A Quiet Disquiet: Anxiety and Risk Avoidance due to Nonconscious Auditory Priming

MICHAEL L. LOWE
KATHERINE E. LOVELAND
ARADHNA KRISHNA

Hearing is our highly sensitive warning system. As a sense, hearing has uniquely evolved to perform this alerting function and is perceptive to subtle ambient cues that are associated with threat. We propose that one aspect of sound that may cue such associations is pitch, such that low-pitch (vs. moderate pitch) background sound nonconsciously primes a threat response resulting in heightened anxiety among consumers. Furthermore, this emotional response manifests itself in the form of increased risk avoidance. Seven studies in varied domains demonstrate that low- (vs. moderate-) pitch background sound results in higher anxiety, which leads to risk-avoidant consumer choices—for instance, being willing to pay more for car insurance or choosing a food option with lower taste uncertainty.

Keywords: nonconscious priming, sensory marketing, atmospherics, advertising, sound, risk

Safety is something that happens between your ears. . ..
—Jeff Cooper

Consumers are endlessly exposed to a complex and multilayered soundscape. We hear the sounds of spokesperson and salesperson voices, in-store background music, product sounds, and jingles. We more commonly hear a multitude of everyday sounds like crowd noise, footsteps, doors opening and closing, shopping carts rattling, traffic noise, machinery, electronics, appliances, and much more. But despite, or perhaps because of, the fact that we experience a rich soundscape virtually every moment of our lives, we pay very little attention to much of what we hear. In fact, in general parlance we use the term "background noise" to describe factors that are irrelevant and undeserving of attention. Consequently, ambient environmental sounds in general are unlikely to be given much attention, if noticed at all, and subtle differences in these sounds will be noticed even less.

Interestingly, environmental cues we never consciously notice can still impact us in meaningful ways. For instance, visual exposure to brand names, brand logos, or even faces that consumers can see if they are made aware of them, but do not notice otherwise, can still influence consumer evaluations, behaviors, and choices (Chartrand et al. 2008; Fitzsimons, Chartrand, and Fitzsimons 2008; Winkielman, Berridge, and Wilbarger 2005). That is, visual stimuli can act outside of conscious awareness, impacting consumer behavior as "nonconscious signals." Additionally, we may casually notice an environmental cue, but still respond to it nonconsciously. For instance, we may be aware of a certain smell (e.g., disgusting odor), but not be aware that it is impacting our responses (e.g., moral judgment; Schnall,

Michael L. Lowe (michael.lowe@scheller.gatech.edu) is an assistant professor of marketing in the Scheller College of Business at Georgia Institute of Technology. Katherine E. Loveland (lovelandk@xavier.edu) is an assistant professor of marketing at the Williams College of Business at Xavier University. Aradhna Krishna (aradhna@umich.edu) is the Dwight F. Benton Professor of Marketing in the Ross School of Business at the University of Michigan. Please address correspondence to Michael L. Lowe. Supplementary materials are included in the web appendix accompanying the online version of this article.

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Haidt, and Clore 2008). Such olfactory and other stimuli can thus evoke a "nonconscious response."

Similarly, we suggest that ambient or background sounds, which we define as any and all sounds in an environment that are not part of the focal experience, can inadvertently influence consumer behavior at a nonconscious level through both nonconscious signals and nonconscious response.

We focus on how the pitch of background sounds in consumer environments can nonconsciously influence emotional states and then impact consumer choice. Specifically, we propose and demonstrate that simple differences in pitch in common background sounds can automatically prime anxiety as a threat response in consumers at a nonconscious level, and that the anxiety provoked by low pitches can increase risk avoidance among consumers. To the best of our knowledge, this research represents the first work to explicitly test for the nonconscious effects of sound on consumer behavior.

Besides adding to research on nonconscious effects, we also contribute to the sensory research on the effects of sound. While much of the work exploring the effects of sound on consumer behavior has focused on elements of marketing media such as music (Lantos and Craton 2012; Zhu and Meyers-Levy 2005) or voice (Chattopadhyay et al. 2003; Krishna 2012), research involving background sound, which represents the vast majority of sound, is relatively sparse (see a notable exception by Mehta, Zhu, and Cheema 2012). We add to this emergent research. Finally, we also contribute to the research on the effects of emotions, specifically anxiety, on risk taking (Raghunathan and Pham 1999; Raghunathan, Pham, and Corfman 2006) by focusing on the nonconscious nature of these effects.

We begin by developing our theoretical framework. After the theoretical framework, we present seven studies that examine the linkages between the pitch of background sound, anxiety, and increased risk avoidance. We conclude with a discussion of the implications of our research and potential directions for future research.

THEORETICAL FRAMEWORK

We discuss nonconscious priming, continue with literature specifically related to sound as a nonconscious prime, and then narrow down further to low-pitch sound as a nonconscious prime for threat. After that, we elaborate on prior research related to threat response and the reduction of perceived threat.

Nonconscious Priming

Sound is constant, yet may be consistently ignored. An ever-growing body of research demonstrates that even unnoticed stimuli can induce a spectrum of emotional and behavioral responses without our conscious awareness. The term "nonconscious priming" refers to the process through which exposure to stimuli implicitly influences an ensuing behavior or response to subsequent stimuli (Bargh 2006; Srull and Wyer 1979). These automatic priming effects can involve the priming of emotions and other concepts (Brasel and Gips 2011; Zemack-Rugar, Bettman, and Fitzsimons 2007) or the nonconscious activation of goal pursuit (Bargh et al. 2001; Fitzsimons et al. 2008), and have been tied to a variety of behaviors. For example, participants nonconsciously primed with memory goal-related words (e.g., "retain," "remember") in a sentence-unscrambling task performed better on a subsequent free-recall task (Chartrand and Bargh 1996). In other work, nonconscious exposure to words associated with guilt resulted in lower subsequent indulgence (Zemack-Rugar et al. 2007).

Nonconscious Signals and Nonconscious Responses. Such nonconscious priming can involve either nonconscious signals (i.e., nonconscious perception), meaning that stimuli is perceived outside of conscious awareness and is thus nonreportable (Chartrand et al. 2008; Fitzsimons et al. 2008), or nonconscious response, meaning that individuals are consciously aware of the stimuli but not of their influence or effect (Schnall et al. 2008).

Nonconscious signals can include what is commonly referred to as "seeing but not noticing" or "hearing but not listening." Thus, nonconscious signals are not below the threshold of human perception—consumers can hear (or see, smell, and feel) these signals *if* they are made aware of them, but do not notice them otherwise.

An illustrative case for nonconscious responses is provided by Brasel and Gips (2011), who found that players assigned to the Red Bull–sponsored car in a driving game drove more aggressively (faster speeds and more crashes), but in follow-up questions were unable to identify a change in their behavior or factors that could have produced a change. Another example is provided by Holland, Hendricks, and Aarts's (2005) research where they found that the scent of cleaning products made accessible the concept of cleanliness and increased tidying behaviors, but follow-up questions demonstrated that participants were not aware of this influence.

Nonconscious priming typically begins with a physical stimulus in some sensory modality, and much of the research in this area relies on visual primes (and some on olfactory primes as illustrated above). There is also some research concerning other modalities; for example, Lee and Schwartz (2010) find that physical movements or bodily positions (proprioception) can prime behaviors, goals, or mind-sets. We assert that sound is particularly well suited to act as a nonconscious prime, although it has been largely overlooked as such.

Sound as a Nonconscious Prime. Given their evolutionary origins, nonconscious processes should be more responsive to stimuli potentially playing some role in survival. The need for physical safety, or the ability to detect and avoid threat, represents a very basic and potent human motivation (Maslow 1943). Thus, our senses have become adept at monitoring environments for even the subtlest signs of threat (Plutchik 2001). A theme in research on the subject of fear suggests that well-established systems in the brain (particularly the amygdala) can respond to potentially threatening stimuli before or even without conscious awareness (LeDoux 1998; Öhman 2005). For example, masked images of potential threats such as spiders or snakes can activate threat responses in individuals, even without conscious awareness (Öhman 2005).

Hearing is quite naturally adapted to play a role in threat detection. Hearing cannot be turned off, is omnidirectional, and has considerable reach. We hear sounds arriving from all directions and over significant distances, even through and around physical barriers, all with little or no deliberate effort (Horowitz 2012). Compared to sound, sight is limited in scope, requires adequate illumination, and can be easily obstructed. Indeed, hearing has shown a tendency to act as an early warning system since it can imperatively capture attention and elicit defensive responses (Scott and Gray 2008; Stanton and Edworthy 1999).

Obviously, sounds explicitly associated with very specific dangers (a roaring lion, gunshots, a crashing car, etc.), with semantic meaning (verbal threats or information regarding threats), or with the element of surprise (loud bangs that cause one to startle or jump in alarm) are likely to elicit threat responses in a more direct, conscious manner. However, a basic descriptive dimension of all sounds—pitch—might also prime a threat response without conscious attention due to its natural association with various constructs and concepts.

Low Pitch as a Signal of Threat. Two key components of sound waves are *wavelength*, often referred to as frequency, which determines the pitch that people perceive (measured in Hertz [Hz]); and *wave height*, often referred to as amplitude, which determines the loudness that people perceive (measured in decibels [dB]). At sufficient amplitude, humans, in general, can detect frequencies between 20 Hz and 20 kHz (Rossing 2007) and will use pitch to infer and predict important information about the sound source itself (Kumar et al. 2011). Within this audible range, and controlling for other aspects of sound, relatively low pitch is consistently associated with several potentially threatening constructs.

To begin, lower pitch is naturally associated with larger physical size (Bien et al. 2012; Spence 2011). Generally speaking, larger objects, both animate and inanimate, produce longer, slower sound waves, and smaller objects produce shorter, faster sound waves. Longer sound waves arrive more slowly and are perceived as lower-pitch sounds; shorter sound waves arrive more quickly and are perceived as higher-pitch sounds (Plack and Oxenham 2005). Thus, a substantial body of research supports an automatic sensory association, a conceptual metaphoric relationship (Krishna and Schwarz 2014; Williams and Bargh 2008), between the pitch of a sound and the size of the object producing the sound (Bien et al. 2012; Walker and Smith 1985).

Indeed, the association between pitch and size is so strong that it has even been demonstrated among preschoolers (Mondloch and Maurer 2004) and occurs at an automatic, perceptual level among adults (Gallace and Spence 2006). All else equal, a larger physical sound source instinctively represents a greater potential threat than a smaller sound source.

Beyond this pitch–size correspondence, and perhaps because of it, work on human vocalizations shows that low pitch tends to be associated with dominance and assertiveness across languages and cultures (for a review, see Ohala 1983). People are more likely to vote for politicians with low-pitch voices because they are perceived as stronger (Tigue et al. 2012). Low pitch is also associated with darkness (Hubbard 1996; Melara 1989) and negative affect (Hevner 1937; Rigg 1940). Pitch is mapped onto emotional expression as well. Anger is typically expressed in low-pitch vocalizations (Mozziconacci 1995; Sobin and Alpert 1999), while fear (a *response* to threat) is typically expressed in high-pitch vocalizations (Mozziconacci 1995; Sobin and Alpert 1999). This is reflected in musicology, as low-pitch musical passages are felt to symbolize threat, while higher-pitch passages communicate submissiveness (Huron, Kinney, and Precoda 2006). The association between low pitch and threat is in fact so natural that it has been observed in the animal kingdom as well, with green frogs lowering the pitch of their vocalizations in order to threaten competitors (Bee, Perrill, and Owen 2000).

Recent work by Ko, Sadler, and Galinsky (2015) did find that higher-pitch vocalizations are associated with higher social rank; however, they explicitly note that past work has clearly suggested that low pitch is associated with physical dominance and they specifically control for the effect of physical dominance in their experiments.

Thus, humans have many instinctive associations between low pitch and concepts potentially associated with threat (size, anger, etc.; see web appendix 1 for a summary), and they are also sensitive to nonconscious primes evoking fear (Larsen et al. 2011; Windmann and Krüger 1998). That is, as humans have learned to associate low pitch with large size, dominance, darkness, and anger, this association has become a grounded conceptual metaphor that has the potential to signal an environmental threat (Krishna and Schwarz 2014; Lakoff and Johnson 1999). Thus, we predict that low pitch, even in commonplace background sounds, will produce an automatic threat response marked by increased anxiety and increased risk avoidance.

Threat Response

Perceived environmental threats trigger both emotional and behavioral responses—defensive behaviors—which function to increase the possibility of survival when one is faced with a threat (Blanchard and Blanchard 2008). At a neurological level, a potential environmental threat activates the amygdala (LeDoux 1998), resulting in heightened emotional anxiety and behavioral vigilance (Blanchard et al. 2011). Work in psychology further supports the idea that anxiety is an evolved response to situations that are perceived as threatening, uncertain, and unpredictable (Kugler, Connolly, and Ordóñez 2012; Lerner and Keltner 2001). Anxiety has also been described as "a state of undirected arousal following the perception of threat" (Epstein 1972, 311). Anxiety and threat perception are thus closely linked.

Furthermore, because of their importance in motivating behavioral responses, emotional responses to environmental stimuli may occur at nonconscious, preattentive levels, before the sound source, or even the sound itself, becomes salient (Plutchik 2001). "Risk avoidance" reflects the degree to which a consumer's decisions and behaviors willfully try to avoid risk, and a higher threat response also involves increased risk avoidance (Kugler et al. 2012; Raghunathan and Pham 1999; Raghunathan et al. 2006). Together, this suggests that even when individuals are unaware of, or inattentive to, an environmental threat, a threat response in the form of heightened anxiety and resultant risk-avoidant behavior can occur.

As with other nonconscious primes, threat response to low-pitch background sound should hold both under conditions of nonconscious signal (I didn't even notice the sound) and nonconscious response (I didn't even realize the sound was affecting me that way; Bargh 2002).

Reduction of Perceived Threat

Based on the preceding discussion, we expect low-pitch background sounds, whether consciously noticed or not, to automatically elicit a nonconscious threat response, unless the sound source is explicitly decoupled from threat. Thus, low-pitch, compared to moderate-pitch, background sound should increase risk avoidance when the sound is not consciously noticed (nonconscious signal). Even if the sound is noticed, low (vs. moderate) pitch should increase risk avoidance if the source of the sound is ambiguous (nonconscious response); however, this response to low pitch should not hold when the sound source is clearly understood to be benign. That is, in the latter nonconscious response situation, we expect that sound source information will moderate the effects of pitch on risk avoidance, such that when the source of the background sound is ambiguous, low-pitch sounds will lead to increased risk avoidance via heightened anxiety; however, when the source of the background sound is considered benign, a low-pitch sound will not impact anxiety (or risk avoidance; see figure 1a and 1b). (Note that when a signal is nonconscious, response to that signal is also nonconscious.)

OVERVIEW OF STUDIES

In all our studies, we compare low- and moderate-pitch sounds, rather than extremely high-pitch sounds, because our interests lie in nonconscious priming effects; high-pitch sounds are much less likely to avoid conscious attention (Suzuki and Takeshima 2004). Note that by using moderate-pitch (rather than high-pitch) sounds, we present a strong test of our hypotheses. Note also that in all our studies participants hear only one version of the stimuli: low pitch or moderate pitch. Importantly, participants in a pretest could not detect the difference between the low-pitch and moderate-pitch sounds, even after hearing both sounds in rapid succession (details follow in the next section).

Studies 1 and 4a focus on nonconscious signals, while studies 3, 4b, and 5 focus on nonconscious responses. That is, in studies 1 and 4a, participants are not consciously aware of the sound. In studies 3, 4b, and 5, participants are consciously aware of sound, but cannot distinguish between low pitch and moderate pitch; hence, any difference in response to these two pitches is nonconscious in nature (i.e., it's a nonconscious response to pitch). Studies 2 and 6 focus on both nonconscious signals and nonconscious responses (see appendix 1 for a summary of the studies).

NONCONSCIOUS PRIMING OF SOUND—STIMULI DEVELOPMENT AND TESTING

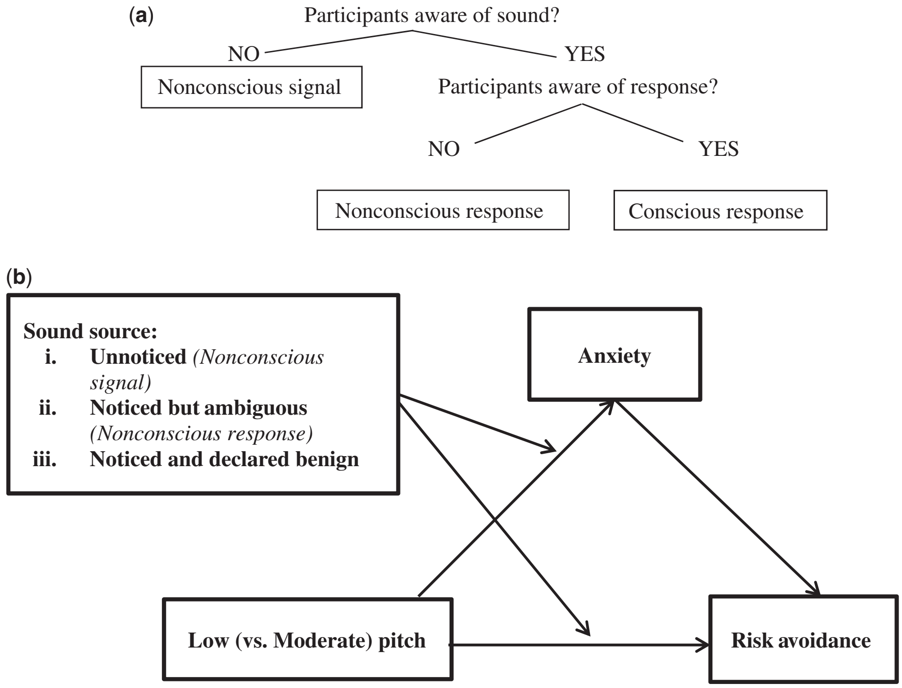
We pretested the stimuli for all studies to ensure that any effect observed could be attributed to nonconscious processing of pitch. A review of the literature suggests that among humans sounds below 250 Hz are generally considered low pitch and sounds above 1,000 Hz are generally considered high pitch (see web appendix 1).

For studies involving nonconscious signals (studies 1, 2, 4a, and 6), we developed sounds that could not be discerned until they were explicitly described and brought to listeners' attention. These sounds were developed and tested by two trained audio engineers and further tested by eight research assistants (links to all the audio clips used can be found in appendix 2).

For studies involving nonconscious response (studies 3, 4b, and 5), we conducted an extremely stringent post-test ($N = 50$) wherein participants listened to both the moderate- and low-pitch versions of the stimuli, back to back, and actively sought differences. Even under these circumstances, where participants heard both versions of the stimuli one after another and looked for differences, 70% of participants could not discern any difference at all between the moderate- and low-pitch versions of the stimuli used in

FIGURE 1

NONCONSCIOUS EFFECT OF LOW-PITCH BACKGROUND SOUND, (A) NONCONSCIOUS SIGNAL AND NONCONSCIOUS RESPONSE, (B) LOW PITCH AS NONCONSCIOUS SIGNAL AND NONCONSCIOUS RESPONSE



study 3, while 72% could discern no difference in the stimuli used for studies 4b and 5. The remaining participants guessed at differences that had nothing to do with pitch and were simply incorrect (volume, spokesperson voice, performance, etc.). Even when asked directly for differences, no participant discerned pitch or anything approximating pitch as differing between conditions.

The lack of perceived difference between low and moderate pitch is especially pertinent for studies on nonconscious response. With these post-tests, any conscious awareness or processing of pitch was effectively ruled out as an explanation for any observed differences between responses to low and moderate pitch sounds; that is, the response to low pitch (vs. moderate pitch) was nonconscious (for full details of the stimuli testing, see appendix 3).

To reiterate, for unnoticed sound source (nonconscious signal) in figure 1b—(i) in the figure—sound was kept so low in volume as to be unnoticed unless attention was brought to it. For noticed but ambiguous sound source (nonconscious response) in figure 1b—(ii) in the figure—participants could not consciously detect differences between the low- and moderate-pitch sounds; hence, any differences in response to the sound could not be attributed to a conscious response to the sound.

Next, we present our studies.

STUDY 1: NONCONSCIOUS EFFECTS OF SOUND ON FINANCIAL RISK TAKING

Study 1 tests our basic hypothesis that nonconscious perception of low-pitch background sounds results in a threat response in the form of increased risk avoidance. In this study we manipulate background sound using hidden speakers that played sine waves that could not be consciously heard by participants, and thus produced a nonconscious signal. We assess risk avoidance using a financial decision-making task.

Design

The study had a three-cell, one-way design: low pitch, moderate pitch, or no added background sounds. Two hundred twenty-nine undergraduate students at a southwestern US university participated in the study in exchange for course credit.

Method

Participants sat at individual computer stations with privacy partitions in an on-campus behavioral lab. When participants entered the room, speakers in the ceiling were already playing a relatively low-pitch sound (80 Hz), a moderate-pitch (720 Hz) sound, or no sound at all. We randomly varied these three conditions across lab sessions.

Sound Conditions. The two selected frequencies represent slightly more than a three-octave difference in pitch while both sitting comfortably in the range of pitch that humans can hear (approximately an E2 and an F#5 on a piano). But, while pitch was comfortably within human auditory range, volume was not. Volumes were set to be perceptively equal to one another according to equal-loudness contours (Suzuki and Takeshima 2004), but were kept at such low intensities as to be imperceptible to three study assistants until attention was explicitly drawn to the sound in pretests (i.e., the sound was unnoticed). No participants in any session appeared to notice, or mentioned noticing, any sound.

Once seated, all participants completed a computer-based survey consisting of a series of 50 dichotomous financial choices. For each choice, participants simply indicated their preference between two hypothetical options: a smaller, certain cash payoff or an unguaranteed chance to get a larger payoff (Griskevicius et al. 2011). The first 25 choices featured decisions between guaranteed payoffs ranging from $20 to $550, in ascending order, versus a 20% chance at winning $1,000. The second 25 choices featured certain payoffs between $970 and $370, in descending order, versus an 85% chance of winning $1,000. The two sets of 25 choices appeared on different screens. Participants then provided their gender and the study concluded. Gender did not affect the results in any study (*ps* $>$ .25) and will not be discussed further.

Results

The primary dependent variable was the sum total of financial "risks" (gambles) that each participant preferred relative to the smaller certain payoff ($M = 14.1$, $SD = 6.56$). An ANOVA with all three conditions was significant ($F(2, 227) = 4.68$, $p = .010$, $\eta^2 = .040$), such that participants in the low-pitch condition took fewer risks ($M_{LowPitch} = –11.5$) than those in both the moderate-pitch ($M_{ModeratePitch} = 14.3$) and no additional sound conditions ($M_{NoSound} = 14.5$). Planned contrasts show that the difference in the number of risks taken was significant between the low-pitch and the moderate-pitch conditions (95% CI = –6.19 to –.69, $t = –2.95$; $p = .003$, $\eta^2 = .037$) and between the low-pitch and no-additional-sound conditions (95% CI = –5.85 to –.25, $t = –2.57$; $p = .011$, $\eta^2 = .028$). However, there was no such difference between the moderate-pitch and no-additional-sound conditions (95% CI = –1.86 to 2.64, $t = .406$; $p = .69$, $\eta^2 = .001$), suggesting that low pitch was key to producing these effects, not the mere presence or absence of sound alone (see figure 2). We also analyzed the data using only the number of economically irrational choices made (when the guaranteed payout provides less economic value than the offered gamble) as our dependent variable and found a similar pattern of results (see web appendix 2).

Discussion

Study 1 provides initial support for our central prediction that low-pitch background sound increases risk-aversive behavior among consumers. In addition, a no-additional-sound condition supports the idea that the effect is driven by the low-pitch sound increasing risk avoidance, rather than the presence of *any* unexplained sound (e.g., moderate pitch) increasing risk avoidance, or a moderately pitched sound decreasing risk avoidance.

It is important to note that for study 1 our results occur via a nonconscious signal; the volume of the sound was kept intentionally unobtrusive and participants did not comment on, or in any way indicate, noticing the presence of the background sound.

STUDY 2: BALLOON ANALOG RISK TASK

Study 1 demonstrated the effects of low pitch on risk aversion in response to a nonconscious signal. In study 2, we test if this effect replicates, and also test for a boundary condition where we explicitly remove any threat that might be associated with the sound source. Study 2 also uses a more established measure of risk taking: the balloon analogue risk task (BART) developed by Lejuez and colleagues (2002) and described below.

Design

Study 2 employed a 2 (background sound: low pitch vs. moderate pitch) × 2 (sound source: unnoticed vs. benign) between-subjects design. A total of 172 undergraduate students in a southern US university participated in the study in exchange for course credit.

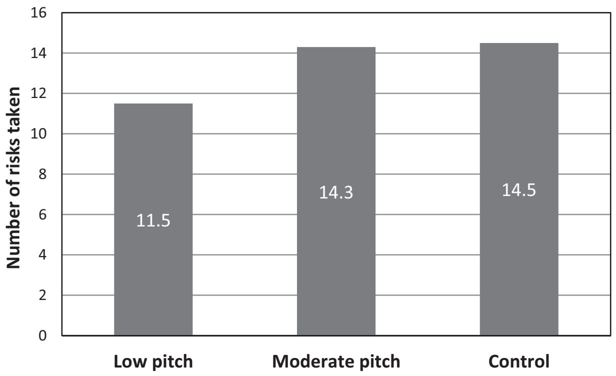
Method

A speaker system and subwoofer were hidden out of view in a corner of the laboratory. Before participants entered the lab, a lab administrator started playing either a 60 Hz (low pitch) or 720 Hz (moderate pitch) sine wave from the speakers. We adjusted the volume to control for the equal-loudness principle (Suzuki and Takeshima 2004), and volume was checked by four independent judges who agreed that no difference in volume could be perceived. The sine wave continued to play throughout the lab session and was alternated by session.

After participants entered the lab, the lab administrator gave an introduction to the lab, including rules and

FIGURE 2

STUDY 1: NUMBER OF RISKS TAKEN BY BACKGROUND SOUND CONDITION



instructions for participants. However, in the benign conditions, the lab administrator paused briefly during instructions and said, "I apologize. We're getting some strange sounds from the air conditioning today. I'm not sure if you hear it," while motioning to a visible air conditioning vent in the same corner of the room as the hidden sound system. In the unnoticed conditions, the lab administrator made no comment at all about any sound, and simply gave instructions as usual. After receiving instructions, participants participated in an unrelated study for approximately two to three minutes before proceeding to the focal task.

The focal task for this study was the balloon analogue risk task (BART) developed by Lejuez and colleagues (2002). In this task, participants play a *Press Your Luck*–style computer-based game wherein they receive a payment ($ .05) each time they pump air into a balloon. However, if the balloon ruptures before the participant releases it, all the money for that particular balloon is lost. Whether the balloon pops or not is determined randomly each time the participant has the opportunity to pump air. Because the only way to earn money is to pump air, but the only way to keep the money is to bank it (by releasing the current balloon and starting a new one), more risk-averse individuals tend to bank their money (i.e., release their balloons) after fewer pumps, resulting not only in fewer popped balloons but also in earning less money per balloon compared to more risk-seeking participants. The number of balloons popped ($M = 2.1$, SD = .816) is typically used as a measure of risk aversion, with more risk-averse individuals popping fewer balloons than their risk-seeking counterparts (Cornil, Chandon, and Krishna 2017). All participants inflated three separate balloons (keeping only money earned for balloons that they released before they popped). After completing these three trials, participants provided their gender and the study concluded.

Results

Only one participant was a clear statistical outlier in terms of amount saved (+ 3 SD above the mean). We removed this one observation for a final N of 171.

Balloons Popped. There was a marginally significant interaction between pitch and sound source on the number of balloons popped ($F(1, 170) = 2.81$, $p = .096$, $\eta^2 = .017$). Planned contrasts revealed that when no information about the sound was provided (unnoticed conditions), the pattern of results is consistent with our findings from study 1. Specifically, participants in the unnoticed conditions were more cautious (risk averse) and therefore popped fewer balloons in the low-pitch condition ($M_{\text{LowPitch}} = .96$) compared to the moderate-pitch condition ($M_{\text{ModeratePitch}} = 1.40$; $F(1, 167) = 7.11$, $p = .008$, $\eta^2 = .041$). In contrast to this, in the benign conditions there was no such difference between the low-pitch ($M_{\text{LowPitch}} = 1.00$) and moderate-pitch ($M_{\text{ModeratePitch}} = 1.03$) conditions $F(1, 167) = .019$, $p = .890$, $\eta^2 = .000$). We also analyzed the average amount of money earned per nonruptured balloon and found a similar pattern of results. These analyses can be found in web appendix 3.

Discussion

First, in the unnoticed conditions we replicated our results from study 1: when no information about the sound is provided, low pitch, compared to moderate pitch, results in more risk-averse behavior as measured by the number of balloons popped in the BART task.

More importantly, study 2 also provides initial evidence in support of our theorizing that risk aversion in response to low-pitch background sound is due to a nonconscious threat response. If our effect is due to a threat response, then removing any potential threat associated with the sound should attenuate the effect of pitch on risk aversion. In accordance with this prediction, when we attributed the sound to a benign source, an air-conditioning unit, the pitch of the background sound no longer had a significant impact on risk aversion (as measured by the number of balloons popped). In other words, when the sound clearly did not present a threat, it ceased to cause risk aversion, even when it was low pitch.

While these results support our theorizing that low-pitch background sounds trigger a threat response, the design of study 2 also presents a potential confound. In the unnoticed condition, where there is no information about the sound, participants are unaware of the sound, and sound is a nonconscious signal. However, we cannot keep sound as a nonconscious signal, and also inform participants that the sound is benign. Hence, in the benign condition, awareness of the sound and knowledge that the sound source is benign are confounded; thus, it is not entirely clear whether the attenuated difference between low- and moderate-pitch sounds in the benign (vs. unnoticed) conditions is being driven by (i) the participants becoming consciously aware of the sound, or (ii) by the removal of a potential threat. Study 3 addresses this issue by removing this confound and making participants aware of the sound in all conditions.

STUDY 3: RISK REDUCING PRODUCT

Study 1 and study 2 (unnoticed conditions) examined the effect of pitch on risk avoidance when sound is received as a nonconscious signal. In study 3, we test if low-pitch sounds can evoke nonconscious risk avoidance in response to consciously heard sounds (nonconscious response), and if this effect is attenuated when the sound source is considered benign. If we obtain the nonconscious response effect of low pitch on risk aversion, and also its attenuation in the benign condition, it implies that the attenuation is driven not by (i) drawing participants' attention to the sound, but by (ii) removing a nonconscious threat.

In addition to providing clarity to the results from study 2, study 3 is also designed to further test our boundary condition by using a less direct method to signal that the sound source is benign: reminding participants that what they are listening to is just an advertisement. Finally, by testing our effect in the context of an advertisement, we are able to demonstrate the marketing implications of our effect.

Design

Study 3 employed a 2 (background sound: low pitch vs. moderate pitch) $\times$ 2 (sound source: ambiguous vs. benign) between-subjects design. A total of 175 undergraduate students in a southern US university participated in the study in exchange for course credit.

Method

To begin, all participants read an introduction explaining that they would be listening to and evaluating an advertisement for an insurance company. After the introduction, but prior to hearing the advertisement, half of the participants (sound-source-benign conditions) also read the following:

> *Remember! Advertisers will manipulate even the slightest details of an ad, including sounds, to try to make you feel a certain way, or to make their product seem more important or desirable. For instance, ads for insurance may be constructed to make you feel anxious. Be sure to keep this in mind as you listen and don't fall for it!*

Participants then put on noise-canceling headphones and listened to a 35 second advertisement for a company selling automotive insurance. In the advertisement, they heard a male spokesperson, and also heard an audio track of traffic noise in the background; this noise was recorded at an actual intersection and is easily audible in both versions of the ad. While in the moderate-pitch conditions the traffic sound was left as originally recorded, in the low-pitch conditions, the background traffic sound was dropped by 20 audio cents (cents are a measure of musical interval or pitch; 100 cents = 1 half-step on a piano keyboard). In all other ways, the two advertisements were identical. The full transcript of the advertisement is available in appendix 2, and audio files of both versions of the advertisement are available in appendix 2.

After hearing the advertisement, participants were given the average monthly insurance payment in their state as a reference point ($83). Then, they indicated how much they would be willing to pay for insurance (that they knew was excellent), on a slider scale with a minimum of $0 and a maximum of $200. We did not ask about willingness to pay for the advertised brand specifically, since we expected a strong negative main effect on brand perceptions among those in the benign condition who had been reminded that advertisements are often designed to manipulate emotions. Finally, participants answered questions regarding their car ownership, current insurance payments, accident history, whether they'd had any problems hearing the ad, the volume at which they'd listened to the ad, and demographic information. Of these measures, only car ownership affected the results and will be discussed subsequently.

Results

Of the 175 participants, one individual was unable to hear the audio, three individuals spent less than 30 seconds completing all the survey measures, and eight individuals were outliers who either left the willingness-to-pay scale untouched or slid it all the way to the other extreme ($0 or $200, 3+ SD from mean). We removed these 12 observations from analysis for a final N of 163.

An ANOVA using sound source and pitch conditions to predict willingness to pay (M = \$91.17, SD = \$25.23) returned a significant interaction ($F(1, 162) = 5.35$, $p = .022$, $\eta^2 = .033$). In the ambiguous conditions, participants indicated a greater willingness to pay in the low-pitch condition (M_{LowPitch} = \$98.98) than in the moderate-pitch condition ($M_{\text{ModeratePitch}}$ = \$88.63, $F(1, 159) = 3.42$ $p = .066$, $\eta^2 = .021$), replicating our previous results. In the benign condition, the effect was attenuated (M_{LowPitch} = \$82.97, $M_{\text{ModeratePitch}}$ = \$91.00, $F(1, 159) = 2.03$, $p = .16$, $\eta^2 = .013$).

Because a large portion of our respondents did not own cars, and therefore are nonconsumers of the advertised product category, car insurance, we also ran our analysis with only car-owning participants ($N = 116$). An ANOVA using sound source and pitch conditions to predict willingness to pay again returned a significant interaction (F(1,

115) = 4.52, p = .036, η^2 = .039). In the ambiguous conditions, consistent with prior results, participants indicated a greater willingness to pay in the low-pitch condition (M_{LowPitch} = \$103.29) compared to the moderate-pitch condition ($M_{\text{ModeratePitch}}$ = \$88.58, F(1, 112) = 4.87 p = .029, η^2 = .042). However, in the benign condition, there was again no significant effect of pitch on willingness to pay (M_{LowPitch} = \$85.83, $M_{\text{ModeratePitch}}$ = \$91.48, F(1, 112) = .675 p = .41, η^2 = .006).

Discussion

In study 3, participants were aware of the sound in all conditions, and we examined nonconscious response to pitch. The study demonstrates that low pitch in a consciously perceived background sound (background sound in an advertisement) also induces risk-avoidant behavior. Results from study 3 indicate that the attenuation of the effect observed in the benign condition in study 2 was not due to drawing participants' attention to the sound, but rather to removing the threat associated with the sound. Specifically, providing individuals with an understanding that the sound source is benign (i.e., "it's just marketing") attentuates individuals' threat response as manifested in their behavior (risk avoidance). This pattern of results provides support to our theorizing that the risk aversion observed in response to a low-pitch background sound is being driven by a threat response.

By testing our effect in the context of an advertisement, we are able to more clearly demonstrate the marketing implications of the effects of pitch on decision-making. Here we demonstrate that lowering the pitch of background sounds in an advertisement for a risk-reducing product, car insurance, increases the willingness to pay for a premium version of that product.

STUDIES 4A AND 4B: THE ROLE OF ANXIETY

We have proposed that low-pitch background sound elicits an automatic threat response that is manifested as an increase in feelings of anxiety, which then generate risk-avoidant behavior (Raghunathan and Pham 1999; Raghunathan et al 2006). Studies 1–3 demonstrate that low-pitch, compared to moderate-pitch, background sounds cause increased risk aversion, and the moderating effect of ascribing the sound to a benign source observed in studies 2 and 3 provides initial evidence that this effect is driven by a threat response. Studies 4a and 4b are designed to provide more direct evidence of the underlying process.

Similar to studies 1 and 2, study 4a employs a sine wave manipulation that is not consciously perceived. We can thus test whether sounds that send a nonconscious signal can elicit an emotionally anxious response. Because participants are not consciously aware of the sound manipulation, we do not expect them to be consciously aware of their emotional reaction. However, we do expect that the feelings of anxiety elicited by the low-pitch background sound will render thoughts related to anxiety more accessible, consistent with the subjective experience of emotions (Bower 1981; De Houwer et al. 2002). In line with this reasoning, study 4a employs an implicit word task (DeMarree, Wheeler, and Petty 2005) to measure anxiety.

Study 4b also employs an implicit task to measure anxiety (specifically, a word search). However, study 4b also moderates the sound source, which allows us to answer an important question raised by studies 2 and 3: at what point does information about the sound source moderate the effect of pitch on risk avoidance: (a) does it attenuate the anxious, emotional response to low-pitch background sounds, or (b) does it simply allow for a more controlled behavioral response even though anxiety has been aroused?

Study 4a: Anxiety and Word Recognition—Does Low Pitch Induce Anxiety?

Design. Study 4a used a two-cell one-way design (low-pitch sound vs. no additional sound) with 130 undergraduate students at a southern US university. The two sound conditions can also be interpreted as the presence or absence of a low-pitch sound. Recall that in study 1 there was no significant difference in risk aversion between the moderate-pitch sound and no-sound conditions.

Method. Students participated in the study in exchange for course credit. This study took place in a behavioral lab with privacy partitions. Participants sat at individual computer stations and read that they would be participating in a study regarding perception and word identification. Participants read that the task would involve recognizing and identifying words that flashed very briefly on their computer screens. Written instructions explained that while the word would appear too quickly to be consciously read, it would be registered subconsciously. Thus, participants should rely on their gut feeling when subsequently identifying the word they felt they had seen from a list of answer choices. Unknown to participants, the "words" flashed on the screen actually consisted of nonsense strings of letters (e.g., FMLPEQZ), shown for a duration of only 17 milliseconds, rendering them impossible to read.

To begin each trial, the computer screen displayed a row of asterisks for 2,000 milliseconds, orienting participants to where the "word" would be displayed. The string of letters was then displayed for 17 milliseconds followed by a masking string of Xs for 75 milliseconds. After each "word" was displayed, participants selected the word they felt they had seen from among a list of four options, each starting with the same initial letter as the letter string that had been displayed. This task is based on the implicit word task developed by DeMarree et al. (2005) and has also been used in the consumer behavior literature to assess thought accessibility and goal activation (Loveland et al. 2010).

Out of 17 trials, seven included one anxiety-related word (anxious, worried, nervous, uneasy, tense, fearful, apprehensive) on the list of possible responses. The dependent variable was simply how many of these anxiety-related words participants selected overall ($M = 2.04$, $SD = 1.21$). After completing the 17 trials, participants provided demographic information, and responded to an open-ended suspicion probe specifically asking if they'd noticed anything unusual about the lab that day. No participants made any mention of a sound in the room. Similar to studies 1 and 2, there was a low-pitch sine wave sound (80 Hz) playing in the room through speakers in the ceiling at a very low volume during half of the lab sessions; no background sound was played during the other sessions.

Results. When there was a low-pitch sound present in the room, participants selected significantly more anxiety-related words ($M_{LowPitch} = 2.35$, $M_{Control} = 1.77$, $F(1, 129) = 7.77$, $p = .006$, $\eta^2 = .057$) from the seven trials possible. In other words, when a low-pitch background sound was present (vs. not), the concept of anxiety was more accessible or salient for participants.

Study 4b: Anxiety and Word Search—Is a Threat Response Allayed before or after Anxiety Is Evoked?

In this study, we manipulate both the pitch of the sound (low vs. moderate) and the sound source (ambiguous or benign—manipulated here as coming from a stranger or a friend). Note that in this study, sound can be consciously perceived in all conditions (as in study 3); additionally, we explicitly draw participants' attention to the sound in *all* conditions by telling them that we are interested in how background sounds influence cognitive processing. We explicitly manipulate the sound source by pairing the sound with either strangers, who pose a potential ambiguous threat, or friends, who pose no threat. We expect to observe a nonconscious response to pitch when the sound source poses an ambiguous threat, but rather than focusing on the behavioral component of threat response (risk avoidance), we focus on the emotional component (anxiety).

As in study 4a, we used an indirect measure of participants' emotional response. While listening to the stimuli, we asked them to find as many words as possible in a word-search puzzle. Unbeknownst to the participants, six of the words hidden in the letter grid were related to anxiety (see below for more details). We designed this task based on the precept that individuals can more quickly process words related to concepts for which they have been primed (Neely and Keefe 1989). Building on this idea, we hypothesized that individuals who experience a threat response will more readily process and identify words related to anxiety than those in a neutral state. This allows us to test whether low-pitch background sounds always elicit a threat response that must be cognitively overridden, in which case we will observe a main effect only for pitch, or whether information about the sound source prevents an automatic threat response altogether, in which case we will observe an interaction between pitch and sound source on the number of anxiety words found.

Design. Study 4b employed a 2 (background sound: low pitch vs. moderate pitch) × 2 (sound source: stranger—ambiguous vs. friend—benign) between-subjects design. A total of 140 participants were recruited via Amazon Mechanical Turk.

Method. Participants received $ .80 in exchange for their participation in our study. To begin, participants read that they were to be part of an experiment examining how everyday sounds affected reasoning and cognition. Participants then learned that they would have three minutes to work on a word-search puzzle that involved finding words hidden in a 15×15 block of letters. Instructions indicated that the words could be included vertically, horizontally, or diagonally, and might be found with the spelling being forward (e.g., example) or backward (elpmaxe).

Participants also read that, because researchers were interested in how everyday sounds impact reasoning and cognition, they would be listening to "an audio recording taken in a public area" through their headphones while completing the word search. The audio recording was a looped 60 second track of sounds recorded in an actual restaurant. The sounds included plate and silverware being bumped together and the general din of conversation, without any specific words being audible. Participants heard one of two versions of this recording: one that had been adjusted upward by 200 cents (moderate pitch), or one that had been adjusted downward by 200 cents (low pitch). Half of the participants imagined that the sounds they would be hearing were being generated by a group of strangers, representing an ambiguous threat; the other half imagined the sounds were being generated by friends, rendering the sounds benign.

We created the word search using an online tool and included a list of seven neutral (parliament, penny, recipe, diamond, poetry, number, and collector) and six anxiety-related (worried, fearful, anxious, uneasy, nervous, and apprehensive) words. Because of the random generation and placement of the other letters in the puzzle, participants found several other shorter words during the course of the study (e.g., sock, nun, tore, toe, arm, maid); these shorter words are accounted for in the results.

When ready, participants put on headphones, completed a sound check, and proceeded to the word-search screen. The restaurant sound played automatically and looped for three minutes while participants found as many hidden words as they could. Participants typed out each word they found. After three minutes, the page advanced automatically. Participants indicated if they'd had any problem hearing the audio and explained the nature of the problem if they had any. Participants also rated how good they were generally at word-search tasks. Then they provided their gender, and the study concluded.

Results. Of the initial 140 participants, one did not finish the study, and nine others had issues with the audio and were thus excluded. In addition, four individuals identified as experts at word searches, and all four of these individuals were sorted into the same study cell (moderate pitch/strangers) despite randomization. These four cases were thus removed for a final N of 126.

We tallied each participant's total words found, total anxiety-related words found, and the average length of words found. Participants found an average of 8.32 words total (SD = 2.60), and an average of 1.74 (SD = 1.33) anxiety-related words. The average word length was 5.62 letters (SD = 1.08), suggesting that some of the words found were shorter words produced inadvertently when the word search was created.

An ANOVA on the effects of pitch and sound source on the number of anxiety-related words showed some significant results. First, there was a marginally significant main effect of pitch, ($F(1, 125) = 3.45$, $p = .066$, $\eta^2 = .028$) such that participants in the low-pitch condition ($M_{\text{LowPitch}} = 1.94$) found more anxiety-related words than those in the moderate-pitch condition ($M_{\text{ModeratePitch}} = 1.50$). There was no such main effect for the sound source ($M_{\text{Friend}} = 1.67$, $M_{\text{Stranger}} = 1.77$; $F(1, 125) = .185$, $p = .667$, $\eta^2 = .002$). Most importantly, the interaction between these two variables was significant ($F(1, 125) = 4.87$, $p = .029$, $\eta^2 = .038$). A set of planned comparisons revealed that this interaction is driven by the ambiguous (strangers) condition. While there was no significant difference between pitch conditions in the benign condition ($M_{\text{LowPitch}} = 1.63$, $M_{\text{ModeratePitch}} = 1.71$; $F(1, 122) = .64$, $p = .801$, $\eta^2 = .001$), there was a stark difference in the ambiguous condition ($M_{\text{LowPitch}} = 2.24$, $M_{\text{ModeratePitch}} = 1.30$; $F(1, 122) = 7.86$, $p = .006$, $\eta^2 = .061$). The significant interaction and contrast suggests that removal of the threat (knowledge about the sound source being benign) attenuates the inducement of anxiety, and that it not the case that anxiety is evoked anyway and the response is adjusted later.

Discussion of Studies 4a and 4b. As in previous studies, when the sound source is unnoticed (study 1) or ambiguous (studies 2 and 3), low pitch produced evidence of an automatic threat response in participants, as measured by an increased proneness to find anxiety-related words in a word-recognition task (study 4a) and a word-search puzzle (study 4b). In other words, when a low-, compared to moderate-, pitch background sound emanates from an unnoticed (study 4a) or ambiguous source (study 4b), the concept of anxiety was more accessible or salient for participants, suggesting the low-pitch sound is perceived as threatening and consistent with the subjective experience of emotions (Bower 1981; De Houwer et al. 2002).

However, when the sound source was identified as benign (study 4b), we found that pitch did not have a measurable influence on the number of anxiety-related words found. The pattern of results in study 4b suggests that the awareness that a sound source is benign can inhibit the effect of pitch on anxiogenic threat perception—that is, low pitch does *not* evince the same anxious response when the sound source is considered benign as it does when the sound source is more ambiguous (e.g., coming from a stranger). In other words, our results provide support for one of two explanations for the attenuation of the low-pitch–risk-avoidance effect we found in studies 2 and 3. Our results suggest that the alternate explanation—that anxiety is produced under low pitch even when the sound source is considered benign, but is later reasoned away—is not supported.

These studies demonstrate that whether people are aware of a sound (study 4b) or not (study 4a), low-, compared to moderate-, pitch sounds result in heightened feelings of anxiety—unless the sound is explicitly linked to something nonthreatening (e.g., friends in study 4b).

It is also worth noting that in study 4b all participants had their attention drawn to the sound and knew that what they were hearing could impact them (since the cover story was that we were interested in how background sounds impact cognitive processing). Thus, study 4b represents a particularly strict test for our proposed process. We find that the effect of pitch on anxiety holds not only when participants can consciously hear the sound, but also when they are explicitly told that the crowd noise they are hearing could impact them.

STUDY 5: FOREIGN FOODS IN RESTAURANTS

Study 5 tests our full model (see figure 1b). While the results of studies 4a and 4b strongly suggest that anxiety mediates the effect of pitch on risk avoidance, study 5 tests this relationship directly.

Design

The study employed a 2 (background sound: low pitch vs. moderate pitch) × 2 (sound source: strangers—ambiguous vs. friends—benign) between-subjects design. A total of 150 undergraduate students in a southern US university participated in the study in exchange for course credit.

Method

The study took place in a behavioral lab at individual computer stations with privacy partitions. Participants read that the study involved evaluating an Asian restaurant in a major city. A description of the restaurant provided to all participants mentioned that the restaurant was located in a neighborhood that historically had rather high crime rates, but that the food at the restaurant was typically well reviewed. Participants viewed an exterior photo of the restaurant while listening to an audio recording ostensibly taken from inside the restaurant during dinner hours. As they listened to the recording, we asked half of the participants to imagine that they were in the restaurant by themselves, and that the sounds in the restaurant were produced by strangers (ambiguous condition). We asked the other participants to imagine that they were at the restaurant with a large group of friends, and that the sounds they heard in the restaurant were largely from friends (benign condition). The audio recordings for the low-pitch and moderate-pitch conditions were the same ones used in study 4b.

After participants had viewed the restaurant photo and heard the recording, we measured perception of anxiogenic threat by asking them to rate their level of agreement that they would feel “safe” and “protected” at the restaurant on seven-point scales anchored on “strongly agree” and “strongly disagree.” Perceived security is among the anxiety-absent measures in the State-Trait Anxiety Inventory (Spielberger 2010). After completing these measures, participants then responded to two questions intended to measure risk avoidance as it pertains to trying strange, new, or unusual foods: “How likely would you be to try anything unique or different at this particular restaurant?” and “How much do you like trying new foreign foods?” measured with seven-point scales anchored on “very unlikely” and “very likely,” and “not at all” and “very much,” respectively. As a manipulation check, participants then indicated whether they had imagined being in the restaurant alone or with friends. Finally, participants provided their gender, and responded to an open-ended suspicion probe.

Results

Of the 150 original participants, four skipped the instructions and hurried through, providing the exact same response to every question, while 10 others had technical audio problems and did not hear the background sound of the restaurant, resulting in a final N of 136.

We averaged the measures of risk taking (r = .55, $M = 4.33$, $SD = 1.57$) and included this aggregate measure in an ANOVA with the four experimental conditions. The interaction between the sound source conditions and pitch conditions was significant ($F(1, 135) = 4.87$, $p = .029$, $\eta^2 = .036$; see figure 3). In the ambiguous (strangers) conditions, participants indicated less willingness to try a potentially risky food when the pitch of the background sound was low ($M_{\text{Low}} = 3.84$, $M_{\text{Moderate}} = 4.80$; $F(1, 132) = 6.72$, $p = .011$, $\eta^2 = .048$). However, in the benign (friends) conditions, the effect was attenuated, as participants were directionally more likely to try a potentially risky item when the background sound was low pitch ($M_{\text{Low}} = 4.46$, $M_{\text{Moderate}} = 4.24$), although this latter contrast was not significant ($F(1, 132) = .311$, $p = .578$, $\eta^2 = .002$).

The measures of feeling “safe” and “protected” ($r = .64$) were also averaged to create a (reverse) measure of feelings of anxiety. The ANOVA using this index resulted in a significant interaction ($F(1, 135) = 4.29$, $p = .040$, $\eta^2 = .031$) such that in the ambiguous conditions participants felt less safe (more anxious) when the background sound was low pitch ($M_{\text{Low}} = 3.59$, $M_{\text{Moderate}} = 4.09$; $F(1, 132) = 3.56$, $p = .061$, $\eta^2 = .026$). However, participants in the benign conditions felt directionally safer (less anxious) when the restaurant sound was low pitch ($M_{\text{Low}} = 4.42$, $M_{\text{Moderate}} = 4.14$), although this latter contrast did not reach significance ($F(1, 132) = 1.11$, $p = .29$, $\eta^2 = .008$). There was also an understandable significant main effect of the sound source condition ($F(1, 132) = 5.47$, $p = .021$, $\eta^2 = .040$), as participants felt safer overall with friends ($M_{\text{Friends}} = 4.28$, $M_{\text{Strangers}} = 3.84$).

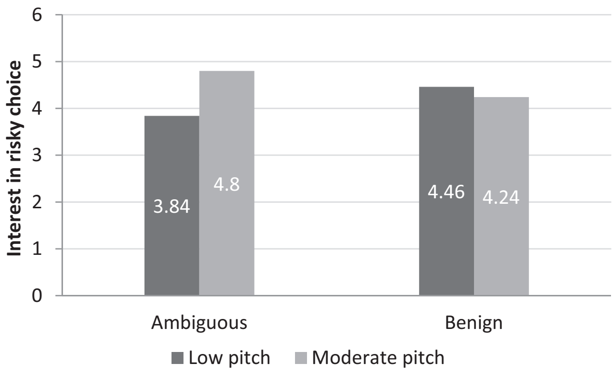
Finally, a bootstrap ($N = 1{,}000$) analysis shows that feelings of safety mediated the interaction of pitch and sound source on risk avoidance, specifically the willingness to consume a risky product ($a_1 \times b_1 = .2325$, 95% CI = .0107 to .6292, $p < .05$).

Discussion

Study 5 provides support for our full moderated mediation model. In support of our theorizing, we find that feelings of threat and its antithesis, safety, play a key role in the relationship between the pitch of background sounds and risk taking. When the sound source is made salient and associated with an ambiguous potential threat (strangers), a low-pitch background sound makes consumers less likely to try something potentially risky; however, when the sound source is understood as benign (friends), pitch does not affect risk avoidance. As removing the potential threat associated with background sound eliminates the relationship between pitch and risk avoidance, study 5 supports our theorizing that it is the perception of threat that leads to risk-avoidant choices in the presence of low-pitch background sounds. Study 5 also provides more direct evidence that risk avoidance in response to low pitch is a threat response by showing that anxiety mediates the effect of pitch on risk aversion. Specifically, we find that it is because participants felt less safe in the low-pitch ambiguous (strangers) condition that they were less willing to try a risky product.

FIGURE 3

STUDY 5: WILLINGNESS TO TAKE FOOD-RELATED RISK



STUDY 6: FIELD STUDY IN A YOGURT SHOP

The purpose of study 6 is twofold. First, we have not yet compared the effects of pitch when the sound is (i) unnoticed, (ii) noticed but from an ambiguous source, and (iii) noticed and from a benign source; that is, we have not had all three conditions within the same study. We do so in study 6. Second, study 6 tests these effects in the field; that is, it examines actual behavior in a real business setting.

Design and Context

Study 6 employed a 2 (low pitch vs. moderate pitch) × 3 (sound source: unnoticed, ambiguous, benign) between-subjects design. The study took place in a self-serve frozen yogurt store during regular weekend business hours. The store consists of seven yogurt machines dispensing 21 different flavors at a "yogurt bar." Customers pick up a bowl (from only one location) and proceed to serve themselves combinations of desired flavors from the machines, and then add toppings; they pay for their product based on the weight of the servings. On the counter facing the machines, sample tasting cups are laid out for customers; these cups are regularly replenished by store employees. Customers are neither required to take any samples nor limited in the number of samples they can take. The purpose of the sample cups is to allow customers to try a small serving of a yogurt flavor before serving themselves a larger portion for purchase, thus reducing risk for the consumer.[1]

Method

Pitch Manipulation. Prior to the study, two speakers and a subwoofer were hidden in a cupboard under the counter behind the yogurt serving station. During the study, one of two sounds played from the speaker (counterbalanced): a low-pitched (80 Hz) sine wave, and a more moderately pitched (320 Hz) sine wave. Volumes were adjusted to ensure equal loudness across conditions. As in studies 1, 2, and 4a, the sound was established to be audible when attention was drawn to the sound, but to go generally unnoticed otherwise. The natural din of the store helped to further mask the sound from drawing attention.

Sound Source Conditions. A stand with a sign was placed in plain view right next to the self-serve bowls, ensuring it would fall in every customer's direct line of sight. This stand was either left empty (unnoticed sound source) or filled with one of two signs. The first sign (ambiguous condition) read, "If you notice a slight 'humming' sound, we apologize. We are working to identify the source as soon as possible." The second (benign condition) read, "If you notice a slight 'humming' sound, we apologize. It is simply one of our speakers acting up and will be fixed very soon!" Thus, customers were exposed to either a moderate-pitch or low-pitch background sound—this sound either had no attention drawn to it (unnoticed sound), had attention drawn to it without having the risk allayed (ambiguous sound), or had attention drawn to it with a harmless explanation (benign sound).

Pitch conditions were alternated every 50 minutes over the space of five hours (low high low high low high), while sound source conditions were alternated every 100 minutes (unnoticed, ambiguous, benign, unnoticed, ambiguous, benign).[2]

The sample or "taster" cups in the store were all located on two clearly visible trays placed next to each other behind the yogurt stations. The total number of sample cups taken was counted each period as the primary dependent variable. This allowed for the greatest possible accuracy rather than relying exclusively on tracking individual consumers given the occasionally crowded nature of the store.

Results

Over the course of the study, 221 individuals entered the store (58.6% female). Not a single customer asked about, or seemed to look for, point to, or identify, the sound in any way. While customers clearly saw the sign(s), no customers inquired further regarding them. Thus, we consider

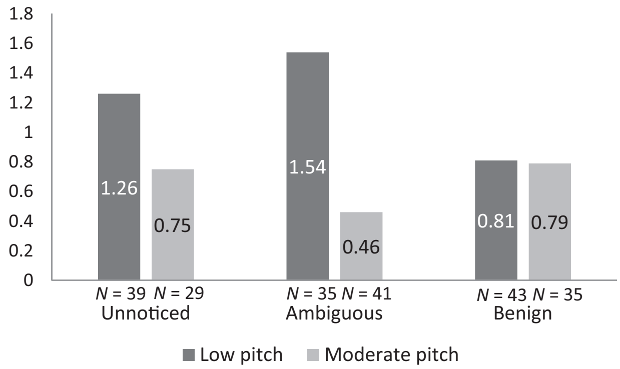
1 A brief survey of 24 customers and three store employees confirmed that overwhelmingly (22/24 customers; 91.7%, and all three employees), customers and employees strongly agreed and acknowledged that the primary purpose of the sample cups was to reduce the risk associated with flavor choice by ensuring that customers knew that they enjoyed the flavor before filling their serving cups.

2 As the flow of store traffic varied slightly throughout the evening, at the end of the five hours we used another 40 minutes to collect additional observations for two conditions (low/ambiguous and moderate/unnoticed) in order to ensure more balanced cell sizes. At this point the store began preparations for closing and the study concluded.

FIELD STUDY (STUDY 6) LOCATION: SELF-SERVE FROZEN YOGURT STORE

FIGURE 4

STUDY 6: AVERAGE SAMPLES TAKEN BEFORE DECISION



our manipulations successful in that the sounds, while audible, caused no distraction and blended seamlessly into the background of the store as desired.

Overall, customers took an average of .95 samples each, with a maximum of four and a minimum of zero. The most common amounts taken were zero and one.

The pattern of results clearly reflects the hypothesized pattern: when the sound was unnoticed, low pitch ($M_{\text{Low}} =$ 1.26 flavors tried per person) led to greater sampling than moderate pitch ($M_{\text{Moderate}} = .90$); when the sound was potentially noticed but from an ambiguous sound source, again low pitch led to greater sampling ($M_{\text{Low}} = 1.54$) than moderate pitch ($M_{\text{Moderate}} = .46$). As in previous studies, the effect of pitch was attenuated when the sound was stated as coming from a benign source, removing any potential threat; then, sampling was about the same in the low- and moderate-pitch conditions ($M_{\text{Low}} = .81$; $M_{\text{Moderate}} = .79$).

Because sampling data was measured as an aggregate-level count based on number of sample cups taken during a time period, we analyze the aggregate count data using both a likelihood ratio test and a z-test. Because of the nature of the data and information regarding distribution, we perform a likelihood ratio test of Poisson means as our statistical test. We note that such count models are preferred to OLS models for this type of data (Jung et al. 2017).

First, the likelihood ratio test was significant overall ($\lambda < .001$, $p < .001$; see figure 4). People sampled more when the background sound was low pitched in both the unnoticed ($M_{\text{Low}} = 1.25$, $M_{\text{Moderate}} = .75$, $\lambda = 13$, $p =$ .043) and ambiguous conditions ($M_{\text{Low}} = 1.54$, $M_{\text{Moderate}} = .46$, $\lambda < .001$, $p < .001$). It is noteworthy that the effect of pitch was apparently even stronger when the sound was pointed out, but not identified as benign (i.e., left ambiguous). In the benign condition, however, there was no such difference between pitch conditions ($M_{\text{Low}} = .81$, $M_{\text{Moderate}} = .79$, $\lambda = .94$, $p = .72$).

A series of z-tests using the highest possible standard deviation for each cell demonstrated a similar result, with a marginally significant difference in the unnoticed condition ($z = 1.40$, $p = .081$), a significant difference in the ambiguous condition ($z = 3.33$, $p = < .001$), and no difference in the benign condition ($z = .063$, $p = .475$).

Discussion

In this field study, we replicate previous results that low-pitch, compared to moderate-pitch, background sound leads to increased risk avoidance. When the sound source was unnoticed (nonconscious signal) and when the sound source was pointed out while leaving the sound source ambiguous (nonconscious response), we find that low-pitch background sound leads to an increase in risk-reducing behaviors (prepurchase sampling). Thus, actual store customers were more prone to sampling before purchase, thereby reducing their exposure to risk, in the low-pitch conditions unless the sound source was explained away as being benign (just the speakers). Study 6 tests both nonconscious response to low-pitch background sound, and low-pitch background sound as a nonconscious signal in the same study. Additionally, study 6 demonstrates the robustness of these results in an actual business setting,

GENERAL DISCUSSION

Across seven studies we demonstrate that slight differences in the pitch of ambient, nonfocal sounds have a measurable impact on both emotional and behavioral responses. All else being equal, a low-pitch background sound indicates a threat, which causes increased risk avoidance (studies 1–3 and 5–6), and this effect is driven by heightened feelings of state anxiety (studies 4a, 4b, and 5). We also introduce an important boundary condition, source threat, which supports our theorizing that the nonconscious cognition of threat is grounded on the audition of "ambiguous" low-pitch sounds. Consequently, the relationships among pitch, anxiety, and risk aversion are attenuated when information is provided that explicitly removes any threat associated with the sound source, whether through labeling the sound as benign (studies 2 and 6), reminding participants that what they are listening to is "just an advertisement" (study 3), or associating the sound with a potential source of safety (studies 4b and 5). The low-pitch–risk-avoidance effect appears to be nonconscious, occurring through both nonconscious perception (studies 1, 2, 4a, and 6) and nonconscious response (studies 3, 4b, 5, and 6).

Test of Process Explanation

We test for our process explanation in several ways. First, through moderation, we demonstrate that when the sound is labeled as benign in some way, the effect of low pitch on risk avoidance (studies 2, 3, 4b, 5, and 6) and anxiety (studies 4b and 5) is attenuated. In other words, when the possibility of a threat is removed, low pitch no longer influences participants' response, providing evidence that perception of threat is driving the response. Second, we show the direct effect of low pitch on our mediator: anxiety. As with risk avoidance, we show that low pitch leads to heightened anxiety both when the sound is not consciously perceived (study 4a) and when it is (studies 4b and 5). Third, we provide process evidence via mediation. In study 5 we find that the extent to which participants feel "safe" and "protected" mediates their willingness to try an unfamiliar food. When they feel less safe and protected (low pitch, strangers condition), participants are less willing to assume risk by trying something unfamiliar.

Our findings contribute to the literature in several ways. First, we add to research on the nonconscious priming effects of environmental cues that one encounters in everyday life. Prior work in the area of nonconscious priming from such cues has primarily focused on priming effects of information delivered by visual cues, such as logos, brand names (Fitzsimons et al. 2008), or even color and shape (Breitmeyer, Ogmen, and Chen 2004). We focus on the effect of nonverbal, nonfocal environmental sounds on consumer perception and behavior. Our work represents, to the best of our knowledge, the first examination of nonconscious priming from incidental auditory environmental cues. We focus on a nonverbal and nonspecific aspect of sound—pitch—and we examine both nonconscious signals from low pitch as well as nonconscious responses to low pitch.

Our work also contributes to research on sound. Specifically, we demonstrate that low-pitch background sound, in a variety of formats and situations, triggers a threat response resulting in increased risk avoidance. While we are constantly surrounded by sound, and consumer sensory experiences have garnered increased attention in research and practice alike (Krishna 2012), relatively little attention has been paid to the basic construct of ambient, background sound. Those works that do address the influence of sound on consumption decisions typically focus on music and the interplay among music, environment, and consumer (Sayin et al. 2015; for a review, see Kellaris 2008). We extend previous work in sensory marketing by focusing on a single element of sound that can be easily manipulated by marketers across a variety of contexts—namely, pitch.

The response to such a basic structural element of sound is shown to be highly automatic and should generalize without raising concerns about fit with image (Vida, Obadia, and Kunz 2007), musical preferences (Caldwell and Hibbert 2002), genre (Wilson 2003), or any one of the many considerations required when using more composed audio elements, such as music. Indeed, it is worth noting that all of the sounds used in our studies are objectively nonthreatening. There is nothing inherently threatening about a sine wave, the din of a restaurant, or street noise; and yet subtly altering the pitch of these common sounds, while controlling for all other aural aspects, causes consumers not only to feel more anxious but to seek ways to reduce their exposure to risk as well.

Additionally, we contribute to the literature on the effects of emotions, specifically anxiety, on risk taking. What sets the current research apart is that it emphasizes the nonconscious nature of anxiety effects. Earlier research on the behavioral implications of anxiety has used overt manipulation of anxiety, from writing essays (Gino, Wood Brooks, and Schweitzer 2012; Kugler et al. 2012) to watching intense video clips (Gino et al. 2012) to reading anxiety-producing scenarios (Raghunathan and Pham 1999; Raghunathan et al. 2006). In each of these previous works, participants' emotions were induced through unambiguous threat manipulations. In the present work, we were able to produce both emotional and behavioral responses simply by lowering the pitch of objectively benign sounds. Indeed, when pretesting our materials we found that even audio professionals were not consciously aware of our manipulations until we drew their attention to them.

Our research also has clear implications for managers. Specifically, we demonstrate that background sound in retail environments and marketing communications can alter a customer's comfort level, the value they place on products that have the potential to reduce risk, and their desire to try products before purchase to decrease risk. For practitioners marketing products with a consumer benefit component of risk reduction (e.g., insurance, preventative health behaviors, security systems), lowering the pitch of background noise in communications, as in study 3, or using acoustic treatments to drop the ambient pitch in retail settings could increase the perceived importance of their products. On the other hand, these results also suggest that for practitioners who wish to encourage risk taking, including product trial, it is potentially optimal to minimize low-pitch background sounds, or ensure that any such sounds are identified as benign.

Future Research

While this work explores one generalizable dimension of sound and its effect on consumer behavior, there are many potential future extensions of our work—for example, using other acoustic variables and examining their mechanisms of influence.

In study 3, we demonstrate that changing the pitch of the background sound in an advertisement can increase the perceived value of an advertised product, within a risk-reducing product category. It is worth exploring how varying the pitch of multiple sources simultaneously (e.g., background noise and spokesperson voice) impacts consumer response. It seems plausible that the most effective communications regarding risk-prevention products would simultaneously use a low-pitch background noise to heighten threat perception, paired with a low-pitch "ally" in the form of a spokesperson.

In addition to focusing on pitch specifically, there are other basic facets of sound—including tempo, variability, and volume—that should be explored, both in combination with pitch and on their own. While we have isolated a single element of sound to demonstrate its impact on emotion and behavior, future researchers will need to isolate and map the effects of other sound elements. As we better understand these various elements of sound, and their impact on behavior, we can more effectively influence desired behavior. In conclusion, broader, more technical approaches are needed to better understand the impact of sound on consumer behavior and the nonconscious effects of environmental cues.

DATA COLLECTION INFORMATION

Study 1

Study 1 was conducted in the Conant Behavioral Laboratory at Texas A&M University in College Station, Texas, in October 2013 under the supervision of the first author and was analyzed by the first author.

Study 2

Study 2 was conducted in the Experiential Laboratory at the Scheller College of Business at Georgia Institute of Technology in Atlanta, Georgia. Study 2 was conducted in September of 2017 under the supervision of the first author and was analyzed by the first author.

Study 3

Study 3 was conducted in the Experiential Laboratory at the Scheller College of Business at Georgia Institute of Technology in Atlanta, Georgia. Study 3 was conducted in November of 2017 under the supervision of the first author and was analyzed by the first author.

Study 4a

Study 4a was conducted in the Conant Behavioral Laboratory at Texas A&M University in College Station, Texas, in February 2014. The study was conducted under the supervision of the first author and analyzed by the first author.

Study 4b

Study 4b was conducted online using Amazon Mechanical Turk in December 2017 under the supervision of the first author. The first author analyzed the data.

Study 5

Study 5 was conducted in February 2016 in the Experiential Laboratory at the Scheller College of Business at Georgia Institute of Technology in Atlanta, Georgia. The study was conducted under the supervision of the first author and data were analyzed by the first author.

Study 6

Study 6 was conducted on location at a self-serve frozen yogurt store in Decatur, Georgia, in May 2018. The study was conducted under the supervision of the first author and the data were analyzed by the first author.

Post-Tests

The post-tests were conducted online using Amazon Mechanical Turk in December 2016 under the supervision of the first author. Data were analyzed by the first author.

APPENDIX A: SOUND AS A NONCONSCIOUS PRIME (NONCONSCIOUS SIGNAL AND NONCONSCIOUS RESPONSE)

TABLE (CONTINUED)

	Manipulation	Nonconscious aspect and sound conditions
Study 1	Sine wave through hidden speakers in lab: Financial Decision-making	**Nonconscious signal:** Participants not aware of sound—sound not noticed in all conditions. Low pitch—Unnoticed (unaware) Moderate pitch—Unnoticed (unaware) No sound
Study 2	Sine wave through hidden speakers in lab: BART task	**Nonconscious signal:** Participants not aware of sound (i.e., sound is unnoticed) until attention brought to it (benign conditions). Low pitch—Unnoticed (unaware) Moderate pitch—Unnoticed (unaware) Low pitch—Benign (aware) Moderate pitch—Benign (aware)
Study 3	Ambient traffic noise in a radio and through headphones: Car insurance	**Nonconscious response:** Participants cannot tell the difference between low- and moderate-pitch sounds. Aware of sound in all conditions. Low pitch—Ambiguous (aware) Moderate pitch—Ambiguous (aware) Low pitch—Benign (aware) Moderate pitch—Benign (aware)
Study 4a	Sine wave through hidden speakers in lab: Word recognition	**Nonconscious signal:** Participants not aware of sound—sound not noticed in all conditions. Low pitch—Unnoticed (unaware) No sound
Study 4b	Ambient restaurant noise: Word search	**Nonconscious response:** Participants cannot tell the difference between low- and moderate-pitch sounds. Aware of sound in all conditions. Low pitch—Ambiguous (aware) Moderate pitch—Ambiguous (aware) Low pitch—Benign (aware) Moderate pitch—Benign (aware)
Study 5	Ambient restaurant noise: Trying foreign foods	**Nonconscious response:** Participants cannot tell the difference between low- and moderate-pitch sounds. Aware of sound in all conditions. Low pitch—Ambiguous (aware) Moderate pitch—Ambiguous (aware) Low pitch—Benign (aware) Moderate pitch—Benign (aware)
Study 6	Sine wave through hidden speakers in a yogurt shop: Trying yogurt flavors	**Nonconscious signal/ Nonconscious response:** Participants not aware of sound (sound unnoticed) until attention brought to it (benign and ambiguous conditions.) Low pitch—Unnoticed (unaware) Moderate pitch—Unnoticed (unaware) Low pitch—Ambiguous (aware) Moderate pitch—Ambiguous (aware) Low pitch—Benign (aware) Moderate pitch—Benign (aware)

APPENDIX B: STIMULI FROM ALL STUDIES

Studies 1, 2, 4a, and 6: Stimuli Links

Moderate-pitch sine wave*: https://soundcloud.com/user-192804655/study-1-moderate pitch-sine-wave
Studies 1, 4a, and 6: Low-pitch sine wave**: https://soundcloud.com/user-192804655/low-pitch-studies-1-and-4a
Study 2: Low-pitch sine wave**: https://soundcloud.com/user-192804655/studies-1–2-low pitch-sine-wave
*For these studies the low-pitch tones were played at approximately 65 dB and the moderate-pitch tone was played at approximately 25 dB.
**A slightly lower sine wave was used in study 2 (60 Hz) relative to studies 1 and 4a (80 Hz) due to minor differences in speaker capabilities.

Study 3: Stimuli Copy and Links

"We live in a world of uncertainty. Even the simplest things don't always go according to plan, like how no one ever leaves the house thinking they will be involved in a car accident, and yet it happens every day to people like you and me. And while we can't control everything that

TABLE A1

RESULTS OF STIMULI POST-TEST

		Moderate pitch	Low pitch	*t*	*p*	Heard diff.	Heard no diff.	Described/ identified pitch
Insurance ad	Like ad	3.76	3.62	–1.41	NS	15 (30%)	35 (70%)	0
	Like spokes-person	3.34	3.14	–0.17	0.096			
	Persuasive	**3.70**	**3.84**	**1.85**	**0.070**			
	Quality	3.66	3.44	1.85	0.070			
Restaurant sound	Like sound	4.88	4.98	0.64	NS	14 (28%)	36 (72%)	0
	Like usage	5.00	5.14	0.96	NS			
	Effective	3.08	3.10	0.15	NS			
	Quality	4.66	4.58	–0.53	NS			

happens, we *can* be prepared. That's why there's Amerisure Insurance. For over 60 years, we've been providing the kind of care and service that helps to make the unexpected a little easier to handle. So no matter what comes your way, you'll have one thing for certain—you'll be covered by Amerisure. Amerisure Insurance: there when it matters most."

Moderate-pitch version: https://soundcloud.com/user-192804655/study-6-insurance-ad-moderate

Low pitch-version: https://soundcloud.com/user-192804655/study-6-insurance-ad-low

Studies 4b and 5: Stimuli Links

Moderate-pitch version: https://soundcloud.com/user-192804655/studies-4b-5-restaurant-sound-moderate

Low-pitch version: https://soundcloud.com/user-192804655/studies-4b-and-5-restaurant-sounds-low

APPENDIX C: POST-TEST FOR STIMULI USED IN MULTIPLE STUDIES

Participants in the post-test were 50 individuals recruited using an online panel. All participants completed a sound check to ensure that each had working audio capabilities. To begin, participants learned that they would be listening to "a few radio ads" and that they would likely be hearing the same advertisement more than once. All participants further learned that they would be asked questions about the advertisements after hearing them.

After reading the instructions, participants heard the two versions of the stimuli used in studies 3, 4b, and 5. The order of the stimuli was randomized, but in pairs, such that participants heard either the moderate-pitch version of each stimulus followed immediately by the low-pitch version of the same stimulus, or vice versa. Participants first listened to both versions of the insurance advertisement used in study 3. After hearing each audio track, participants were asked how much they liked the advertisement and how much they liked the spokesperson, and then rated the both the persuasiveness and the quality of the advertisement. Participants used seven-point scales to respond to each question. Participants then heard both versions of the restaurant sound used in studies 4b and 5. The restaurant sound was given a separate introduction, described simply as a "background track" used by marketers to liven up public places. For this stimulus, participants rated how much they liked the audio and how much they liked the thought of the audio being used in public places, and then rated the audio on quality and effectiveness.

In between hearing each pair of stimuli and responding to measures for both versions, participants were specifically asked, "Did you feel like there was any difference between the two times you heard the ad?" and answered simply "Yes" or "No." Underneath this question, space was provided for participants to explain the difference between the two advertisement versions that they had perceived, if they had indeed felt there was any difference at all.

Finally, we asked participants to guess the purpose of the post-test, and provide demographic info including gender, age, and race.

Results. We compared results from the moderate- and low-pitch versions of each stimulus. There were no differences between moderate- and low-pitch versions of the advertisement that reached significance for any measure. However, for the insurance advertisement, there was a marginal difference in both perceived quality and liking for the spokesperson, with both being slightly higher in the moderate-pitch version. This is a bit odd, since the exact same recording of the exact same spokesperson was used in both versions (but note that this works against our results). Also of note was that for the insurance advertisement, participants rated the low-pitch versions of the advertisements as marginally more persuasive, which lends additional support to the central theory of this research (see table A1).

Overall, in 69.3% of the cases participants perceived no difference between the two versions of the advertisement. For the 30.7% of cases where a difference was supposedly identified, not once did participants describe or identify pitch. Most cases where a difference was described were simply incorrect guesses at differences (e.g., different spokesperson, different volume). In the remaining cases several participants actually described the low-pitch versions as more "negative," "ominous," or "dramatic," suggesting that there was a real difference in the way the sound made them feel, even when no participant was able to correctly identify the cause of this difference.

Discussion. The post-test lends support to the nonconscious nature of the effects discussed in the article. Even when hearing both versions back to back, participants were primarily unable to identify any difference, and entirely unable to identify or describe a difference in pitch. In addition, participants felt that the low-pitch versions of the advertisement promoting insurance (a risk-reducing product) was more persuasive and also described increased feelings of anxiety associated with the low-pitch versions.

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