

## **Product interaction sounds influence product personality**

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## Abstract

We report an experiment designed to test the hypothesis that the sonic interaction between the type of sole used in high-heeled shoes (polypropylene vs. leather) and the type of flooring (ceramic vs. carpet) influences the attribution of personality traits to the product sound. Forty-eight women walked down a “virtual runway” while listening to the modified interaction sounds of shoe heels contacting the floor. After being exposed to each sound, the participants filled in a questionnaire to measure product sound personality traits and the valence associated with each sound. The results revealed that different personality traits were assigned to distinct product sounds with the floor material influencing the attribution of such characteristics. These results promote awareness of the relevance of designing the environments where users interact with products to shape product sound personality.

**Keywords:** auditory perception; sonic interaction; multisensory perception; user experience; consumer behaviour.

## 1 Introduction

Design tends to focus on delivering solutions to enhance products’ visual attributes (Schifferstein and Hekkert, 2008). However, with the rapid growth of interest in the study of multisensory perception (Calvert et al., 2004; Bremner et al., 2012; Stein, 2012; Spence, 2021), more and more attention is now being devoted to understanding the impact that sensory stimuli exert on the user as a way of enhancing the quality of consumers’ products experience (e.g., Lyon, 2000; Özcan Vieira and Van Egmond, 2006, 2012; Van Egmond, 2008; Batra et al., 2015).

Sound is an essential attribute of user experience, influencing the perception of product feel and product qualities (Spence and Zampini, 2006; Spence, 2021). The engagement between sound and other multisensorial elements is critical to the successful design of products since it establishes additional points of contact between an experience and the consumer’s memory (Özcan Vieira, 2008). Thus, designers should consider sound as a means of reinforcing the consumer’s multisensory product experience (Schifferstein and Hekkert, 2008; Segura and Pérez, 2018). The idea is to create emotional bonds with the user and hopefully generate sensory differentiation points, mainly because sound is currently an under-exploited dimension in most industrial products.

Studies of the appeal of product sounds reinforce the importance of this sense on how individuals perceive and respond to products (Spence, 2021). Such sounds may, for example, be designed to be more pleasant (McDermott, 2013) and to provide abstract meanings such as power, efficacy (Wolkomir, 1996), comfort, and sophistication (Blauert and Jekosch; 1997; Bisping, 1997; Lyon, 2000; Van Egmond, 2008; Wang & Spence, 2019).

People’s semantic associations with product sounds are based on perceptual factors. They are correlated with cognitive (e.g., familiarity/unfamiliarity) and emotional variables (e.g., unpleasantness) (Özcan Vieira and Van Egmond, 2012). Such sounds may influence products’ perceived affordances, i.e., their possible uses or ways to be used (Jeon, 2019).

Even though a product’s appearance is typically a more significant source of pleasure than its sound, product sounds are still highly relevant from a user perspective (Sapherstein, 1998; Özcan Vieira et al., 2017). The degree of pleasantness of a product sound can be modelled as a linear combination of sharpness, loudness, roughness, tonality, and fluctuation strength. Among these

attributes, sharpness is usually reported as the most influential factor as far as pleasantness is concerned (Knörferle, 2011).

While there is undoubtedly growing interest in the field of design as far as the study of sound is concerned, many professionals often appear to limit themselves to working only to reduce the noise emitted by products (e.g., Lyon, 2000). Recent studies have focused on developing metrics to evaluate product sound quality from a consumer perspective (e.g., Tuze et al., 2020; Benghanem et al., 2021). However, research on sound design should include all sonic dimensions of a product, including the sounds resulting from its interaction with the environment (Zattra et al., 2018).

To help fill this gap in the literature, the study reported in this paper expands our knowledge concerning how the manipulation of the materials used in products (e.g., shoes) and environments (e.g., stores) can change auditory stimuli (interaction sounds) and the meanings attributed by users to these different stimuli, namely “product personality”. It is aligned with previous research on how floor surfaces actively emit sounds that may inform people on how to navigate their environments (e.g., NIW – Natural Interactive Walking project, 2021).

### *1.1 Product sound personality and sonic interaction with the environment*

The sounds that are associated with products can be designed to promote different perceptions related to products. Intercultural differences may play a role in users’ emotional reactions to sounds (cf. Youssef et al., 2017) since individuals tend to differ in their enjoyment of specific sounds, according to their personal/cultural background (Tonetto et al., 2014). Thus, manipulating the sounds made by artifacts can impact how users perceive and attribute personality to them (e.g., Lageat et al., 2003).

Product personality is “*the profile of personality characteristics that people use to describe a specific product variant and to discriminate it from others*” (Govers, 2004, pp. 15). It is a meaningful tool for the designers of consumer durables to help communicate specific symbolic meanings (Jordan, 2002; Govers, 2004). For example, a product can be experienced as aggressive, sophisticated (Özcan Vieira, 2008), generous, or confident (Tonetto and Trevisan, 2012).

Designers may translate personality characteristics into the product through sound (e.g., Govers et al., 2004; Özcan Vieira, 2008). Products can have signature sounds (Sapherstein, 1998), and the modification of the sound may help highlight a particular product or brand attribute (e.g., Lindstrom, 2005; Spence & Zampini, 2007; Byron, 2012; Van Egmond et al., 2019). There is also the possibility of product and brand differentiation by means of the incorporation of distinctive sounds, both from the product – such as the sound of opening a package (Spence and Wang, 2017; Wang & Spence, 2019) – and from the interaction of the product with the environment – such as pouring sounds, in the case of beverages (Spence and Wang, 2015; Wang and Spence, 2019).

Designers may not only modify the sounds of products but also their sonic interactions with the environment (Franinović and Serafin, 2013). Products may emit meaningful sounds interacting with retail spaces, thereby impacting the user’s emotional experience (e.g., experimenting higher valence when evaluating gelati flavours while listening to park sounds, compared to food court, fast food restaurant, cafe, and bar background sounds; Lin et al., 2019).

Besides users’ emotional experiences, environmental sounds also tend to affect people’s behaviours. Users may become more or less likely to approach products, stay for shorter or longer periods at a store, and purchase more or fewer products (e.g., Hussain and Ali, 2015; Spence, 2021). The congruency between products and their sounds (e.g., the sound of uncorking a champagne bottle) is crucial to consumers as it facilitates their experiences as shoppers (e.g., finding a product

at a supermarket; Knoeferle et al., 2016; Knöferle and Spence, 2012) and may even stimulate them to purchase certain products (e.g., Berger and Fitzsimons, 2008). This is true in both physical and online shopping environments (Knoeferle et al., 2016).

Focusing on product sound personality, the present study investigates a product with solid symbolic value: high-heeled shoes. This type of shoe produces very distinctive interaction sounds with the environment. However, these sounds may change, altering the user's perception of the artifact according to the type of flooring and material used in the sole/heel of the footwear (Tonetto et al., 2014). Previous research has already measured the impact of manipulating the floor material on people's behaviour (see Bresin et al., 2010; Meyers-Levy et al., 2010), and some professionals reputedly already design their high heels taking into consideration the materials used to change the sound produced by footwear (cf. Quinn, 2010).

In the present study, an experiment was conducted to test the hypothesis that there is an effect of sound interaction between the type of sole used in high-heeled shoes and the type of flooring in the attribution of personality traits to the product. The sound emitted by the contact of soles with different flooring materials tends to induce the attribution of different personality traits to the same product. We investigated the impact of interaction sounds between different soles (polypropylene vs. leather) and flooring types (ceramic vs. carpet) on the assignment of personality traits to the resulting sounds.

## 2 Methods

### 2.1 Sample

In a within-participants experimental design, 48 female participants were selected (mean age of 23.5 years, SD=6.6 years; average height of 1.64m, SD=0.76m; mean weight of 60.6kg, SD=9.2kg; and average body mass index of 22.5, ranging from 18.8 to 26.6). They were recruited through convenience sampling. The directors of a university department approved the project and allowed the researchers to invite students to participate in the research by the first author of this paper. The experiment was carried out following the local ethical regulations, according to the Institutional Review Board of *Universidade do Vale do Rio dos Sinos (Unisinos, Brazil)*.

### 2.2 Stimuli

The sounds resulting from the interaction between heels and flooring were recorded in a recording studio. The shoes used were 8.5 cm high and had heels that were 2.5 cm thick. Two versions of the same model of the shoe were used to record the sounds. One had its original polypropylene sole, while the other had a leather sole. The latter was manipulated by a shoemaker who replaced the original polypropylene sole with a leather one. It should be noted that leather and polypropylene soles were chosen because they are widely used in this type of shoe in the country where the experiment was carried out. Likewise, ceramic and carpet floors are common types of flooring used in local fashion retail outlets (see Tonetto et al., 2014).

An adult female wearing the high-heeled shoes in their versions (polypropylene and leather soles) walked on ceramic and carpet floors to generate the four sounds used in the experiment. A Zoom H4N recorder was used to register the audio in 96kHz/24 bits, converted to 44.1kHz/16 bits, due to compatibility with CD reproduction systems. The sounds were recorded as stereo files with a pair of Neumann diaphragm condenser microphones (Model KM 184), using the XY technique.

### 2.3 Procedures for data collection

The data collection was performed individually in a design lab. Before initiating the experiment, participants were asked to complete a preliminary questionnaire concerning their weight, height, and age.

The women were informed that they would walk around a ‘virtual runway’ four times and would fill in a second kind of questionnaire immediately after each walk (i.e., four times), answering questions about the sounds produced by their walking. The runway was built using Makey Makey (<http://www.makeymakey.com>). It consisted of 12 metal steps (approximately 10 inches wide by 16 inches long), placed in a circular array and connected via wires to a computer, and fixed on the floor with adhesive tape. When the participant’s feet made contact with the metal plates placed on the floor, they heard the sounds synchronized with their steps, played back via the computer’s loudspeaker (an Apple MacBook Pro), positioned 2 feet from the first step.

The participants walked barefoot on the runway. The sounds were reproduced electronically as sound perception could have been influenced by product appearance and the users’ perceptions of comfort due to different foot sizes and BMI. The four auditory stimuli were presented to the participants individually in random order. For the exposition to each sound, the participants took 24 steps (two laps) while listening to the same contact sound repeated 24 times (i.e., once with each step).

After being exposed to a sound, the participants filled in a questionnaire to measure personality traits attributed to each sound. They were asked the following question: “After hearing the sound of this high-heeled shoe, how would you describe it? Note that the question is about the *sound* of the shoe.” We used a technique called Product Personality Assignment (PPA), developed by Phillips Design (Jordan, 1997). In this approach, personality is understood and measured as an experiential property of a product (Jordan, 2000). These traits were measured using 5-point semantic differential scales – from -2 to +2 – in seventeen types of personalities constituted by opposing characteristics (Kind x Unkind, Honest x Dishonest, Serious-minded x Light-hearted, Bright x Dim, Stable x Unstable, Narcissistic x Humble, Flexible x Inflexible, Authoritarian x Liberal, Value-driven x Non-value-driven, Extroverted x Introverted, Naive x Cynical, Excessive x Moderate, Conformist x Rebellious, Energetic x Unenergetic, Violent x Gentle, Complex x Simple, Pessimistic x Optimistic; proposed by the Product Personality Assignment of Jordan, 2000). Importantly, the version of the PPA translated into Brazilian Portuguese, which was adopted in this study, has been previously used in experiments on sound personality with native Portuguese speakers, who were able to understand its contents (Tonetto and Trevisan, 2012).

The participants also evaluated valence (defined as the degree of pleasantness of a stimulus) using the Self-Assessment Manikin (SAM), which is a self-assessment scale (Bradley and Lang, 1994). The participants were presented with the following question: “How did you feel while you listened to the sound of this high-heeled shoe?” SAM is a pictorial assessment technique, shown in Figure 1, to measure valence using a 9-point scale, from -4 to +4.

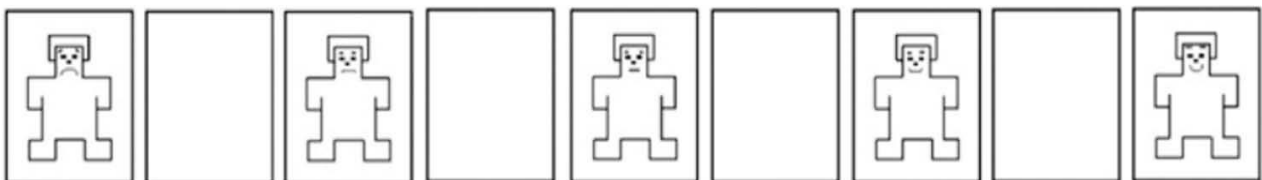


Figure 1. Pictorial ratings of valence by Bradley and Lang (1994).

## 2.4 Procedures for data analysis

The analyses were carried out using the Statistical Package for the Social Sciences (version 21.0). We used Variance Analysis to evaluate differences in the mean ratings of personality traits attributed to the different sounds and the Bonferroni Test to make pairwise comparisons. We used Spearman Correlation to analyse the association between personality traits and valence.

### 3 Results

The mean evaluation of users regarding the range of 17 personality traits attributed to the sounds arising from interactions between different types of soles (polypropylene and leather) and flooring (ceramic and carpet) are shown in Table 1.

Table 1: Product sound personalities.

Personality traits	Polypropylene Ceramic			Leather Ceramic			Leather Carpet			Polypropylene Carpet		
	M	SD	N	M	SD	N	M	SD	N	M	SD	N
Dishonest/Honest	.21	1.02	47	.74	0.92	47	.19	.97	47	.43	0.88	47
Unkind/Kind	.13	1.38	47	.70	1.30	47	-.06	1.29	47	.23	1.27	47
Serious-minded/Light-hearted	-.23	1.24	48	.33	1.08	48	-.42	1.24	48	-.19	1.18	48
Dim/Bright	.77	.89	47	1.00	0.81	47	-.77	1.01	47	-.70	1.00	47
Unstable/Stable	1.33	1.00	48	1.08	1.16	48	.00	1.47	48	-.27	1.44	48
Humble/Narcissistic	0.75	1.12	48	.46	1.24	48	-.42	1.25	48	-.54	1.22	48
Inflexible/Flexible	-0.46	1.24	48	-.33	1.14	48	-.44	1.41	48	-.10	1.46	48
Non-value-driven/Value-driven	-0.25	.89	48	.08	.90	48	.00	1.09	48	.31	1.06	48
Introvert/Extrovert	.91	1.07	46	.85	1.17	46	-.89	1.02	46	-.59	1.38	46
Naive/Cynical	1.00	1.01	48	.73	.87	48	.02	1.38	48	-.10	1.17	48
Moderate/Excessive	.89	1.22	46	.52	1.33	46	-.65	1.29	46	-.78	1.07	46
Conformist/Rebellious	.44	1.05	48	.44	.94	48	-.63	1.27	48	-.83	1.04	48
Unenergetic/Energetic	.23	.93	48	1.08	1.01	48	-.21	1.38	48	-.48	1.37	48
Gentle/Violent	.79	1.11	48	.38	1.18	48	.21	1.29	48	-.25	1.18	48
Simple/Complex	.44	1.15	48	.38	1.18	48	-.19	1.27	48	-.29	1.34	48
Pessimistic/Optimistic	.60	.96	48	.92	.94	48	-.33	1.08	48	.02	1.06	48
Authoritarian/Liberal	-.31	1.32	48	.08	1.22	48	-.60	1.07	48	-.21	1.15	48

There was an effect of the type of floor on sound personality in eleven of the evaluated traits, independent of the type of heel. All of the effects revealed higher average ratings of the sound produced by the interaction between the heel and the ceramic floor, as compared to the sound made on the carpet. The sound of heels on ceramic was judged as brighter than on carpet ( $F(1, 46) = 84.873$ ,  $p < .001$ ); The sound was also rated more stable ( $F(1, 47) = 29.290$ ,  $p < .001$ ), more narcissistic ( $F(1, 47) = 20.109$ ,  $p < .001$ ), more extroverted ( $F(1, 45) = 44.838$ ,  $p < .001$ ), more cynical ( $F(1, 47) = 21.714$ ,  $p < .001$ ), more excessive ( $F(1, 45) = 27.983$ ,  $p < .001$ ), more rebellious ( $F(1, 47) = 32.098$ ,  $p < .001$ ), more energetic ( $F(1, 47) = 46.356$ ,  $p < .001$ ), more violent ( $F(1, 47) = 6.101$ ,  $p < .05$ ), more complex ( $F(1, 47) = 8.113$ ,  $p < .01$ ), and more optimistic ( $F(1, 47) = 32.039$ ,  $p < .001$ ).

There was an interaction between the type of sole and flooring on the attribution of sound/product personality traits for six of the evaluated variables. Four of these six personality traits were attributed to interaction sounds of leather soles on the ceramic floor having significantly higher scores than the sound produced by this type of heel when contacting carpet. This sound was considered to have a more honest personality ( $F(1, 46) = 12.384$ ,  $p < .001$ ), kinder ( $F(1, 46) = 9.497$ ,  $p < .01$ ), more light-hearted ( $F(1, 47) = 6.672$ ,  $p < .05$ ), and more liberal ( $F(1, 47) = 6.204$ ,  $p < .05$ ).



The other two – out of six – effects of interaction between soles types and types of floors on the attribution of sound/product were:

- Non-value-driven x Value-driven ( $F(1, 47) = 12.894, p=.001$ ): interacting with polypropylene sole, the carpet floor produced a sound that had higher ratings than ceramic ( $p<.001$ ), being considered more value-driven.
- Gentle x Violent ( $F(1, 47) = 10.452, p<.01$ ): in interaction with the ceramic floor, polypropylene sole has shown superior mean ratings than the leather sole ( $p<.01$ ), being considered more violent.

There was no effect of the type of sole on the rated personality of the sound.

Attributing a personality trait to a product sound does not necessarily mean that the association is pleasant; thus, we ran correlation analyses between valence and such characteristics. To this end, we considered that the type of floor impacted sound personality but that the kind of sole did not. We generated mean scores for each personality trait attributed to the sounds of the two flooring types (grouping the scores for both types of sole). The mean valence associated with ceramic sounds was 1.04 ( $SD=1.66$ ), and with carpet sounds was -.46 ( $SD=1.55$ ), indicating that the louder/sharper ceramic sounds were rated as more pleasant. Spearman correlation coefficients between valence and personality traits are shown in Table 2. Appendix A presents results of a principal component analysis carried out to demonstrate the scale's dimensionality using valence personality data of the most pleasant sound (heels on ceramic flooring).

Table 2: Spearman correlation coefficients between mean valence and product sound grouped by type of floor.

<i>Personality traits</i>	<i>Carpet</i>	<i>Ceramic</i>
Dishonest/Honest	.430**	.305*
Unkind/Kind	.187	.395**
Serious-minded/Light-hearted	.017	.264
Dim/Bright	.465**	.358*
Unstable/Stable	.419**	.352*
Humble/Narcissistic	.136	.306*
Inflexible/Flexible	.017	-.003
Non-value-driven/Value-driven	.029	.073
Introvert/Extrovert	.336*	.376*
Naive/Cynical	.331*	.423**
Moderate/Excessive	.112	.337*
Conformist/Rebellious	.102	.343*
Unenergetic/Energetic	.215	.475**
Gentle/Violent	.143	.244
Simple/Complex	-.003	.342*
Pessimistic/Optimistic	.365*	.447**
Authoritarian/Liberal	.209	.381**

\*. Significant correlations at .05 level (2 tailed)

\*\*. Significant correlations at .01 level (2 tailed)

Visual inspection of Table 2 reveals that valence was positively correlated with many personality traits in both cases (carpet and ceramic sounds). Scatter plots displaying the relationships between valence and each personality trait can be observed in Appendix B. It is clear that all correlations



between valence and personality traits attributed to carpet sounds (lower and gentler sounds) were also detected with ceramic sounds (louder and sharper sounds): Dishonest / Honest, Dim / Bright, Unstable / Stable, Introvert / Extrovert, Naïve / Cynical and Pessimistic / Optimistic. On the other hand, some positive correlations occurred exclusively when listening to ceramic sounds: Unkind / Kind, Humble / Narcissistic, Moderate / Excessive, Conformist / Rebel, Unenergetic / Energetic, Simple / Complex and Authoritarian / Liberal. Therefore, louder and sharper product sound, in this case, seemed to reinforce product personality pleasantly, making it clear to consumers.

#### 4 Discussion

The intentional design of product sounds requires the manipulation of the structural and material configuration of products and the environment in which they are likely to be experienced - because such sounds typically result from the interaction between static object parts and the environment, its functionality or the interaction of the product with the environment (Özcan Vieira, 2008). Following this approach, we studied the impact of the manipulation of sound resulting from the interaction of different materials that may be used in products and environments, such as stores, about the users' perception and the meanings associated with these stimuli.

Products have meaning associations that can be expressed through the perception of personality traits (Jordan, 1998; Jordan, 1999; Özcan Vieira, 2008). The results reported here confirm the hypothesis that such traits may be influenced by the sonic interaction between product and environment. The sound shoes produced with different flooring materials occasioned the assignment of distinctive personality traits to them. A similar effect was not identified when observing solely shoe sole types.

The results of the present study demonstrate that designers can define product meaning auditorily. It has already been well-established that changing product sounds can modify product perception (Lageat et al., 2003; Västfjäll et al., 2003; Van Egmond, 2006, 2008), but this study provides evidence that changing interaction sounds between products and the environment (e.g., heel and floor) can also affect the user experience, specifically product sound personality.

Our findings indicate that regardless of the type of soles used, the floor material was responsible for shaping the configuration of sounds and personality traits that were attributed to such sounds. Furthermore, in the case of high-heeled shoes, sharper and louder sounds seemed to be more effective in reinforcing associations with a pleasant product personality. These results may inform sound product designers in paying close attention to designing the environment in which users will interact with the product. It should also be highlighted that the point of sale is commonly where the first physical interaction between user and product happens. As sound is a dimension of the product, product sound may impact users' judgment about the product (Lageat et al., 2003; Tonetto et al., 2014) and influence their purchasing decisions. Thus, designing product sounds should not be a process dissociated from designing retail spaces (see Spence, 2021).

Our findings may also relate to branding (Lindstrom, 2005; Byron, 2012; Van Egmond et al., 2019). In the case of high-heeled shoes, we can assume that designing a retail space (i.e., manipulating the flooring) tends to impact product sound and personality. For example, the sound of heels on ceramic flooring instead of carpet was considered extroverted, rebellious, and energetic. Such personality traits may or may not positively reinforce brand image; thus, they should be aligned with branding strategies. Once again, this finding suggests that product sound designers should embrace retail design to strengthen brand image.

The symbolic dimension of a product is generally accepted as one of its most important attributes (Govers et al., 2004). Our study aligns with the ongoing search for a reliable means of guiding the

embodiment of a specific meaning through product sounds (Schifferstein and Hekkert, 2008). We argue that the PPA tool can be used to assess the impact of the manipulation of product sounds on their personality. Thus, professionals may benefit from the PPA to design product interaction sounds to increase product personality efficiency. As mentioned earlier in the text, we have chosen the PPA because it had been used in studies with Brazilian Portuguese native speakers (Tonetto et al., 2014). Hence, those working elsewhere might choose a different scale.

Meaning attribution is the result of partially perceptual and partially cognitive processing of a stimulus. Therefore, the designer is responsible for creating these meaningful relationships regarding auditory ergonomics, well-being, user satisfaction, product identity, and brand differentiation (Özcan Vieira, 2008). Sound is an inherent property of a product. Just as a product's visual (form, geometry, colours) and tactile (materials, texture, weight) properties, the sound can also be manipulated to create the desired user experience and prime specific associations. The design of the most appropriate product sound should be integrated into the main design process (Ludden and Schifferstein, 2007; Tonetto and Trevisan, 2012), considering the product's multisensory context to improve the user experience both on ergonomic and hedonic levels.

## 5 Conclusions

The results of this study suggest that the design approach introduced here can help designers to embody a particular personality trait into a product sound. This research, therefore, illustrates how designers can influence the meaning of a product sound by varying the sound attributable to the materials used in the environment in which that product is experienced. Such product sounds may reinforce the meaning a company expects consumers to attribute to a product sound and thus strengthen the brand image (see also Wang and Spence, 2019).

The present results add to a growing body of research highlighting the importance of product interaction sounds to multisensory product experience. In contrast to much of the previous research in this area, however, it is important to stress that the rich interaction sound that modified people's perception in the present study results from the combined influence of both product and flooring. Further consideration of the emotional associations (personality traits) of such interaction sounds, as elucidated by the study reported here, will likely be of interest both to basic researchers working on auditory contributions to multisensory perception (see Stanton & Spence, 2020, for a recent review of this literature) as well as to those working in an applied (e.g., retail) setting (see Spence et al., 2014; Tonetto et al., 2014).

There are three potential limitations with the present study that should be bear in mind. First, the kind of experimental manipulation used was within participants. This choice of robust experimental design might inadvertently have drawn undue attention to the experimental manipulation under study, thus perhaps facilitating the observation of some effects. In the type of experimental setting created, participants' attention was drawn to the product-environment interaction sounds more than might typically be the case (consider only the background music that is a distinctive feature of so many retail environments; Elliott, 2014; Spence et al., 2014). Considering the results, it can be seen as an opportunity to be explored in further research. Second, we only studied females' experiences with high-heeled shoes using the PPA. Future study opportunities are investigating similar effects with consumers of different genders, evaluating their experiences with other types of shoes, and using additional product personality assessment tools. Third, this research focused solely on product sound. Although we intentionally isolated the effect of product sound on product personality, recent literature advocates that consumers use all their senses, not only audition, to judge products (Schifferstein, 2010). Hence, an integral design process is needed to align product sound with specific product personality and consider the overall multisensory user experience.



## References

- Bradley, M.M. and Lang, P.J. (1994) 'Measuring emotion: the self-assessment manikin and the semantic differential', *Journal of Behavior Therapy and Experimental Psychiatry*, Vol. 25, No. 1, pp.49-59.
- Batra, R., Seifert, C. and Brei, D. (Eds.), (2015) *The psychology of design: creating consumer appeal*, Routledge, London.
- Benghanem, A., Valentin, O., Gauthier, P. and Berry, A. (2021) 'Sound quality of side-by-side vehicles: investigation of multidimensional sensory profiles and loudness equalization in an industrial context', *Acta Acustica*, Vol. 5, pp.1-19.
- Berger, J. and Fitzsimons, G. (2008) 'Dogs on the street, pumas on your feet: how cues in the environment influence product evaluation and choice', *Journal of Marketing Research*, Vol. 45, No. 1, pp.1-14.
- Bisping, R. (1997) 'Car interior sound quality: experimental analysis by synthesis', *Acustica*, Vol. 83, pp.813-818.
- Blauert, J. and Jekosch, U. (1997) 'Sound quality evaluation: a multi-layered problem', *Acustica*, Vol. 83, pp.747-753.
- Bremner, A.J., Lewkowicz, D.J. and Spence, C. (Eds.), (2012) *Multisensory development*, Oxford University Press, Oxford.
- Bresin, R., de Witt, A., Papetti, S., Civolani, M. and Fontana, F. (2010) 'Expressive sonification of footstep sounds' in *Interaction Sonification workshop (ISon) 2010*, Stockholm, Sweden, pp. 51-54.
- Byron, E. (2012) The search for sweet sounds that sell: Household products' clicks and hums are no accident; Light piano music when the dishwasher is done? The Wall Street Journal. [http://online.wsj.com/article/SB10001424052970203406404578074671598804116.html?mod=googlenews\\_wsj#articleTabs%3Darticle](http://online.wsj.com/article/SB10001424052970203406404578074671598804116.html?mod=googlenews_wsj#articleTabs%3Darticle). (Accessed 15 December 2016)
- Calvert, G., Spence, C. and Stein, B.E. (Eds.). (2004). *The handbook of multisensory processes*. MIT Press, Cambridge.
- Elliott, A. F. (2014) 'Lights up, sound down, clothes on: Abercrombie & Fitch tones down its nightclub-themed stores in a bid to win back disinterested teens', *Daily Mail Online*, May 23<sup>rd</sup>. <https://www.dailymail.co.uk/femail/article-2637492/Lights-sound-clothes-Abercrombie-Fitch-tones-nightclub-themed-stores-bid-win-disinterested-teens.html>.
- Franinović, K. and Serafin, S. (2013) *Sonic interaction design*, MIT Press, Cambridge.
- Govers, P.C.M. (2004) *Product personality*, Delft University of Technology, Delft.
- Hussain, R. and Ali, M. (2015) 'Effect of store atmosphere on consumer purchase intention', *International Journal of Marketing Studies*, Vol. 7, No. 2, pp.35-43.
- Jeon, M. (2019) 'Exploring design constructs in sound design with a focus on perceived affordance' in *Proceedings of the Human Factors and Ergonomics Society 2019 Annual Meeting*, Nantes, France, pp.1199-1203.
- Jordan, P. (1997) 'Putting the pleasure into products', *IEE Review*, Vol. 43, No. 6, pp.249-252.
- Jordan, P. (1998) 'Human factors for pleasure in product use', *Applied Ergonomics*, Vol. 29, No. 1, pp.25-33.

- Jordan, P. (1999) 'Pleasure with products: human factors for body, mind and soul, in Green, W. S. and Jordan, P. W. (Eds.), *Human factors in product design: current practice and future trends*, Taylor & Francis, London, pp.206-217.
- Jordan, P. (2000) *Designing pleasurable products: an introduction to the new human factors*, Taylor & Francis, London.
- Jordan, P. (2002) *Designing pleasurable products*, CRC Press, EUA.
- Knoeferle, K., Knoeferle, P., Velasco, C. and Spence, C. (2016) 'Multisensory brand search: how the meaning of sounds guides consumers' visual attention', *Journal of Experimental Psychology: Applied*, Vol. 22, No. 2, pp.196-210.
- Knöferle, K. M. (2011) *Acoustic influences on consumer behavior: empirical studies on the effects of in-store music and product sound*. Unpublished PhD thesis, University of St. Gallen, St. Gallen, Switzerland.
- Knöferle, K. and Spence, C. (2012) 'Product-related sounds speed visual search', *Seeing and Perceiving*, Vol. 25, pp.193-193.
- Lageat, T., Czellar, S. and Laurent, G. (2003) 'Engineering hedonic attributes to generate perceptions of luxury: consumer perception of an everyday sound', *Marketing Letters*, Vol. 14, pp.97-109.
- Lin, Y.H.T., Hamid, N., Shepherd, D., Kantono, K. and Spence, C. (2019) 'Environmental sounds influence the multisensory perception of chocolate gelati', *Foods*, Vol. 8, No. 4, p.124.
- Lindstrom, M. (2005) *Brand sense: how to build brands through touch, taste, smell, sight and sound*, Kogan Page, London.
- Ludden, G.D. and Schifferstein, H.N. (2007) 'Effects of visual-auditory incongruity on product expression and surprise', *International Journal of Design*, Vol. 1, No. 3, pp.29-39.
- Lyon, R. (2000) *Designing for product sound quality*, CRC Press, New York.
- McDermott, K. (2013) 'Modern express kettles 'can be as loud as an electric drill with decibel levels of 95'', *Daily Mail Online*. <http://www.dailymail.co.uk/news/article-2375084/Modern-express-kettles-loud-electric-drill-decibel-levels-95.html>, 2013. (Accessed 15 December 2016)
- Meyers-Levy, J., Zhu, R. and Jiang, L. (2010) 'Context effects from bodily sensations: examining bodily sensations induced by flooring and the moderating role of product viewing distance', *Journal of Consumer Research*, Vol. 37, No. 1, pp.1-14.
- NIW – Natural Interactive Walking project. [online] [www.di.univr.it/?ent=progetto&id=2052](http://www.di.univr.it/?ent=progetto&id=2052) (Accessed 10 April 2021).
- Özcan Vieira, E. (2008) *Product sounds-fundamentals and applications*, Delft University of Technology, Delft.
- Özcan Vieira, E., Cupchik, G.C. and Schifferstein, R. (2017) 'Auditory and visual contributions to affective product quality', *International Journal of Design*, Vol. 11, No. 1, pp.35-50.
- Özcan Vieira, E. and van Egmond, R. (2006) 'Product sound design and application: an overview' in *Proceedings of the Fifth International Conference on Design and Emotion*, Chalmers University of Technology, Gothenburg, Sweden, pp.1-19.
- Özcan Vieira, E. and Van Egmond, R. (2012) 'Basic semantics of product sounds', *International Journal of Design*, Vol. 6, No. 2, pp.41-54.
- Quinn, B. (2010) *Fashion futures*, Merrell, London.

- Sapherstein, M.B. (1998) The trademark registrability of the Harley-Davidson roar: A multimedia analysis. [online] Boston College Intellectual Property & Technology Forum, Boston College, Boston. <http://bciptf.org/wp-content/uploads/2011/07/48-THE-TRADEMARK-REGISTRABILITY-OF-THE-HARLEY.pdf> (Accessed 18 March 2021)
- Schifferstein, H.N.J. (2010) 'From salad to bowl: the role of sensory analysis in product experience research', *Food Quality and Preference*, Vol. 21, No. 8, pp.1059-106.
- Schifferstein, H.N. and Hekkert, P. (Eds.), (2008) *Product experience*, Elsevier, London.
- Segura, R.S. and Pérez, E.M. (2018) 'Product sound design as a valuable tool in the product development process', *Ergonomics in Design: The Quarterly of Human Factors Applications*, Vol. 26, No. 4, pp.20-24.
- Spence, C. (2021) *Sensehacking: how to use the power of your senses for happier, healthier living*, Viking Penguin, London.
- Spence, C., Puccinelli, N., Grewal, D., and Roggeveen, A.L. (2014) 'Store atmospherics: a multisensory perspective', *Psychology & Marketing*, Vol. 31, No. 7, pp.472-488.
- Spence, C. and Wang, Q. (2015) 'Sonic expectations: on the sounds of opening and pouring', *Flavour*, Vol. 4, p.35.
- Spence, C. and Wang, (Q.) J. (2017). Assessing the impact of closure type on wine ratings and mood. *Beverages*, Vol. 3, No. 4, p.52.
- Spence, C. and Zampini, M. (2006) 'Auditory contributions to multisensory product perception', *Acta Acustica united with Acustica*, Vol. 92, No. 6, pp.1009-1025.
- Spence, C. and Zampini, M. (2007) 'Affective design: modulating the pleasantness and forcefulness of aerosol sprays by manipulating aerosol spraying sounds', *CoDesign*, Vol. 3 (Supplement 1), pp.107-121.
- Stanton, T.R. and Spence, C. (2020) 'The influence of auditory cues on bodily and movement perception', *Frontiers in Psychology*, Vol. 10, p. 3001.
- Stein, B.E. (Ed.), (2012). *The new handbook of multisensory processing*, MIT Press, Cambridge.
- Tonetto, L.M., Klanovicz, C.P. and Spence, C. (2014) 'Modifying action sounds influences people's emotional responses and bodily sensations', *i-Perception*, Vol. 5, No. 3, pp.153-163.
- Tonetto, L.M. and Trevisan, R.B.L. (2012) 'Testing affective responses to different brand vocal and sound logo stimuli: a case study', in Bronner, K. Hirt, R. and Ringe, C. (Eds.), *Audio Branding Academy Yearbook 2012/2013*, Nomos Verlagsgesellschaft, Baden-Baden, Germany, pp. 141-151.
- Tuze, E., Erdogan, K. and Cetin, M.O. (2020) 'Sound quality characteristics of refrigerators' in *INTER-NOISE and NOISE-CON Congress and Conference Proceedings (InterNoise20)*, Seoul, pp.3120-3129.
- Van Egmond, R. (2006) 'Designing an emotional experience for product sounds' in *5th International Conference on Design and Emotion*, Gothenburg, Sweden, pp.1-12.
- Van Egmond, R. (2008) 'The experience of product sounds' in Schifferstein, H.N.J. and Hekkert, P. (Eds.), *Product experience*, Elsevier, Amsterdam, pp.69-89.
- Van Egmond, R., Özcan Vieira, E., Gentner, A. and Favart, C. (2019) 'Incorporating brand identity in the design of auditory displays' in Filimowicz, M. (Ed.), *Foundations in sound design for embedded media: a multidisciplinary approach*, Routledge, London, pp. 155-193

- Västfjäll, D., Kleiner, M. and Gärling, T. (2003) 'Affective reactions to interior aircraft sound quality', *Acustica*, Vol. 89, No. 4, pp.693-701.
- Wang, Q. (J.) and Spence, C. (2019) 'Sonic packaging: how packaging sounds influence multisensory product evaluation', in Velasco, C. and Spence, C. (Eds.), *Multisensory packaging: designing new product experiences*, Palgrave MacMillan, Cham, Switzerland, pp.103-125
- Wolkomir, R. (1996) 'Decibel by decibel, reducing the din to a very dull roar', *Smithsonian Magazine*, February, pp.56-65.
- Youssef, J., Youssef, L., Juravle, G. and Spence, C. (2017) 'Plateware and slurping influence regular consumers' sensory discriminative and hedonic responses to a hot soup', *International Journal of Gastronomy & Food Science*, Vol. 9, pp.100-104.
- Zattra, L., Misdariis, N., Pecquet, F., Donin, N. and Fierro, D. (2018) 'Analysis of sound design practices [ASDP] research methodology' in *XXII Colloquio di Informatica Musicale (Congresso d'Informatica Musicale CIM)*, Udine, Italy, pp.168-175.



## Appendix A: Principal component analysis demonstrating the scale's dimensionality

Principal Component Analysis was used to assess data dimensionality. For this analysis, we used personality traits attributed to the sound of heels on ceramic flooring as they were the most pleasant sounds. The factors' composition indicates how the PPA reveals personality dimensionality as the 17 personality traits were grouped into five coherent factors, as shown in the following analyses.

Dataset evaluation:

- Cronbach's alpha for the 17 items was .84, indicating good internal consistency.
- The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy was .75, indicating that the dataset is suited for factor analysis.
- Bartlett's test of sphericity was 448.25 ( $p < .001$ ), indicating that the correlation matrix was not an identity matrix and, thus, using factor analysis was adequate.
- The lowest communality of all the 17 items (personality traits) was .56 (mean .75), implying that each variable shared a good amount of variance with the others.

Principal Component Analysis:

- Five factors were identified. They explain 74.7% of the total variance, with the lowest factor explaining 9.8% and the highest factor representing 18.2% of the total variance.
- All eigenvalues are equal to or above 1.0, indicating that the number of factors should be accepted.

Descriptive statistics, factor analysis, and factor composition can be observed in Tables 3, 4, and 5.

Table 3: Means and standard deviations for the 17 personality traits associated with ceramic sounds.

<i>Personality traits</i>	<i>Mean</i>	<i>SD</i>
Dishonest/Honest	.48	.79
Unkind/Kind	.37	1.17
Serious-minded/Light-hearted	.05	.84
Dim/Bright	.88	.69
Unstable/Stable	1.21	.92
Humble/Narcissistic	.60	.94
Inflexible/Flexible	-.40	.90
Non-value-driven/Value-driven	-.08	.79
Introvert/Extrovert	.88	.96
Naive/Cynical	.87	.71
Moderate/Excessive	.71	1.03
Conformist/Rebellious	.44	.74
Unenergetic/Energetic	1.16	.76
Gentle/Violent	.58	1.02
Simple/Complex	.41	.93
Pessimistic/Optimistic	.76	.78
Authoritarian/Liberal	-.12	1.10

Table 4: Factor analysis before and after Varimax Rotation.

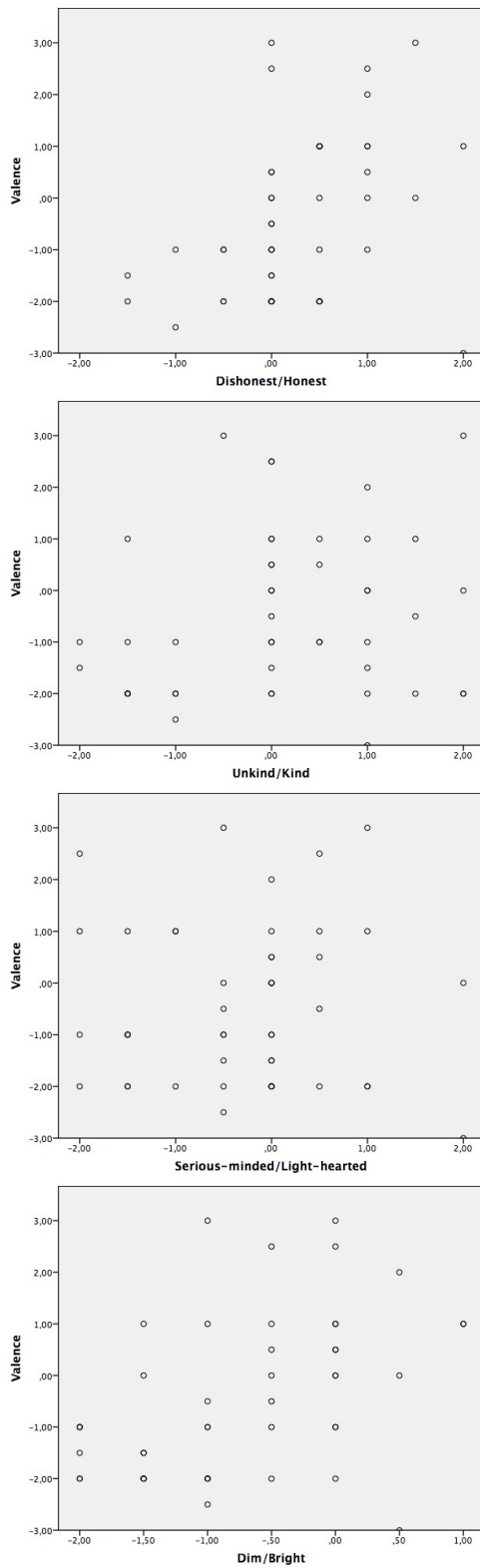
<i>Components</i>	<i>Initial extraction</i>			<i>After Rotation</i>		
	<i>Total</i>	<i>% of variance</i>	<i>Cumulative %</i>	<i>Total</i>	<i>% of variance</i>	<i>Cumulative %</i>
1	5.905	34.733	34.733	3.095	18.203	18.203
2	3.013	17.724	52.457	2.839	16.700	34.903
3	1.505	8.853	61.310	2.633	15.490	50.394
4	1.269	7.464	68.774	2.459	14.468	64.861
5	1.005	5.913	74.687	1.670	9.826	74.687

Table 5: Rotated Component Matrix (Varimax Rotation with Kaiser Normalization).

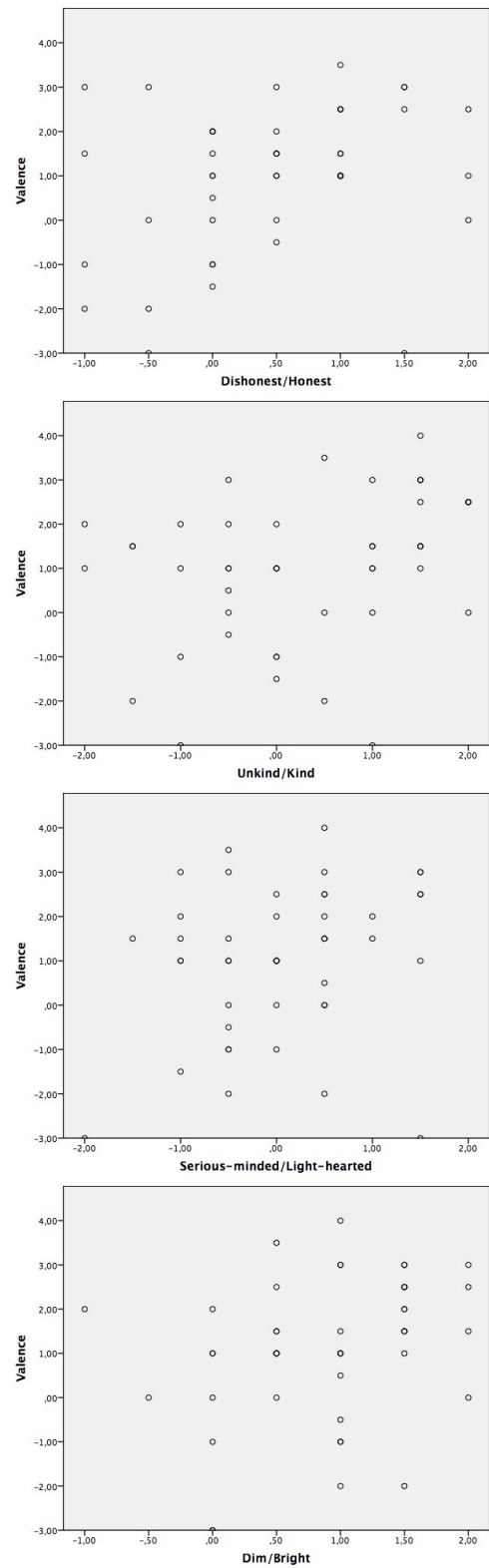
<i>Personality traits</i>	<i>Component</i>				
	<i>1</i>	<i>2</i>	<i>3</i>	<i>4</i>	<i>5</i>
Gentle/Violent	.823				
Unstable/Stable	.800				
Naive/Cynical	.791				
Moderate/Excessive	.593				
Simple/Complex		.807			
Conformist/Rebellious		.746			
Introvert/Extrovert		.533			
Unkind/Kind		.488			
Pessimistic/Optimistic			.817		
Dim/Bright			.788		
Unenergetic/Energetic			.668		
Humble/Narcissistic				.786	
Dishonest/Honest				.760	
Serious-minded/Light-hearted				.641	
Non-value-driven/Value-driven				.634	
Inflexible/Flexible					.835
Authoritarian/Liberal					.667

## Appendix B: Scatter plots displaying the relationships between valence and personality traits of carpet (left column) and ceramic (right column) product sounds

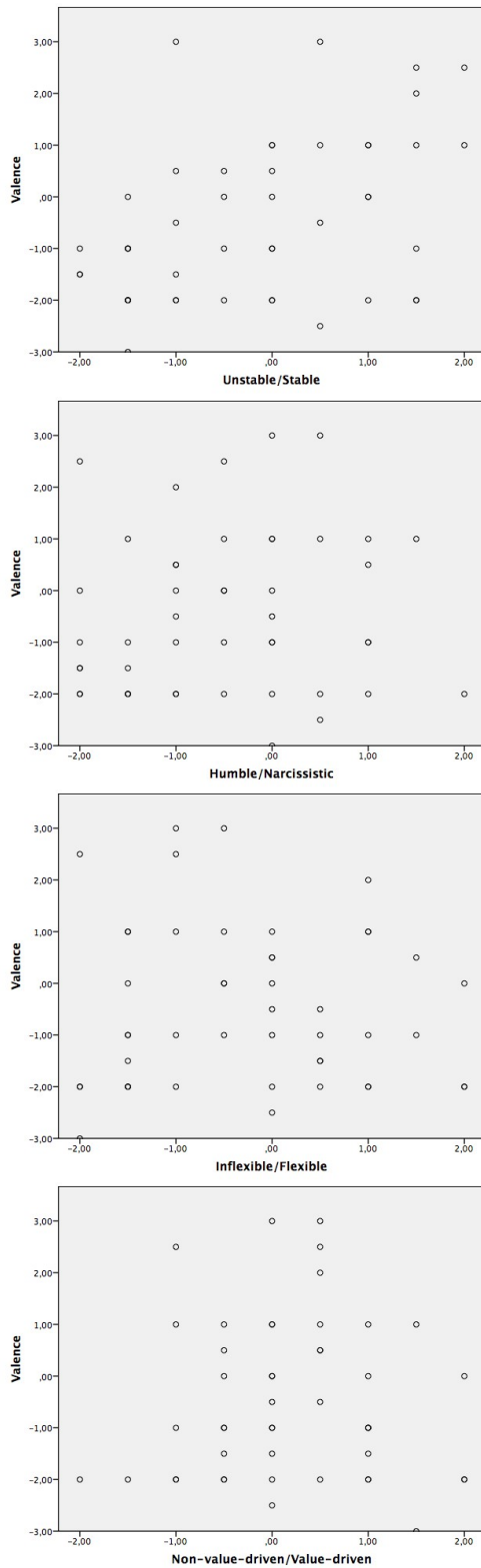
Carpet sounds



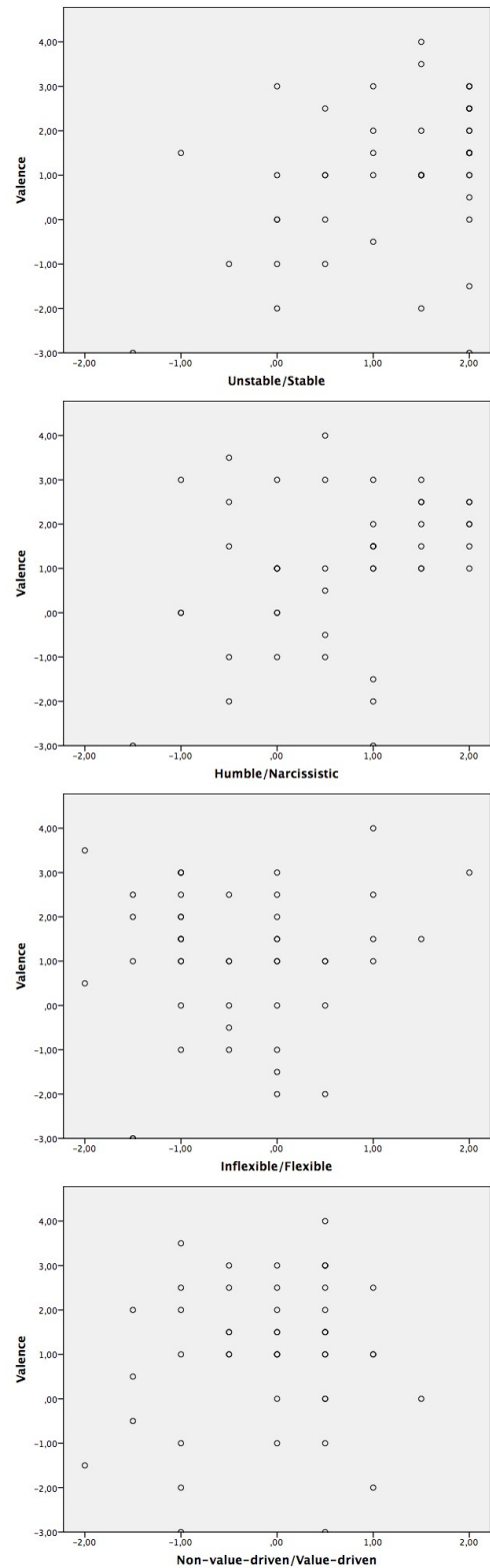
Ceramic sounds



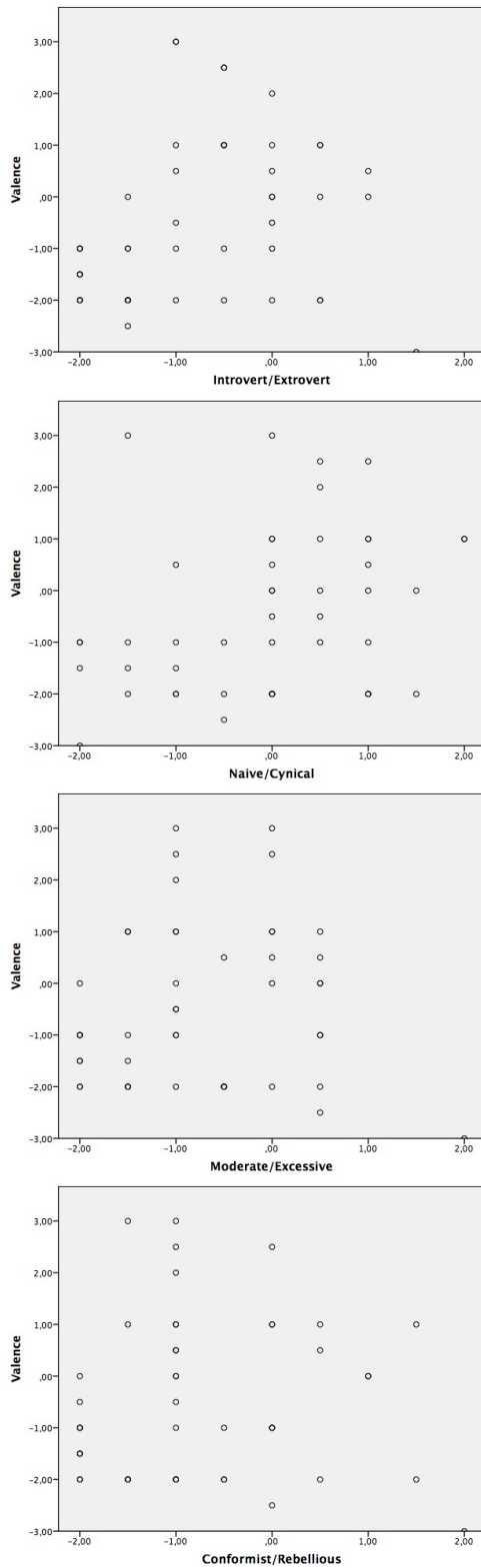
## Carpet sounds



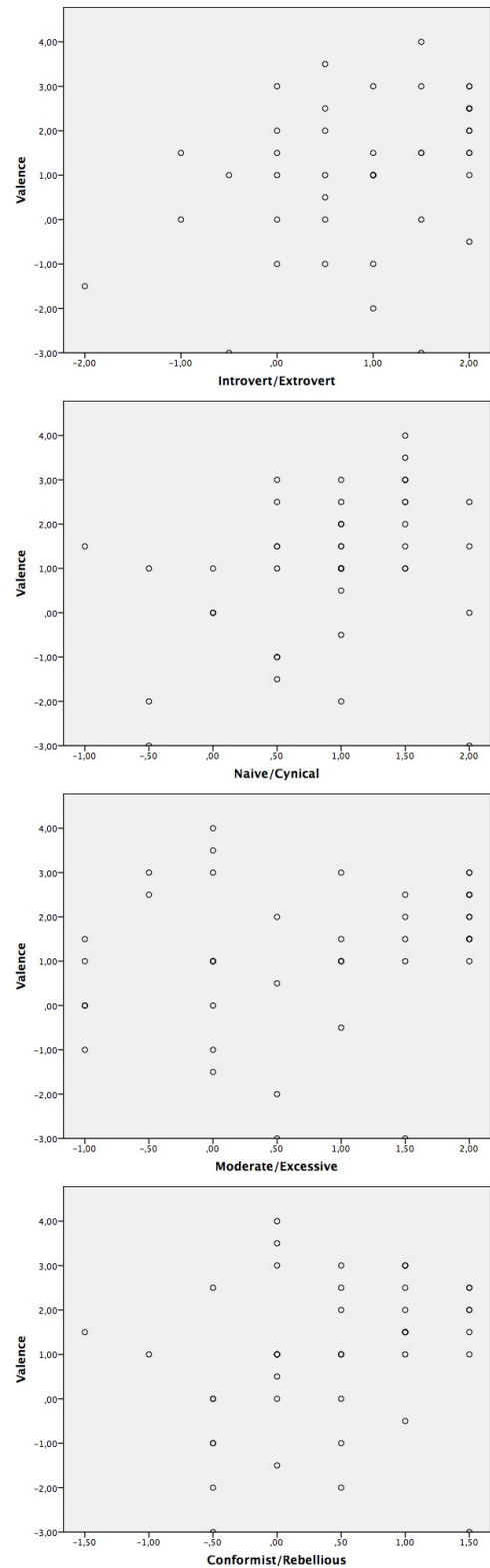
## Ceramic sounds



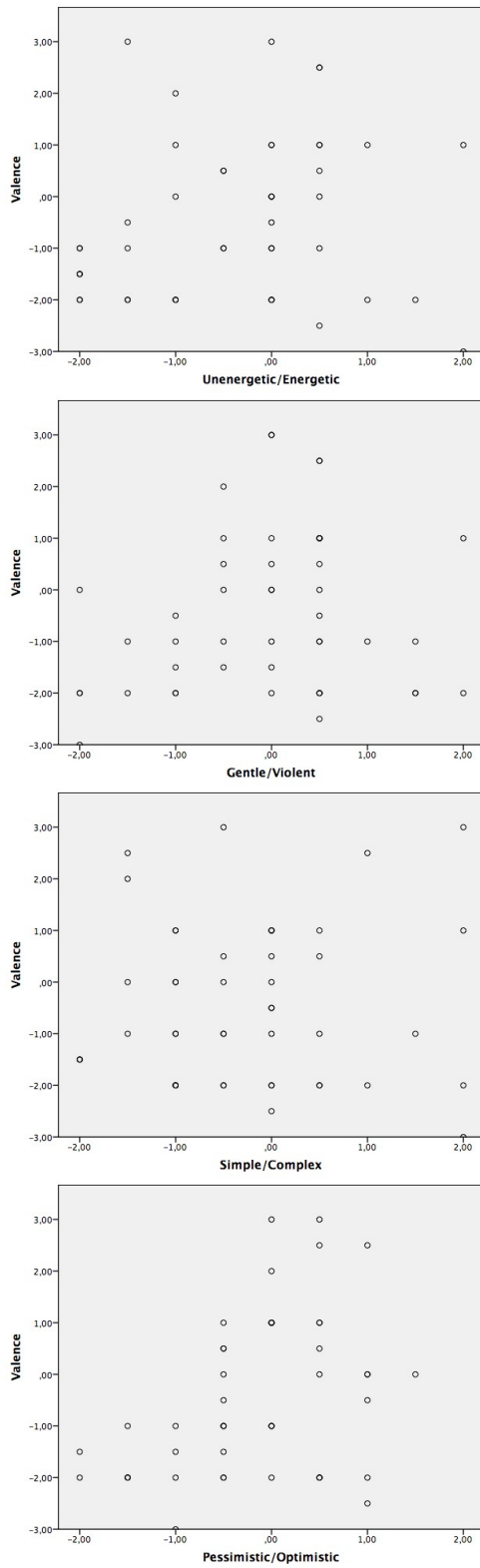
## Carpet sounds



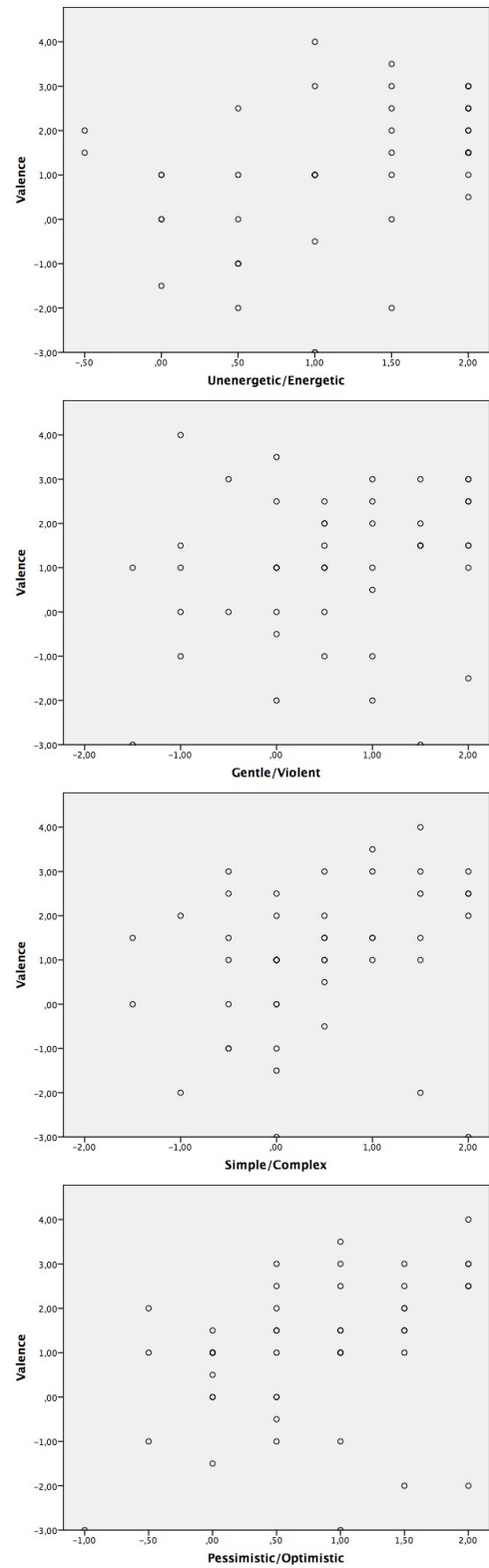
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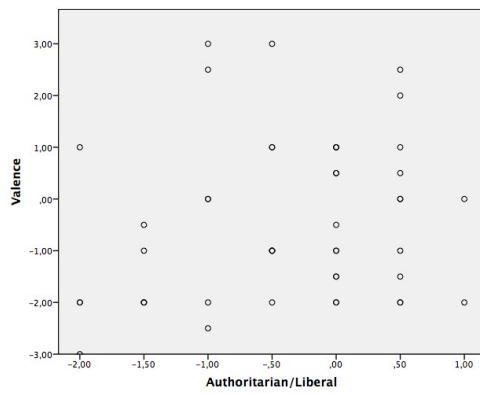
## Carpet sounds



## Ceramic sounds



### Carpet sounds



### Ceramic sounds

