual financial implications. Second, this experiment is the first to demonstrate both main and interactive effects for two low-level structural properties. Third, knowledge about the impact of the structural properties of music can move practitioners beyond guessing or reliance on intuition, thereby facilitating scientific selection of effective in-store music.

Below we summarize previous research regarding how selected structural properties of in-store music may impact consumer behavior. Following that, we report a field experiment wherein music tempo and mode are manipulated, and effects upon actual retail sales are measured. Finally, implications of our findings as well as avenues for future research are discussed.

## Structural Properties of Music and Consumer Behavior

Music is categorized by the objective structural properties of time, pitch, and texture (Bruner, 1990). Examples of properties along the time dimension are tempo, meter, rhythm, and phrasing while the pitch dimension includes the properties of mode, harmony, melodic contour, and ambitus. The dimension of texture includes timbre as well as instrumentation and dynamics. Tempo and mode are held as particularly important determinants of listeners' responses to music with regard to consumer behavior (Kellaris & Kent, 1991).

Tempo refers to the speed or pacing of a musical piece measured in beats per minute (BPM; Sadie & Tyrrell, 2001). Research has demonstrated that faster tempo can raise arousal (Husain, Thompson, & Schellenberg, 2002), increase perception of pleasure (Kellaris & Kent, 1993), and affects consumers' perceptions of time (Oakes, 2003). Oakes (2003), for example, showed that time spans filled with slow music are perceived as shorter than those filled with fast music. A field study by Milliman (1982) examined the effects of music varying in tempo on actual customer behavior. It found slow music to decrease pace of in-store traffic flow in a supermarket, thereby leading to greater sales whereas fast music accelerated pace of in-store traffic flow, corresponding to lower sales.

Mode is a musical variable that defines the configuration of musical intervals used within a scale, a chord, or a piece of music (Sadie & Tyrrell, 2001). In Western music, the major and minor modes have been the predominant tonal systems for several centuries although many different tonal systems are known and have been used (e.g., pentatonic or atonal). From a retail atmospherics perspective, previous research regarding mode gives rise to two lines of argument resulting in sometimes conflicting implications.

On the one hand, mode is known to be one of several factors that may determine valence (i.e., perceived sadness or happiness) of music (Gagnon & Peretz, 2003). Consequently, mode has been shown to influence mood and arousal (Kellaris & Kent, 1993). In a laboratory experiment conducted by Husain et al. (2002), listening to a piece of music in major mode changed participants' moods in a positive direction whereas listening to the same piece of music in minor mode negatively affected participants' moods. Previous atmospherics research suggests a positive correlation between customer mood and store evaluation, time spent in the store, and spending (Donovan & Rossiter, 1982). Following this line of reasoning, one would therefore predict that music in a major mode (i.e., positively valenced) will lead to greater sales than music in a minor mode (i.e., negatively valenced).

On the other hand, work in consumer psychology supports the idea that mode influences listeners' temporal perceptions. Kellaris and Kent (1992) found that time spans filled with music in minor keys are perceived as shorter than spans filled with music in major keys. Thus, shoppers exposed to music in minor mode may underestimate actual time spent in a store while those exposed to music in major mode may overestimate their time spent. Both under- and over-estimations of subjective time could affect actual time spent in a store (i.e., lead to prolonged or shortened visits). Important to retailers is the fact that customers spending more time in a store are more likely to interact with sales personnel, make a greater number of unplanned purchases, and spend more money (Donovan & Rossiter, 1982; Inman, Winer, & Ferraro, 2009).

Existing research discussed above suggests two main effects: By influencing shoppers' temporal perceptions, 1) Slow music will lead to a higher gross sales volume than fast music, and 2) Music in a minor mode will lead to a higher gross sales volume than music in a major mode in retail environments. Importantly, the current research assumes that tempo and mode interact in such a way that 3) The effects of tempo and mode on sales will fully emerge only when both variables act in the same direction rather than contradicting each other.

# Experiment

Our research questions were tested in a field experiment with actual sales constituting the dependent measure of consumer response. Music was experimentally manipulated through synchronous playback in three stores of a large Swiss department store chain offering a broad range of premium products involving fancy foods, wine, clothing, house wares, and accessories. The three stores had been open for several decades, and thus have a relatively stable customer base. A 2 (mode: minor vs. major) × 2 (tempo: slow vs. fast) full factorial, repeated-measures design was implemented.

The main experiment took place over four weeks beginning May 14 to June 10, 2010, a period selected to avoid spring and summer holiday periods. Managerial constraints limited treatment to three days a week with each condition assigned to one randomly selected Thursday, one randomly selected Friday, and one randomly selected Saturday to insure a counterbalanced design. Additionally, identical experimental conditions were never administered on directly succeeding days to avoid boredom and/or negative sales staff reactance to the musical selections. Experimental treatments were administered without interruption from open to close; playlists for each condition were played in two alternating a priori randomized orders. Volume was adjusted such that the music was clearly audible throughout each of the stores (determined by pretest), while at the same time soft enough to be perceived as a background (as opposed to foreground) stimulus. After initial calibration, volume remained constant across all conditions.

## Stimulus Materials

Working from an initial set of 330 songs made available by a commercial business music provider, a 90-minute playlist was created for each condition. It is important to note that the 330 songs formed a single music program (“Sophisticated”) from this provider, and were relatively homogeneous in terms of global style and genre (original pop/rock songs from the years 1999 to 2009). Moreover, the set was representative of a music program that would normally be played in this department store chain.

The 330 songs were analyzed using the online music listening algorithm EchoNest API (Jehan, 2005). This analysis provided estimates of the mode (i.e., minor vs. major) and tempo (in BPM) of each song as well as confidence values for the reliability of each of these estimations. Results of this analysis were reviewed by a musicologist (the first author) and errors were corrected. Based on the corrected results, the initial set of songs was partitioned in a factorial manner: Songs had been classified as minor or major with regard to mode; songs slower than 95 BPM were assigned to slow conditions and songs faster than 135 BPM were assigned to fast conditions. Thus, four stimulus subsets were created: *minor-slow*, *minor-fast*, *major-slow*, and *major-fast*. The subsets were then further reduced; from each of the four sets, 24 songs were retained including those with the highest confidence values. The resulting playlists had mean BPM values of 85.0 BPM (minor slow), 161.9 BPM (minor fast), 82.5 BPM (major slow), and 157.1 BPM (major fast) and approximately equal duration (90.4-93.3 min).

## Measures

Gross sales data in Swiss francs for all checkouts ($N$ = 60) in the three stores were collected hourly for each of the 12 days of the field experiment. If no purchases were recorded for a specific checkout during a given hour the timeframe was coded as missing. As the sales variable was non-normally distributed, a logarithmic transformation was used to achieve a normal distribution (Fox, 2008). In order to eliminate external influences as far as possible, we controlled for the effects of day of the week as well as of a general weather variable that is composed of two highly correlated indicators (using PCA) on gross sales.

# Results

A linear mixed model was used to appropriately model the data (Fitzmaurice, Laird, & Ware, 2004). Such a model allows us to explicitly account for unobserved but constant heterogeneity between individual checkouts by specifying a random intercept. The model was estimated using the lme()-function of the nlme package of the statistic software R (Pinheiro, Bates, DebRoy, Sarkar, & the R core team 2011). The model contained fixed effects for the independent variables tempo, mode, and their interaction as well as for weather, and day of the week. Additional random intercepts were specified to model the three-level hierarchical structure resultant to checkouts being nested inside store departments, and store departments nested inside stores. The model yielded significant coefficients for mode ($b$ = −0.066, $SE$ = 0.015, $t$ = −4.465,

$p < 0.001$), tempo ($b = -0.089$, $SE = 0.015$, $t = -6.046$, $p < 0.001$), and the interaction term of mode and tempo ($b = 0.056$, $SE = 0.020$, $t = 2.751$, $p = 0.006$). The included covariates reached significance on the .01 (day of week) and .05 (weather) level.

**Figure 1**
**Effects of tempo and mode on log-transformed sales**

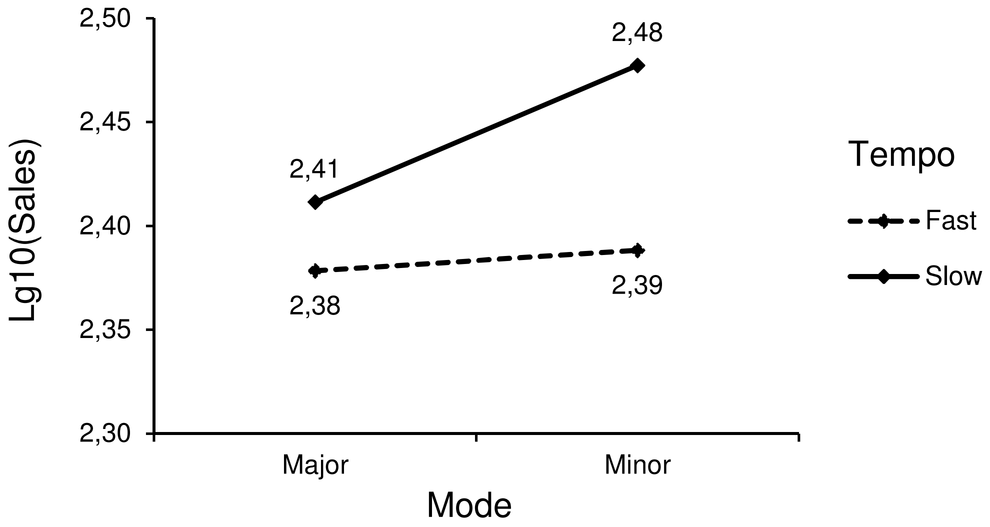


Figure 1 graphically depicts the ordinal interaction of mode and tempo on log-transformed sales indicated by the three-level hierarchical structure. Interestingly, while an initial look at the results suggests main effects of mode and tempo on sales with minor mode and slow tempo more effective, a significant interaction between tempo and mode qualifies these main effects: fast music varies only slightly in effectiveness by mode in the current study while music in a minor mode was significantly more effective when accompanied by a slow tempo.

## Discussion

Although suggested by Bruner (1990), little research has confirmed the interactions between different structural elements of music. The current research has made progress in that regard by demonstrating main effects of both musical mode and tempo on gross sales volume as well as an interaction effect. The pattern of our results lends support to the assumption that mode and tempo influence sales through affecting consumers' perceived and actual shopping time, rather than to the rivaling assumption that mode influences sales through affecting the affective state of shoppers.

It is important to note that our results, while statistically significant, are more conservative (from an effect size perspective) than those of Milliman's (1982) report of gross sales increase of 38.2%. We believe that our results are likely a more realistic estimate of the effect of music on actual retail sales due to a stricter control of external influences (e.g., weather) and to applying statistical tools which are able to account for the hierarchical structure and the repeated measurements in the data.

From a practitioner's perspective, our findings imply that retailers can improve the effectiveness of their in-store music by using slow music rather than fast music and music in minor mode rather than music in major mode. This improvement can easily be implemented for virtually any kind of music, irrespective of genre and most other musical variables. In order to design appropriate playlists, practitioners may adopt the method we described in the "Stimulus materials" section of the present research.

The current work, while providing evidence of an important interaction between structural properties of music, raises issues that motivate further research: First of all, future research should try to identify the affective and cognitive processes that underlie our findings. We particularly encourage researchers to examine main and interactive effects of musical mode and tempo on customers' real versus perceived shopping times in realistic shopping environments. Second, it would be worthwhile to examine the influence of mode and tempo as a function of the time of day. It may well be the case that time of day affects the preferred stimulation level of shoppers, and that musical variables can be tailored to provide the optimal level of stimulation. Last, the question arises if the influence of different levels of mode and tempo varies across specific store departments or product categories. For example, musical treatments may have different effects for low- versus high-involvement products.

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