Journal of Business Research 121 (2020) 1–12

Contents lists available at ScienceDirect

Journal of Business Research

journal homepage: www.elsevier.com/locate/jbusres

Interactions between instrumental timbre and consumers' regulatory focus

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ARTICLE INFO

Keywords:
Musical instrument
Timbre
Regulatory focus
Advertising
Music psychology
Sensory marketing

ABSTRACT

Although music is widely used as a sensory marketing tool and incorporated in multisensory consumer–computer interactions, the role of timbre in marketing has not been extensively discussed. This study used five experiments which demonstrate that compared with violin/flute timbres, the piano timbre fits listeners' prevention focus. This is because the piano timbre is familiar to individuals and induces feelings of security congruent with the listener's prevention orientation. When exposed to a piano (vs. violin/flute) timbre as background music in an advertisement, consumers evaluate both the advertisement and the product/service more positively when they are prevention (vs. promotion) focused or when the advertisement message is framed in a preventive (vs. promotional) way. However, the timbre's effect exists only when consumers' cognitive load is low. This research contributes to sensory marketing in theory and practice and suggests that marketing managers should avoid using obsessive sensory stimuli in virtual and augmented reality.

1. Introduction

Music contributes to how the world is shaped and experienced and influences our daily lives (Hultén, 2015). Music impacts consumer behaviour from many perspectives. For example, the sounds and background music that people hear while eating play a critical role in the dining experience (Spence, 2017). In addition, music is widely used in TV commercials and as background score on websites. In recent years, music has become a crucial and indispensable element of multisensory marketing that employs novel technologies such as virtual reality (VR) and augmented reality (AR) (Hwang, Oh, & Scheinbaum, 2020).

Music affects consumers' perceptions and behaviours, such as store/product evaluations and satisfaction, time perception, shopping, waiting, and dining time, purchase intention, product choice, willingness to pay, expenditure, and customer–employee interactions (Knoeferle, Paus, & Vossen, 2017; North, Sheridan, & Areni, 2016; Reinoso-Carvalho, Dakduk, Wagemans, & Spence, 2019; Spence, Reinoso-Carvalho, Velasco, & Wang, 2019). A wide range of *objective* characteristics of music, such as volume, tempo, key, texture, frequency, and genre (such as classical, pop, hip-hop, and jazz), have been extensively studied (e.g. Ferguson & Burkhalter, 2015). Similarly, *subjective* aspects of music, such as arousal, familiarity, liking, complexity, and mood, have also been shown to impact consumers' minds and actions (North et al., 2016).

However, one important characteristic of music—timbre, also known as the sound colour or quality of sound (McAdams, 2019)—has been underexplored, with rare exceptions (e.g. Oakes & North, 2006), despite its high relevance to business in a traditional context or in a setting of human–computer interaction. Although musicians, designers, chefs, and artists create music and ambient sounds specifically for eating/drinking experiences, marketing managers have seldom focused on the acoustic properties of background music, such as timbre, pitch, and loudness, in their advertisements and stores (Spence, 2017).

To fill this gap in theory and practice, the current research hypothesizes and demonstrates how timbre interacts with consumers' motivation in the domain of regulatory focus and thus influences consumers' product/ad evaluations and their behavioural intentions as downstream effects. According to regulatory focus theory, two kinds of regulatory orientations can motivate consumers' judgements, decisions, and behaviours: promotion- and prevention-focused orientations (Higgins, 1997). Our research suggests that the piano timbre fits listeners' prevention focus with a boundary condition of cognitive load, which is especially applicable for current business trends. Although the application of technologies in marketing often increases consumers' enjoyment and interest, VR and AR stimuli might occupy too much of consumers' attention (Moon & Kim, 2001; Park and Yoo, 2020). In other words, VR and AR stimuli are very likely to increase consumers' cognitive load, resulting in limited mental resources to process the crucial

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https://doi.org/10.1016/j.jbusres.2020.08.014
Received 19 December 2019; Received in revised form 6 August 2020; Accepted 8 August 2020

information that marketers want them to process. Thus, our research warns marketers of the overuse of multisensory tools in marketing communication since the timbre's effect on regulatory focus, which influences product and ad evaluation, will be attenuated if consumers have high cognitive load.

2. Theoretical background

2.1. Timbre

Timbre has two broad characteristics that contribute to the perception of music: (1) it involves a multifarious set of abstract sensory attributes (e.g. attack sharpness, brightness, or richness), and (2) it is a primary perceptual vehicle for the recognition, identification, and tracking of a sound source over time and the absolute categorization of a sound (McAdams & Giordano, 2008).

However, it is difficult to define and manipulate timbre based on controlled scientific attributes; in fact, 'there is no single widely accepted operational or constitutive definition of timbre from which researchers can build empirical methods and models' (Hajda, Kendall, Carterette, & Harshberger, 1997, p. 253). Some studies have identified acoustic dimensions correlated with timbre perceptions (Saitis & Weinzierl, 2019; Zacharakis, Pastiadis, & Reiss, 2015). For instance, the proportion of high-frequency energy, attack time, and decay time are positively related to the perceived brightness, harshness, and roughness of the sound, respectively (Alluri & Toiviainen, 2010; Pressnitzer & McAdams, 1999; Rozé, Aramaki, Kronland-Martinet, & Ystad, 2017). Nevertheless, many studies in music psychology (Eerola, Ferrer, & Alluri, 2012; Hailstone et al., 2009; Halpern & Müllensiefen, 2008; Lahdelma & Eerola, 2016) and advertising (Oakes & North, 2006) have operationally defined timbre in terms of a musical instrument. This operationalization has a strong advantage in terms of practice because it is easier for managers to manipulate the musical instrument of background music than timbre itself or acoustic dimensions correlated to it, such as attack time. Therefore, from a practical viewpoint, instruments were used as representatives of timbres in this research; specifically, we chose the sound of a violin to represent the timbre of strings, the sound of a flute to represent woodwinds, and the sound of a piano to represent the mixed timbre of percussion and strings (Fletcher & Rossing, 2012).

2.2. Timbre of the piano and its familiarity

Individuals' familiarity with timbre plays a crucial role in their music perception (Huron, 2006). Compared with the sound of strings, woodwinds, and brass, individuals are more familiar with the sound of a piano (Arthurs, Beeston, & Timmers, 2018; Halpern & Müllensiefen, 2008; Oakes & North, 2006). Crisinel and Spence (2010) found that the timbre of a piano was rated the most pleasant, whereas the timbre of brass instruments was rated the most unpleasant sound. In the cross-modal sensory research domain, the authors further showed that the sounds of the piano were associated with familiar tastes, whereas the timbre of brass instruments was associated with unfamiliar tastes (Crisinel & Spence, 2010). In their experiments, the timbres of strings and woodwinds were identified by the participants in 14.7% and 13.2% of cases, respectively whereas the timbre of piano was identified in 100% of cases. In addition to the recognition test, Halpern and Müllensiefen (2008) asked participants to rate the familiarity of different timbres, which revealed that the average familiarity rating was significantly higher for the piano/church organ than for the banjo/recorder.

Research has not determined why people feel more familiar with the timbre of piano than with other timbres. One possible reason for this could be that like infants can memorize a melody's timbre after one week of daily exposure (Trainor, Wu, & Tsang, 2004), our frequent exposure to the piano's timbre than to other timbres makes it sound more familiar (Marvin & Brinkman, 2000). Another speculation stems from the uniqueness of the piano. The piano is a both stringed and a percussion instrument, and the interaction of the waves caused by its hammers and strings makes its vibration more complex than that of other instruments (Bank & Chabassier, 2018; Suzuki & Nakamura, 1990). Human beings might feel more familiar with complex stimuli than with simple stimuli (Caron & Caron, 1968; Lewis & Baldini, 1979). Finally, research in psychology has empirically tested and shown that the phenomenon of recognition without identification (RWI, meaning that human beings can naturally feel familiar with a face or a tune even without identifying the person or the song) commonly exists in timbre (Kostic & Cleary, 2009). This finding suggests that humans' cognition of timbre might still be underdeveloped.

2.3. Music fit in advertising

The concept of 'music fit' in advertising was originally proposed by MacInnis and Park (1991) and developed by Kellaris, Cox, and Cox (1993). By using 12 unfamiliar, pure instrumental pieces as background music in a 30-second radio commercial, Kellaris et al. (1993) demonstrated that consumers paid more attention to high (vs. low) attention-gaining music—which was selected based on pretest ratings—only if the music evoked message-congruent thoughts. When congruency was low, even high attention-gaining music did not enhance the participants' cognitive responses to the advertisement (in their study, brand/message recall and recognition).

Oakes and North (2006) investigated the effects of timbres, specifically of the piano, church organ, and steel drum, on advertisement effectiveness. In their experiment, the congruency between timbre and the advertisement message was manipulated based on the results of the pretests in which the participants unanimously reported that the timbres of the church organ and steel drum were inappropriate to the ad, while the piano timbre was appropriate. The researchers selected the church organ and steel drum timbres due to their associations with marriages or funerals and Caribbean music, respectively, which were not congruent with the target service (cosmetic surgery). Oakes and North (2006) revealed that the higher the congruency between timbre and the advertisement message, the higher the advertisement effectiveness. These findings provide a foundation for timbre research on music fit. When the timbre used in an advertisement represents a good fit with the product/message/ad, the effectiveness of the advertisement increases. We postulate that when a timbre used in the background music of an advertisement fits the viewers' motivation status, specifically their regulatory focus, the effectiveness of the advertisement should also increase in terms of positive consumer product/ad evaluations and behavioural intention.

2.4. Regulatory focus in sensory marketing

In the context of sensory marketing, the way that consumers' regulatory orientation fits into the processing of sensory stimuli plays a role in influencing consumer choice and evaluation (Zhu & Meyers-Levy, 2007). Promotion-focused consumers tend to use eagerness approach strategies when they strive for goals and take risks, while prevention-focused consumers are inclined to use vigilance avoidance strategies; they focus on reducing errors of omission and tend to be risk-averse when making decisions (Cesario, Grant, & Higgins, 2004; Pham & Avnet, 2004; Zhou & Pham, 2004). Roy and Phau (2014) illustrated a connection between visual research and regulatory focus. They demonstrated that promotion-focused consumers preferred image-based (vs. analytical) information in an advertisement because their promotional regulatory focus engages them with imagery processing styles. Prevention-focused consumers engaged with analytical processing styles. Furthermore, Zhu and Meyers-Levy (2007) investigated the relationship between the thematic ambiguity of visuals in an advertisement and regulatory focus. They found that the responses of promotion-focused consumers to the advertisement were more positive when the visuals of the advertisement were not clearly related to the target product than the responses of prevention-focused consumers that were more positive when the visuals were directly related to the target product.

We believe that auditory sensory information should also be associated with regulatory focus. Music, in general, is a resource that

motivates individuals during exercise, enhancing their vigour, coordination, and endurance and thereby promoting physical, affective, and behavioural engagement (DeNora, 2000). For example, the New Zealand national rugby team regularly performs Haka, a traditional Maori battle cry, prior to competitions to boost their fighting spirit. Music can make people feel more powerful, happier, and empowered, which in turn leads to greater risk-taking (Brodsky, 2001; Elvers & Steffens, 2017; Elvers, Fischinger, & Steffens, 2018; Laukka & Quick, 2011). This mechanism indicates the proactive function of music and is consistent with the behaviour of people with promotion-focused motivation. Music can also reduce anxiety (Elvers, 2016). This mechanism indicates another function of music that is similar to how people with prevention-focused motivation feel.

2.5. Hypotheses

The association between regulatory orientation and music has also been shown in neuroscience. Wallmark et al. (2018) revealed that, compared with unfamiliar music, familiar music caused increased activation in a large region of the right prefrontal cortex, the same area that is associated with a prevention regulatory focus (Amodio, Shah, Sigelman, Brazy, & Harmon-Jones, 2004). Familiar stimuli can reduce perceived risk (Song & Schwarz, 2009) and make people feel secure. This feeling of security fits with the prevention regulatory focus (Aaker & Lee, 2001; Cesario et al., 2004; Higgins, 1997; Pham & Chang, 2010). Familiar timbre induces individuals' feelings of security, which fit a prevention regulatory focus. Thus, we hypothesize the following:

H1: Compared with violin and flute timbres, background music played by a piano leads to more positive evaluation of advertisements/products with higher behavioural intention when the consumers or the advertisement messages are prevention-focused (vs. promotion-focused).

H2: The interaction effect between instrumental timbre and regulatory focus is mediated by individuals' feeling of security caused by familiarity.

Although music acts as a distraction in many daily life situations, both online and offline, when consumers focus on goal-oriented central elements, such as product information in an ad, they pay little attention to peripheral elements, including music (Chaney, Lin, & Chaney, 2004; Nelson, Yaros, & Keum, 2006). Low (vs. high) cognitive load broadens (narrows) the mental spotlight and makes people detect peripheral stimuli faster as well as more accurately (Chong, Mirchi, Silva, & Strybel, 2014). Moreover, Chong et al. (2014) empirically demonstrated that participants' detection of auditory peripheral stimuli was slower and less accurate than their detection of visual peripheral stimuli, indicating that people are unlikely to pay attention to auditory peripheral information under high cognitive load. Therefore, consumers will pay attention to background only when they have sufficient cognitive resources to do so. Under a high cognitive load, although familiar timbres can evoke consumers' feeling of security, they do not have the opportunity to experience the fit between the feeling of security and their regulatory focus because of limited cognitive resources and narrow mental scope. As a result, the effect of timbre is attenuated. Thus, we hypothesize the following:

H3: The mediational effect of the feeling of security occurs only under low cognitive load.

3. Overview of studies

Five experiments were conducted to test the hypotheses. Study 1 determined the familiarity of participants with piano timbre compared with violin and flute timbres. Study 2 analysed whether familiarity mediated the effect of timbre on the feeling of security. Studies 3a and 3b evaluated whether piano timbre fit the consumer's prevention focus and drove downstream effects on product/ad evaluations and behavioural intentions. This effect was tested in an online setting with participants from diverse demographic backgrounds and in a behavioural lab with more controls. Studies 3a and 3b were only conducted under low cognitive load. Study 4 examined whether the effect of music fit on consumers' product/ad evaluation and purchase intention was moderated by cognitive load. Data from the five studies were collected from Europe, Asia, and the US and revealed consistent results, which notably increases the generalizability of our research findings.

4. Study 1

In this study, we empirically tested and found that the participants were more familiar with piano timbre than with other instrumental timbres, such as violin and flute.

4.1. Method

Seventy-one participants of British nationality aged 20–60 years (female = 67.6%, M_{age} = 33.7, SD = 10.41) were recruited from a UK-based Prolific crowdsourcing platform (Prolific.ac.) in exchange for GBP 0.50 (approximately USD 0.62). None of the participants reported having any hearing issues. They were randomly assigned to one of the three conditions: the timbre of piano, violin, or flute.

The participants were asked to listen to the same arpeggio (a chord whose notes are played in rapid succession rather than simultaneously) played on a piano, violin, or flute. The stimulus was created from a musical instrument digital interface (MIDI) file, and only the instrumental timbre was manipulated. Other acoustic elements such as frequency, loudness, and speed were kept constant. The manufacturers, libraries (sample database of music), and sound sources are shown in Table 1 and were used in all the studies. The length of the arpeggio was 25 s for all conditions.

After listening to the arpeggio, participants' feeling of familiarity with the *sound of the instrument* (timbre) was measured using a seven-point Likert scale (1 = *not familiar at all*; 7 = *very familiar*).

In addition to familiarity, we further measured other semantic and evaluative perspectives of timbre. Since timbre has semantic dimensions such as luminance and texture (Saitis & Weinzierl, 2019), the participants were asked to indicate how they would describe the sound of the instrument using four words measured by seven-point bipolar scales: 1 = *bright*; 7 = *dark* (or luminance) and 1 = *harsh*; 7 = *soft* (or texture). The order of the antonyms within each pair (right/left of the scale) was counterbalanced among the participants. Subsequently, the evaluation of the sound of the instrument (timbre) was measured by a seven-point scale with four descriptive words, *like/pleasant/comfortable/good*, where 1 represented *not at all* and 7 represented *very much*. The responses were averaged, and an evaluation score was calculated (α = 0.951).

4.2. Results and discussion

First, as a control analysis, we conducted a 3 (timbre: piano vs. violin vs. flute) × 2 (gender: male vs. female) analysis of covariance (ANCOVA) on familiarity with age as a covariant. The results revealed a significant effect of timbre, $F_{timbre}(2, 64) = 4.123$, $p = .021$. However, neither gender nor age affected the participants' perceived familiarity with the timbres, $F_{gender}(1, 64) = 0.108$, $p = .172$, $F_{age}(1, 64) = 0.002$, $p = .963$. Consequently, these factors were excluded from consideration in the following analyses.

Table 1
Summary of the stimuli in studies 1–4.

Timbre	Manufacturer	Library	Sound source
Piano	Native Instruments	KONTAKT 5	THE GRANDEUR
Violin	Native Instruments	Session Strings	SustainAccent
Flute	Steinberg	HALION SONIC SE	Soft Vibrato Flute

The result of a one-way ANOVA on familiarity revealed a significant difference in timbre, $F(2, 68) = 8.309$, $p = .001$. Tukey's honestly significant difference test revealed that the participants' familiarity with the piano timbre ($M_{piano} = 5.45$, $SE = 1.74$) was higher than their familiarity with the violin ($M_{violin} = 4.20$, $SE = 1.71$, $t = 2.492$, $p = .047$) and the flute ($M_{flute} = 3.33$, $SE = 1.86$, $t = 3.989$, $p < .001$). The difference between the violin and flute was not significant ($t = 1.701$, $p = .207$). This result suggests that the participants felt more familiar with the piano timbre than with the violin and flute timbres.

A one-way ANOVA on the evaluation score was also conducted and revealed no significant differences among the three timbres, $M_{piano} = 5.51$, $SD = 1.42$, $M_{violin} = 5.43$, $SD = 1.08$, $M_{flute} = 4.97$, $SD = 1.36$, $F(2, 68) = 1.217$, $p = .302$. In addition, all three instruments were perceived as equally bright ($M = 2.48$, $SD = 1.38$) and harsh ($M = 3.97$, $SD = 1.36$, all $ps > 0.10$).

5. Study 2

Study 1 fundamentally supported that individuals felt more familiar with the piano timbre than with the violin and flute timbres. Note that there was no significant difference among the timbres in terms of the evaluation, such as liking and pleasantness. Study 2 further tested whether familiarity explained the relationship between instrumental timbre and individuals' feelings of security. We also tested and ruled out mood as a potential alternative mediator of the relationship.

5.1. Method

A total of 241 participants of British nationality (female = 56.8%, $M_{age} = 37.7$, age group = 20–60 years, $SD = 10.46$) were recruited from Prolific.ac in exchange for GBP 0.70 (approximately USD 0.92). No participant reported having any hearing difficulty.

The participants were randomly assigned to one of the three conditions (timbre: piano vs. violin vs. flute). They were instructed to set the speaker's volume level according to their own comfort and keep the level constant throughout the study. The participants were allowed to use a headset or earphones. The music stimuli were created from a MIDI file of a version of *Canon* by Johann Pachelbel. The average frequencies of the piano, violin, and flute versions were 123.35, 123.64, and 123.39 Hz, respectively. Only the timbre was manipulated; the other acoustic elements remained unchanged from the original versions. Perceived loudness, rather than physical loudness, was kept constant across all experimental conditions (i.e. −15 loudness unit full scale [LUFS]; Sunaga, 2018). The length of the music was 70 s for all three conditions.

After listening to the music, all participants were asked to indicate their current feeling in terms of being *secure* and *safe* using a seven-point scale (1 = *not at all*; 7 = *very much*). The responses were averaged to form a feeling of security score ($\alpha = 0.862$). This score served as the dependent measure of this study. The participants were then asked whether they recognized the instrument on which the music was played (*piano/violin/flute/for some reason I did not hear any music/I heard the music, but I cannot tell*). Subsequently, familiarity with the *sound of the instrument* and with the *melody* was measured using a seven-point scale (1 = *not familiar at all*; 7 = *very familiar*). The participants were also asked to describe their mood using two sets of words measured by seven-point bipolar scales—*bad/good* and *tired/energetic*—which were averaged to form a mood score ($\alpha = 0.713$). Demographic questions were asked at the end.

5.2. Results and discussion

In the piano condition, 97% of the participants correctly identified the instrument, which was significantly more than those who identified correctly in the violin and flute conditions (57.5% and 48.7%, respectively; $\chi^2 = 52.11$, $df = 2$, $p < .001$). This result was in line with the finding of study 1 in that people are more familiar with the timbre of a piano than with that of a violin or flute.

There was no difference between the three conditions in terms of participants' familiarity with melody or mood, $M_{melody} = 5.19$, $SD = 1.60$, $F(2, 238) = 0.792$, $p = .454$; $M_{mood} = 4.75$, $SD = 1.19$, $F(2, 238) = 1.760$, $p = .174$. However, the result of a one-way ANOVA on the feeling of security revealed a significant difference, $F(2, 238) = 4.965$, $p = .008$, $\eta_p^2 = 0.040$. A contrast analysis revealed that when exposed to the piano timbre, the participants felt more secure ($M_{piano} = 5.34$, $SD = 1.16$) than when they were exposed to the violin and flute timbres, $M_{violin} = 4.74$, $SD = 1.33$, $F(1, 163) = 9.436$, $p = .002$, $\eta_p^2 = 0.055$; $M_{flute} = 5.02$, $SD = 1.15$, $F(1, 159) = 3.090$, $p = .081$, $\eta_p^2 = 0.019$.

A mediation analysis using the Hayes PROCESS model 4 (Hayes, 2018a) was conducted to test whether individuals' familiarity with the piano timbre explained their feelings of security. Timbre, as an independent variable, was coded as 1 or 0, where 1 represented piano timbre and 0 represented violin or flute timbre. After 5000 bootstrapping resamplings, the output showed a significant indirect effect of familiarity on the direct effect of timbre on the feeling of security ($M_{familarity} = 0.319$, $SE = 0.105$, 95% boot CI = [0.120, 0.538]; see Fig. 1).

To rule out the alternative explanation that mood might also play an indirect role in creating a feeling of security, another mediation analysis was conducted in the same way but using the score of mood as a mediator. The output did not identify any significant results (indirect effect: $M_{mood} = 0.158$, $SE = 0.088$, 95% $CI = [-0.011, 0.335]$). Therefore, the results of study 2 confirmed that the participants' familiarity with the piano timbre could induce their feeling of security rather than their mood.

6. Study 3a

Since the feeling of security is a feature of prevention focus, in this study and in study 3b, we tested the interaction effect between timbres and regulatory focus in the context of marketing. Additionally, studies 1 and 2 were performed online, which leads to a lack of control over the exact parameters of stimulus presentation. For instance, the participants could listen to the acoustic stimuli at different volume levels, which might affect the proposed effects. Thus, this study was conducted in the more controllable environment of a behavioural lab.

6.1. Method

A total of 172 graduate students (female = 61.6%, $M_{age} = 20.20$, $SD = 0.87$) at a private business school in France participated in this study in exchange for partial course credit. The study was held in a marketing behavioural lab with ten workstations equipped with computers.

A 3 (timbre: piano vs. violin vs. flute) × 2 (regulatory focus: prevention vs. promotion) between-subjects design was conducted, and the participants

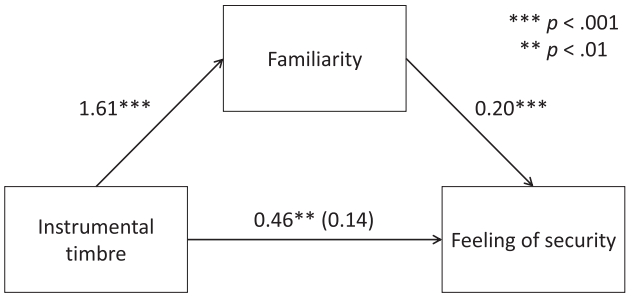

Fig. 1. Mediating role of familiarity on the effect of timbre on feeling of security in study 2.

were randomly assigned to one of the six conditions. At the beginning of the study, the participants were instructed to put on their earphones to listen to the music to cancel out the ambient noise so that they could concentrate on answering the questions online. Throughout the study, they were exposed to the same music used in study 2: a piano, violin, or flute version of Pachelbel's *Canon*. They received the same instructions regarding speaker volume as the participants in study 2.

The participants were then asked to evaluate a print advertisement of a public transportation service: a light-rail train. The manipulation of regulatory focus was included in the description of each version of the ad. The manipulation message was adapted from Zhang and Yang (2015, p. 452) and emphasized the train's benefits. In the promotion focus condition, the advertisement's description read as follows: '*Going to college opens a window of opportunity. So does taking public transportation with us. VTA helps deliver your aspirations*'. In the prevention focus condition, the advertisement's description read as follows: '*Being punctual and responsible is important as a college student. We value the same characteristics. VTA helps fulfil your obligations*' (see Appendix A). Both versions of the advertisement used the same four pictures.

After viewing the ad, the participants were asked to evaluate the train service using three seven-point items: 1 = *bad*, *unfavourable*, and *negative*; and 7 = *good*, *favourable*, and *positive* (Zhang & Yang, 2015). A product evaluation score was created by averaging the participants' responses to the three items (α = 0.927).

6.2. Results and discussion

The ANOVA output showed a significant main effect of regulatory focus, F (1, 166) = 4.019, p = .047, η_p^2 = 0.024. The participants in the prevention focus condition evaluated the train service more positively ($M_{prevention}$ = 4.66, SD = 1.44) than those in the promotion focus condition ($M_{promotion}$ = 4.24, SD = 1.35). The interaction effect between timbre and regulatory focus was not significant but showed a certain trend towards significance, F (2, 166) = 2.487, p = .086, η_p^2 = 0.029 (see Fig. 2). A contrast analysis revealed that when exposed to the piano timbre, the participants in the prevention condition evaluated the train service more positively ($M_{prevention}$ = 5.13, SD = 1.36) than those in the promotion condition, $M_{promotion}$ = 4.03, SD = 1.40, F(1, 53) = 8.488, p = .005, η_p^2 = 0.138. However, when exposed to the violin and flute timbres, regulatory focus did not influence the participants' evaluation of the train service, $M_{violin\_prevention}$ = 4.50, SD = 1.30, $M_{violin\_promotion}$ = 4.32, SD = 1.18, F(1, 50) = 0.270, p = .606; $M_{flute\_prevention}$ = 4.33, SD = 1.52, $M_{flute\_promotion}$ = 4.32, SD = 1.49, F(1, 63) = 0.001, p = .976. Furthermore, when presented with the prevention-focused message, the participants evaluated the service more positively when they listened to the piano timbre (M_{piano} = 5.13, SD = 1.36) than when they listened to the violin and flute timbres (M_{violin} = 4.50, SD = 1.30; M_{flute} = 4.33, SD = 1.52). The difference was not statistically significant but borderline significant, F(2, 88) = 2.846, p = .063, η_p^2 = 0.061. No other effect was identified as significant.

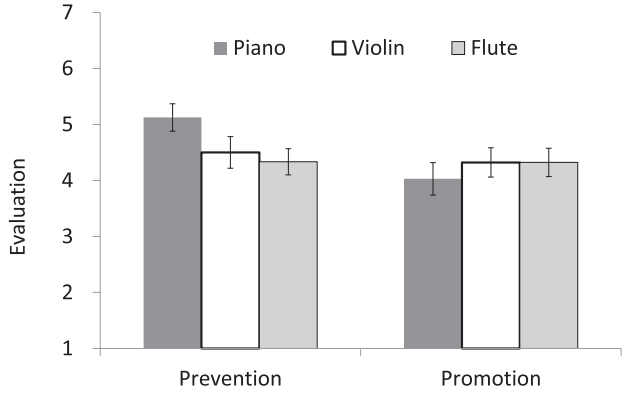

Fig. 2. Interaction effects between timbre and regulatory focus on evaluations in study 3a. *Note*: Error bars represent the standard errors of the means.

The results in study 3a were consistent with the previous experiments and supported H1. Under more controlled conditions, this study indicated that when participants were exposed to the piano timbre, they tended to evaluate the same train service more favourably when the advertisement included a prevention-focused message than a promotion-focused message.

7. Study 3b

In the previous study 3a, the regulatory focus was manipulated by advertisement messages, and we found an interaction effect between the timbre and regulatory-focused messages. However, we wanted to further understand whether there is an interaction between timbre and individuals' regulatory orientation. Thus, using a different manipulation of regulatory focus, this study tested H1, specifically, whether the interaction effect between timbre and regulatory focus would occur in terms of consumers' evaluation as well as their behavioural intention.

7.1. Method

A total of 291 Japanese participants were recruited online from the Yahoo Crowdsourcing service in Japan, all currently residing in the country (female = 46.7%, M_{age} = 44.26, aged 20–60 years, SD = 9.74). A 3 (timbre: piano vs. violin vs. flute) × 2 (regulatory focus: prevention vs. promotion) between-subjects design was conducted, and the participants were randomly assigned to one of the six conditions. They received JPY 10 (approximately USD 0.09) for this study.

The study consisted of two ostensibly unrelated parts. In the first part, we primed the participants' regulatory focus by a writing task in which they reflected on past and current hopes and goals in the promotion condition or their past and current duties and obligations in the prevention condition (Kirmani and Zhu, 2007; Pham & Avnet, 2004; Roy & Phau, 2014; Zhang & Yang, 2015). In the second part, they were asked to evaluate a café's advertisement video with the background music (the same music piece as in studies 2 and 3a) manipulated by different timbres (piano, violin, and flute). The same instructions regarding speaker volume and headset use as in the previous studies were provided. The length of the video clip was 15 s, and six images of a café (such as the interior, roasting coffee beans, and seats on the terrace) were shown sequentially for 2.5 s each (see Appendix B) with no subtitles or vocal elements except for the background music. The perceived loudness of the music was kept constant across all experimental conditions (-15 LUFS).

The participants viewed the video clip and were asked to evaluate the advertisement and the service (the café) and indicate their behavioural intention, which were our dependent measures in this study. To measure their evaluation of the café and the ad, they were asked, 'Please indicate your opinion about the café featured in the video clip' and 'Please indicate your opinion about the video clip' using three seven-point scales, where 1 = *dislike*, *unappealing*, and *not impactful* and 7 = *like*, *appealing*, and *impactful*; α_{video} = 0.815, $\alpha_{café}$ = 0.841). Their behavioural intention was measured by the question, 'Would you go to the café featured in the video clip?' using a seven-point scale where 1 = *definitely would not go* and 7 = *definitely would go*. The order of the antonyms within each pair was counterbalanced among the participants. Demographic questions were asked at the end.

7.2. Results and discussion

7.2.1. Evaluation of advertisement and product

We averaged the three evaluation items to form one score each for advertisement evaluation and café evaluation and ran the ANOVAs. The results of the dependent measures of advertisement evaluation and café

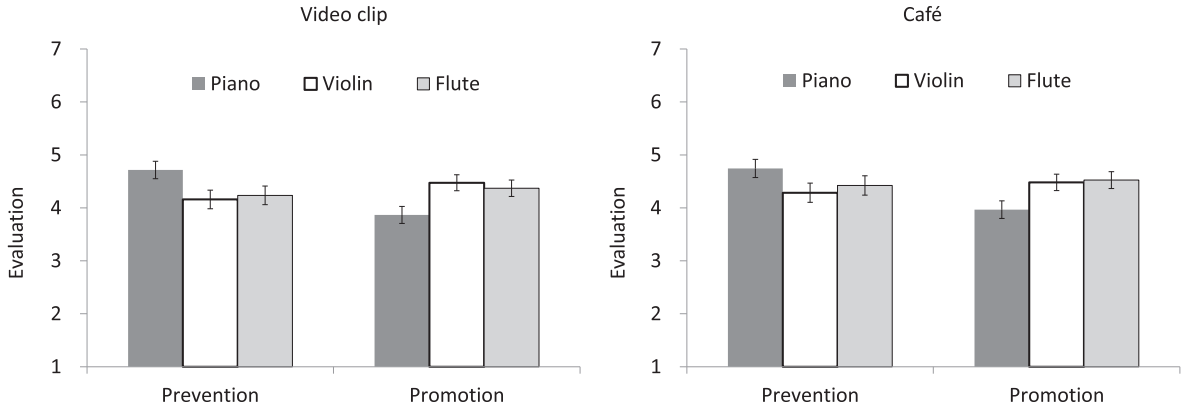

Fig. 3. Interaction effects between timbre and regulatory focus on evaluations in study 3b. *Note*: Error bars represent the standard errors of the means.

evaluation showed a similar pattern. We did not identify any significant main effect (all *ps* > 0.1), but there were significant interaction effects between timbre and regulatory focus, $F_{video}(2, 285) = 7.383$, $p = .001$, $\eta_p^2 = 0.049$; $F_{café}(2, 285) = 5.066$, $p = .007$, $\eta_p^2 = 0.034$ (see Fig. 3).

Contrast analyses revealed that when exposed to background music with piano timbre, the participants in the prevention-focused condition evaluated the video and the café more positively ($M_{video} = 4.72$, $SD = 1.04$; $M_{café} = 4.74$, $SD = 1.05$) than those in the promotion-focused condition, $M_{video} = 3.87$, $SD = 1.37$, $F(1, 285) = 13.618$, $p < .001$, $\eta_p^2 = 0.046$; $M_{café} = 3.97$, $SD = 1.34$, $F(1, 285) = 10.706$, $p = .001$, $\eta_p^2 = 0.036$. In the promotion-focused condition, the participants exposed to the background music of the piano timbre evaluated the video and the café less positively ($M_{video} = 3.87$, $SD = 1.39$; $M_{café} = 3.97$, $SD = 1.34$) than those exposed to the background music with the violin timbre, $M_{video} = 4.47$, $SD = 0.96$, $F(1, 105) = 7.168$, $p = .009$, $\eta_p^2 = 0.064$; $M_{café} = 4.48$, $SD = 1.04$, $F(1, 105) = 4.991$, $p = .028$, $\eta_p^2 = 0.045$, and the flute timbre, $M_{video} = 4.37$, $SD = 1.06$, $F(1, 102) = 4.448$, $p = .037$, $\eta_p^2 = 0.042$; $M_{café} = 4.52$, $SD = 1.15$, $F(1, 102) = 5.235$, $p = .024$, $\eta_p^2 = 0.049$. On the other hand, in the prevention-focused condition, the participants exposed to the piano timbre evaluated the video clip more positively ($M_{piano} = 4.72$, $SD = 1.04$) than those exposed to a background music with the violin timbre, $M_{violin} = 4.16$, $SD = 1.27$, $F(1, 87) = 5.170$, $p = .025$, $\eta_p^2 = 0.056$, and the flute timbre, $M_{flute} = 4.24$, $SD = 1.08$, $F(1, 86) = 4.486$, $p = .037$, $\eta_p^2 = 0.050$. No other effect was significant.

7.2.2. Behavioural intention

The output of the ANOVA on behavioural intention showed no significant main effect but a significant interaction effect between timbre and regulatory focus, $F(2, 285) = 4.371$, $p = .013$, $\eta_p^2 = 0.030$ (see Fig. 4). A contrast analysis revealed that when exposed to the piano timbre, the participants in the prevention condition indicated higher behavioural intention ($M_{prevention} = 5.06$, $SD = 1.13$) than those in the promotion condition, $M_{promotion} = 4.32$, $SD = 1.60$, $F(1, 95) = 6.932$, $p = .009$, $\eta_p^2 = 0.068$. When exposed to violin and flute timbres, regulatory focus did not influence the participants' behavioural intention, $M_{violin} = 4.68$, $SD = 1.30$, $F(1, 97) = 0.143$, $p = .707$, $\eta_p^2 = 0.001$; $M_{flute} = 4.87$, $SD = 1.29$, $F(1, 93) = 1.586$, $p = .211$, $\eta_p^2 = 0.017$. The participants in the promotion-focused condition reported lower behavioural intentions when they listened to the piano timbre ($M_{piano} = 4.32$, $SD = 1.60$) compared with those who were exposed to the violin timbre, $M_{violin} = 4.72$, $SD = 1.21$, $F(1, 105) = 2.161$, $p = .145$, $\eta_p^2 = 0.020$, and the flute timbre, $M_{flute} = 5.02$, $SD = 1.14$, $F(1, 102) = 6.665$, $p = .011$, $\eta_p^2 = 0.061$. There was no other significant effect.

In this study, we manipulated participants' regulatory orientation in a different way from that of study 3a and obtained consistent results with those revealed in previous studies. The piano timbre fit a prevention focus in terms of product/ad evaluation. More importantly, the fit occurred in terms of the participants' behavioural intention. Participants with a prevention focus showed a higher intention to attend the café than those with a promotion focus when they were exposed to background music with the piano timbre. The results thus support H1.

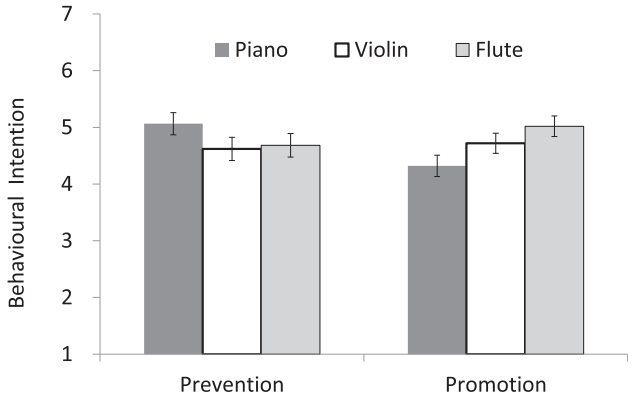

Fig. 4. Interaction effects between timbre and regulatory focus on behavioural intention in study 3b. *Note*: Error bars represent the standard errors of the means.

8. Study 4

The aim of this study was to test the mediation and moderation effects on the relationship between timbre and regulatory focus (H2 and H3). Mental capacity is required for individuals to pay attention to peripheral cues during performance of mental or physical work, such as evaluating a product or making a purchase decision (Chaney et al., 2004; Nelson et al., 2006). In this study, we manipulated the cognitive load and predicted that when the participants did not have the opportunity to pay attention to peripheral cues (high cognitive condition), the mediation effect of the feeling of security in the relationship between timbre and regulatory focus would be attenuated. However, when they had the opportunity to do so (low cognitive condition), a consistent result of music fit, as shown by the previous studies, should be obtained. Importantly, the feeling of security should mediate this effect.

8.1. Method

A total of 595 participants of US nationality, aged 20–60 years (female = 53.3%, $M_{age} = 32.43$, $SD = 9.70$), were recruited from Prolific.ac. No participants reported having hearing difficulties. A 3 (timbre: piano vs. violin vs. flute) × 2 (regulatory focus: prevention vs. promotion) × 2 (cognitive load: low vs. high) between-subjects design

was conducted. The participants were randomly assigned to one of the 12 conditions. They received GBP 0.48 (approximately USD 0.63) for participating.

The regulatory focus manipulation was the same as in study 3b. The participants also received the same instructions about speaker volume and headsets as those used in previous studies. We manipulated cognitive load by modifying the length of the advertisement message. The participants were shown a 16-second advertisement of a fictitious car brand, Allegre. Four sequential images of a car were shown to them across all conditions for 4 s each and each image had bottom captions that included a headline, descriptions of the brand's superior attributes, or its tagline. The description messages were adopted from Roy and Phau's work (2014, study 1). In the low cognitive load condition, the participants read an average of 4.25 words from the car brand description per image, while in the high cognitive load condition, they read multiple lines of text with 20.25 words on average. The images and captions are presented in Appendix C.

To replicate and extend the results of prior studies using different acoustic stimuli and to consequently verify the proposed effect, study 4 used *Home Sweet Home* by Henry Rowley Bishop, which was created from a MIDI file, as the background music; it was played in all three versions - the piano, violin, and flute. The perceived loudness was kept constant across all experimental conditions (-15 LUFS). The average frequencies of the piano, violin, and flute versions were 392.13, 395.81, and 392.07 Hz, respectively.

After completing the regulatory focus manipulation task, the participants were asked to watch the video clip advertisement as they normally would. Purchase intention was measured by the question, 'Would you consider owning the brand (Allegre) as you observed in the ad?' on a seven-point scale (1 = *definitely no*; 7 = *definitely yes*). Familiarity with the *sound of the instrument* and the *melody of the music* were measured on a seven-point scale (1 = *not familiar at all*; 7 = *very familiar*). The participants were also asked, 'In your opinion, how appropriate are the following words [*secure* and *safe*] for the music?' on a seven-point scale (1 = *not at all*; 7 = *very much*). The responses to *security* and *safety* were averaged to derive a feeling of security score (α = 0.727). The participants were also asked to report the perceived cognitive load on seven-point scales of seven items (Leppink, Paas, Van der Vleuten, Van Gog, & Van Merriënboer, 2013), which were averaged to form a cognitive load score, such as 'Please indicate your opinions about the advertisement video clip you viewed; The message of the advertisement was very complex' (1 = *strongly disagree*; 7 = *strongly agree*; α = 0.874), as a manipulation check (Appendix D). The participants were asked whether they recognized the instrument on which the music was played by choosing between *piano*, *violin*, *flute*, *for some reason I did not hear any music*, and *I heard the music, but I cannot tell*. They were also asked whether they recognized the music as *Home Sweet Home* and some control questions, such as whether they had hearing problems or professional instrument training, along with their demographic attributes.

8.2. Results and discussion

Data from seven participants (1.2%) were excluded from further analysis because they reported 'for some reason I did not hear any music' (hence, n = 588, female = 53.2%, M_{age} = 32.46, SD = 9.67).

8.2.1. Manipulation check

A 3 (timbre: piano vs. violin vs. flute) × 2 (regulatory focus: prevention vs. promotion) × 2 (cognitive load: low vs. high) ANOVA on the cognitive load score revealed a significant main effect of cognitive load, F (1, 576) = 172.931, p < .001, η_p^2 = 0.231, but it did not reveal a main effect of regulatory focus and timbre or any significant interaction effect. The participants in the high cognitive load condition used more cognitive effort in the study (M_{high} = 4.02, SD = 1.38) than those in the low cognitive load condition (M_{low} = 2.64, SD = 1.14). The results validated the manipulation of cognitive load used in this study.

8.2.2. Analysis of moderated moderated mediation

To test moderated mediation in a moderated condition, we conducted a 'moderated moderated mediation analysis' in which the moderation of the indirect effect by one variable is dependent on the second moderator (Hayes, 2018b). This model (see Fig. 5) indicated that compared with the violin or flute timbres, the piano timbre increased the participants' feeling of security, which in turn enhanced their behavioural intention to own the car. However, this was only true for the participants with a prevention (vs. promotion) regulatory focus under a low (vs. high) cognitive load.

The analysis used the Hayes PROCESS macro v3.3. (Model 20; Hayes, 2018a) to estimate the conditional, indirect effect of the piano timbre (1 = piano, 0 = violin or flute) on purchase intention through the feeling of security as moderated by regulatory focus (1 = promotion vs. 2 = prevention) and cognitive load (1 = high vs. 2 = low). After 5000 iterations of bootstrap resampling, the results indicated a significant moderated moderated mediation effect of the feeling of security on the effect of timbre on purchase intention (conditional indirect effect: M = 0.336, SE = 0.140, 95% CI = [0.094, 0.636]). When the cognitive load was low, the conditional moderated mediation by regulatory focus was significant (M = 0.190, SE = 0.105, 95%

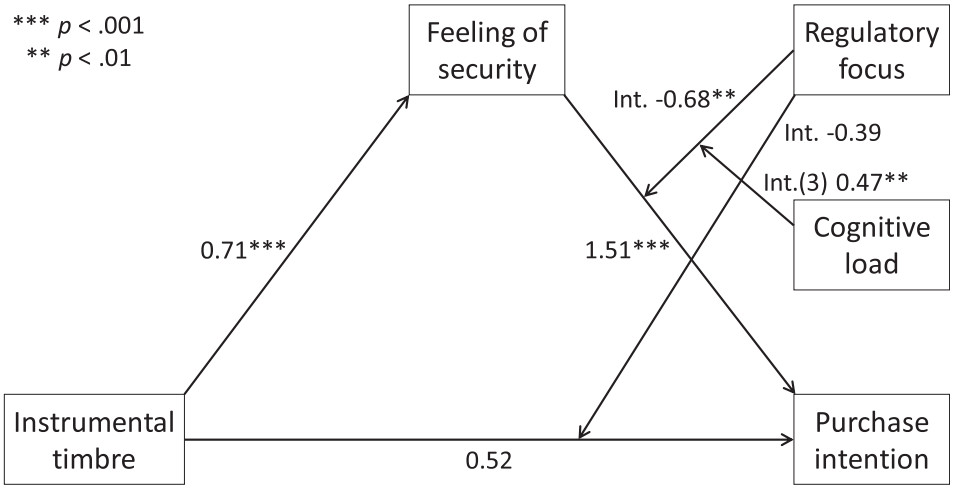

Fig. 5. Moderated moderated mediating role of feeling of security on the relationship between timbre and purchase intention in study 4. *Note*: Int. = Interaction; Int. (3) = Three-way interaction.

CI = [0.006, 0.421]). However, when the cognitive load was high, there was no such significant conditional indirect effect (M = −0.146, SE = 0.081, 95% CI = [-0.318, 0.003]).

Furthermore, the three-way interaction effect among the feeling of security, regulatory focus, and cognitive load on purchase intention was significant (b = 0.47, t = 2.83, p = .005). Under low cognitive load, the conditional interaction effect between the feeling of security and regulatory focus was significant, M = 0.266, $F(1, 578)$ = 4.558, p = .033.

The results of study 4 indicated a significant moderated moderated mediating effect of a feeling of security on the effect of timbre on purchase intention. The participants felt more secure when exposed to the piano timbre than when they were exposed to the violin and flute timbres; this, in turn, enhanced their behavioural intention to own the car, especially when they had a prevention focus. This effect was significant only under low cognitive load. Therefore, study 4 supports H2 and H3.

9. General discussion

The current research examined how timbres interact with individuals' regulatory focus. We found that combining the piano timbre with individuals' prevention focus enhanced their product/ad evaluations and behavioural intention. This is because the piano timbre is perceived as familiar, which in turn induces listeners' feeling of security. This feeling fits with a prevention regulatory focus. Five studies were conducted in a behavioural lab and online in France, the UK, Japan, and the US using advertisements across different product categories in a printed or video clip format. The pieces of music (*Canon* and *Home Sweet Home*) were also varied as different stimuli when the timbres were manipulated.

The interaction effect between timbre and regulatory focus was only significant when individuals had the mental capacity to process the information, supporting the idea that the effect is not automatic or subliminal but cognitive and required attention. Previous literature, including neuroscience literature, has shown that people often hear their own voice pronouncing texts while reading them silently (Perrone-Bertolotti et al., 2012). Our findings are compatible with those of these works. According to Perrone-Bertolotti et al. (2012), the 'inner voice' process is modulated by attention—specifically, individuals tend to use or rely on inner auditory images more often as texts become more difficult to read or linguistic complexity increases (Alexander & Nygaard, 2008; Jobard, Vigneau, Simon, & Tzourio-Mazoyer, 2011). It is highly possible that many words in the advertisement in the high cognitive load condition required the participants to use inner auditory images (i.e. inner voice), which in turn could have interfered with the external auditory processing.

9.1. Theoretical contributions

To the best of our knowledge, there is no published research that has examined how instrumental timbres used in advertisements are related to consumers' regulatory focus, advertisement and product evaluation, and behavioural intentions as downstream effects. Despite the cross-modal correspondence research between taste/flavour attributes and timbre (e.g. Crisinel & Spence, 2010, 2012), the marketing literature has scarcely discussed how timbre might play a role in consumers' motivation, thoughts, and behaviours (Hultén, 2015; Krishna, 2012).

Our findings add value to the study of multisensory consumer–computer interaction, which has a longstanding connection with music (Tanaka, 2019). An application for musical interfaces to support composition of music would offer better user experience if it could automatically select an instrument suitable for composers' regulatory focus (i.e. their motivations to compose music). In the field of human–computer interaction, there has been extensive work on storytelling systems designed to foster creativity and collaboration among children. For example, Cao, Lindley, Helmes, and Sellen (2010) developed a system called *TellTable* that enables children to make their own stories through photography and drawing on a multi-touch interactive table. In such systems, would a function of automatic selection of the sounds (i.e. instrumental timbre) of background music suitable for a scene inspire children's creativity and collaboration? Would the regulatory focus of a character affect children's choices of musical instruments for the background music? Our research provides a foundation for answering these questions.

Cesario and Higgins (2008) suggested that regulatory fit could be a better perspective to understand the effects of subtle nonverbal cues, such as gestures and speech rate, on persuasion and the formation of impressions. Our study contributes to the literature by demonstrating that timbre—a novel, nonverbal cue—can interact with consumers' regulatory focus. Oakes and North (2006) found that a piano timbre was more appropriate for an advertisement for cosmetic surgery rather than the timbre of a church organ or a steel drum. However, the authors did not explain the underlying process of this finding in terms of acoustic properties. We believe that since people generally feel anxious about the risks associated with cosmetic surgery, they are more likely to have prevention-focused motivation. Therefore, a piano timbre fits consumers' prevention orientation.

9.2. Managerial implications

Our research also has clear managerial contributions. Some industries, such as insurance or pharmaceuticals, have prevention-focused orientations by nature. They should choose a piano timbre over other instruments in their advertisements or play piano music in their stores since violin and flute timbres do not fit with a prevention-focused orientation. In their advertisements, they should avoid including overwhelming information because our research shows that the interaction effect occurs only when consumers have a low cognitive load.

Recently, electronic speakers that produce a directional beam of sound and create fields of sound that spread much less than most traditional speakers (e.g. 'SRAY' by CatchFlow) have been developed. Such equipment can personalize the delivery of background music; as a result, audiences, customers, or employees in the same room can hear different music depending on their location. By changing instrument types, managers can manipulate the timbre of background music according to audiences' regulatory orientation, the positioning of the product, or job requirements. For instance, music played by the piano might be suitable for prevention-focused individuals such as consumers who order a low-calorie menu or workers in charge of accounting. This is applicable to the personalized delivery of sounds that most frequently use digital technology at the dining table (Spence, 2017).

Music can be easily utilized in both VR and AR. If marketers want to promote new products or services through AR or VR, they need to avoid using music with a piano timbre. However, for some marketing or prosocial campaigns conducted in VR and AR aimed at preventing consumers from overeating, smoking, social media addiction, or drug abuse, the sound of a piano is highly recommended as background music.

Prior research has shown that there are cultural differences in regulatory focus such that, compared with individuals from a Western cultural background, individuals with an Eastern cultural background tend to be more prevention oriented than promotion oriented (Lockwood, Marshall, & Sadler, 2005; Lee, Aaker, & Gardner, 2000; Higgins, Pierro, & Kruglanski, 2008). However, the current research did not find cultural differences in the five studies. When participants across the four countries were primed by prevention orientation, they all showed higher preference for the timbre of the piano than for that of the violin or flute. We believe that our conclusions have international implications and are applicable to global marketing—at least to consumers in the four countries.

9.3. Limitations and future research

In line with prior research, the series of studies reported here consistently showed that piano timbre was familiar to audiences. However, it is unclear why people perceive the piano timbre as more familiar than other instrumental timbres. People might feel a greater sense of familiarity upon hearing piano timbre because they culturally have more experience listening to the piano.

To test whether the above was true, we found that 33 participants in the piano condition, 16 in the violin condition, and 13 in the flute condition in study 4 had formal training on either the violin, flute or both and were engaged in professional activities for more than one year (ten participants had training on both the violin and flute). Although the sample size was not large (n = 62), we conducted a *t*-test to compare their familiarity with all three timbres. We found that although all participants had a vast amount of experience listening to violin or flute timbres, they still perceived the piano timbre as more familiar (M_{piano} = 6.24, SD = 1.00) than that of the violin or flute, $M_{violin/flute}$ = 5.34, SD = 1.54, $t(60) = 2.751$, $p = .008$, $d = 0.70$. This result ruled out the possible explanation by mere exposure to the sound of the piano as being the reason for people's familiarity with its timber's sound.

Pachelbel's *Canon*, which was used as the acoustic stimuli in studies 2–3b, is commonly played with string instruments but very rarely with the flute. Nonetheless, the participants tended to perceive the piano version as more familiar than the violin version. Additionally, they did not perceive the violin version as more familiar than the flute version. These results ruled out another possibility: that higher familiarity with the piano timbre existed among the participants because they were exposed more frequently to the piece played with the piano than other instruments.

Why do individuals feel more familiar with the piano than other instruments? We attempted to find evidence from the physical waveform of the timbres. Research has shown that when amplitude (loudness) and frequency (pitch) are controlled, the waveform of the timbre played by a string instrument with a bow (e.g. violin) usually presents as a saw-tooth waveform (Bader, 2013; Burg, Romney, & Schwartz, 2017; Schumacher & Woodhouse, 1995; Smith, 1997), and the timbre played by a percussion instrument (e.g. drum) usually presents as a scattered waveform. Timbres played by brass and woodwinds (e.g. trumpet and flute) usually present as a sine waveform (Bernier & Stafford, 1972; Burg et al., 2017; Giordano, 2010; Mazzola et al., 2018). Although the instruments have different patterns of timbre waveforms, all these waveforms are simple and clear in terms of their shapes and are easily described in mathematical terms (Burg et al., 2017).

However, piano timbre has a complex waveform (Jenkins, 2020). As mentioned earlier, the piano has both hammers and strings, and the timbre of the piano is created through the piano's hammer–string interactions (Fletcher & Rossing, 2012). Furthermore, in contrast to a violin, for which each string consists of one string, the piano uses two or three strings to make one note (except for several low notes), which makes the vibration very complex (Bank & Chabassier, 2018; Suzuki & Nakamura, 1990). These complicated synthesis processes involving the entire instrument body make the sound of the piano very complex compared to that of other musical instruments.

Research in cognitive psychology has shown that complex visual stimuli are less likely to decrement the observing behaviours of infants compared with simple visual stimuli (Caron & Caron, 1968). This 'complexity effect' should also be valid for the auditory mode. People tend to pay longer attention to a complex (vs. simple) auditory stimulus, which, in turn, gives them a sense of familiarity with the complex auditory stimulus (Lewis & Baldini, 1979).

Consequently, we believe that the complex waveform is one of the most prospective attributes that induces listeners' familiarity with piano timbre. To confirm that the piano timbre has a more complex waveform than the violin and flute do, we calculated fractal dimensions of the waveforms of the three arpeggios used in study 1.

Using the Fractal analysis system for Windows (2006), we computed the fractal dimensions using the box-counting method (Gunasekaran & Revathy, 2008; Sink et al., 2011). The results indicated that compared to the violin (FD_{violin} = 1.38) and flute (FD_{flute} = 1.30) timbres, the piano timbre used in the study had more complex waveforms (FD_{piano} = 1.41). Note that according to Makabe and Muto (2014), who used the same method, the difference in fractal dimension between the most regular sound waveform and Brownian motion is just 0.5, which means that the index has a very narrow range in this case. However, whether the difference induces different familiarity with timbre is not clear. The complexity of the waveform might unconsciously affect listeners' perceived familiarity. Thus, it is not a feasible solution to ask participants to indicate their perceived complexity of instrumental timbre. Although we believe a relationship exists between the complexity of the waveform and familiarity with timbre, this relationship requires further research.

It would also be worthwhile to test whether the same results can be obtained from participants who live in culturally different areas and have low levels of familiarity with the instrument types used here, such as among indigenous tribes in the US or Mexico. Studies using culturally novel instruments with complex/simple waveform timbres would also be beneficial.

From the viewpoint of multisensory consumer experiences, it would be fruitful to test whether and how any cross-modal association occurs between timbre and other sensory modalities—visuals, olfactory, touch/haptics, and/or tastes—in both real and virtual environments. For instance, research questions such as 'Do/How do people associate specific timbres with particular shapes and/or bodily movements?' should be promising (Bremner et al., 2013).

Emotion is another factor which can be considered in future studies. In study 1, in addition to familiarity with the sounds of the instruments that the participants heard, we directly asked the participants how pleasant the sound was and how much they liked it. Since the timbre manipulation used in this study did not affect the participants' perceived pleasantness and liking of the sounds, the possibility of confounding may not be high. Nevertheless, further research is needed to rule out the potential alternative explanation by pleasantness, especially in the marketing context.

Appendix A

See Fig. A1.

Acknowledgment

Funding: This work was supported by the JSPS Grants-in-Aid for Scientific Research (C) Number 15K03753.

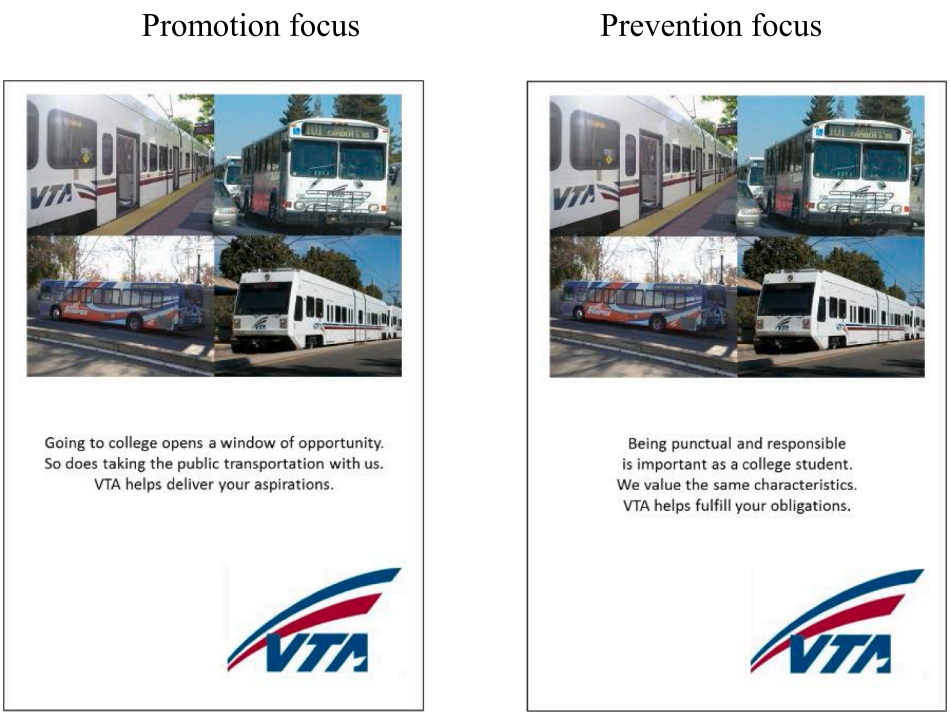

Fig. A1. Stimuli used in study 3a. *Note*: The advertisements were created by the authors based on Zhang and Yang (2015).

Appendix B

See Fig. B1.

Fig. B1. Images of the video clip advertisement in study 3b.

Appendix C

See Fig. C1 and Table C1.

Fig. C1. Images of the video clip advertisement in study 4.

Table C1
Bottom captions of the video clip advertisement in study 4.

	Low cognitive load	High cognitive load
1	Athletic, Reliable, Versatile	Athletic, Reliable, Versatile A touring machine like no other.
2	Glass Sunroof, Premium Sound System	Glass sunroof with a menu of sunshade functions in the standard model. A premium sound system (200 W and 10 speakers) designed to simply thrill the first time you get in. And every time.
3	Five-Year Unlimited Warranty, Cutting-edge Security System	Five-year unlimited warranty at no additional cost. Cutting-edge system that allows you to control all the security features at a distance of one mile from your car.
4	Allegre. Just Unbeatable	Let others dream of unparalleled luxury and efficiency. Allegre. Just Unbeatable

Note: The bottom captions were based on Roy and Phau (2014; Study 1).

Appendix D. Measurement of cognitive load in study 4

(1) The message of the advertisement was very complex.
(2) The message of the advertisement was very unclear.
(3) The words in the advertisement were ambiguous.
(4) The information in the advertisement was difficult to process.
(5) I used a lot of effort to understand the message of the advertisement.
(6) It took me a long time to understand the message of the advertisement.
(7) There were a lot of words in the advertisement.

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