Is Noise Always Bad? Exploring the Effects of Ambient Noise on Creative Cognition

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This paper examines how ambient noise, an important environmental variable, can affect creativity. Results from five experiments demonstrate that a moderate (70 dB) versus low (50 dB) level of ambient noise enhances performance on creative tasks and increases the buying likelihood of innovative products. A high level of noise (85 dB), on the other hand, hurts creativity. Process measures reveal that a moderate (vs. low) level of noise increases processing difficulty, inducing a higher construal level and thus promoting abstract processing, which subsequently leads to higher creativity. A high level of noise, however, reduces the extent of information processing and thus impairs creativity.

Creativity is ubiquitous in the realm of consumption. On the one hand, we as consumers engage in everyday creative behavior such as home decor, fashion, or planning meals with limited resources (Burroughs and Mick 2004; Burroughs, Moreau, and Mick 2008). On the other hand, many businesses thrive on consumers' ability and desire to be creative. For example, consumers' ability to understand and appreciate creative and metaphorical persuasive messages is an essential element of any successful creative advertising campaign. Similarly, consumers' desire to be creative has a significant impact on the success of many products, including play kits (e.g., model trains, paint-by-numbers kits), how-to guides (e.g., cookbooks, landscaping; Dahl and Moreau 2007), and many other innovative new products.

Because creativity permeates the consumption environment, it is not surprising that a great deal of research has explored factors that can affect consumers' creative ability and performance, including external constraints (Moreau and Dahl 2005), involvement (Burroughs and Mick 2004), analogical thinking (Dahl and Moreau 2002), systematic training (Goldenberg, Mazursky, and Solomon 1999), and life experiences (Maddux and Galinsky 2009). However, extant research in this domain has largely ignored the impact of physical environment on an individual's creativity (for exceptions, see Mehta and Zhu 2009; Meyers-Levy and Zhu 2007). The current study attempts to fill this gap in the literature by investigating the effects of an important environmental variable—ambient noise—on creativity.

Although extensive research has examined the impact of noise on human cognition and behavior in general, little research has focused on the effects of noise on creativity per se. Furthermore, this limited research shares two key weaknesses. First, studies examining the noise-creativity relationship have yielded inconclusive findings. While most studies find that noise hurts creativity (Hillier, Alexander, and Beversdorf 2006; Kasof 1997; Martindale and Greenough 1973), there is some evidence that for highly original individuals, moderate noise may lead to improved creative performance (Toplyn and Maguire 1991). Second, although researchers have proposed different reasons as to why noise may affect creativity, such as arousal (Martindale and Greenough 1973; Toplyn and Maguire 1991), stress (Hillier et al. 2006), attention span (Kasof 1997), very little research has actually examined these mechanisms empirically. Thus, there is no clear understanding of why noise affects creativity.

In this research we examine the underlying mechanism

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through which ambient noise affects creative cognition. We theorize that a moderate (vs. low) level of ambient noise is likely to induce processing disfluency or processing difficulty, which activates abstract cognition and consequently enhances creative performance. A high level of noise, however, reduces the extent of information processing, thus impairing creativity. A series of five experiments offers systematic support to our theory. In addition, findings from our last experiment extend our theorizing by showing that a moderate level of noise also increases buying likelihood of innovative products.

This research promises to make several contributions. First, it contributes theoretically to the noise literature by demonstrating an inverted-U relationship between noise and creativity, thus reconciling the mixed findings observed in the current literature. Second, it adds to the creativity literature by identifying ambient noise as an important factor affecting creative cognition and by providing process evidence for this relationship. Finally, it adds support to the growing recognition that subtle cues in our physical environment can indeed affect human cognition and behavior. The results from this research also have important practical implications in terms of inducing consumer creativity and encouraging adoption of new products.

THEORETICAL BACKGROUND

Noise and Creativity

By definition, any unwanted sound is called "noise." A *sound* is defined as a vibration, or a traveling wave that is an oscillation of pressure transmitted through a medium (solid, liquid, or gas). The pressure of these vibrations within a given frequency range stimulates sensation in the ears and enables hearing. Hearing is thus sensitive to the sound pressure level, or "sound level," measured in decibels (dB). (See appendix table A1 for a list of sound sources and their sound levels.) It is worth noting that sound level is not equivalent to loudness; the latter is a psychological correlate and a subjective measure of sound level. There is a complex relationship between the two, such that a 10 dB increase in sound level approximately corresponds to a twofold increase in loudness ("Noise Pollution," *The Columbia Encyclopedia*, 6th ed. [2008]).

Although considerable research has examined the effects of noise on human cognition and behavior (Hamilton and Copeman 1970; Hockey 1969, 1970a, 1970b; Hygge, Evans, and Bullinger 2002; Nagar and Pandey 1987; O'Malley and Poplawsky 1971; Weinstein 1974), there has been little focus on the effects of noise on creativity. Furthermore, this limited area of research has not only produced inconclusive results but also proposed different process mechanisms through which noise might affect creativity. The most common finding is that high levels of noise hurt creativity. Researchers have focused on primarily white noise and pink noise in this line of research. White noise is a sound that is artificially created by combining all audible frequencies (i.e., every frequency within the range of human hearing, generally from 250 Hz to 8,000 kHz) in equal amounts. White noise sounds like a gentle hiss. Pink noise is also artificially created and is a variant of white noise. Pink noise sounds something like the buzz on an empty television station. For example, Martindale and Greenough (1973) demonstrate that a high level of white noise reduces performance on the Remote Associates Test (RAT), a task commonly used to measure creativity; they conjecture that high arousal induced by the high level of white noise is responsible for the reduced creativity they observed. Kasof (1997) demonstrates that creative performance in writing poetry is impaired by exposure to a high level of pink noise, and speculates that the high noise level may have hurt creativity by narrowing attention. Hillier et al. (2006) argue that stress induced by a high level of white noise is responsible for reduced performance on a creative task (RAT). None of these studies, however, actually tested their proposed process mechanism.

One exception in this line of research is the finding that for highly creative individuals, a moderate noise level may lead to higher creative performance relative to both low and high noise levels (Toplyn and Maguire 1991). Toplyn and Maguire had participants complete a number of creativity tasks and used their performance on one such task (the RAT) to assess their baseline creativity level. They found that highly creative individuals (defined as those who scored high on the RAT) exhibited greater creativity on other tasks when presented with a moderate level of white noise than when the noise level was either high or low. Toplyn and Maguire speculate that arousal may underlie this effect. For less creative individuals, on the other hand, no significant difference was observed among low, moderate, and high levels of noise.

The above review of the extant literature on the impact of noise on creativity thus reveals a number of problems. First, this literature not only has produced inconclusive results but also lacks rigorous testing of the proposed mechanisms through which noise affects creativity. In the current paper, therefore, we empirically test the cognitive mechanism through which we propose ambient noise affects creativity. Second, most extant research has employed nonrealistic noise stimuli that are neither common nor sustainable in typical consumption contexts, such as white noise (Hillier et al. 2006; Martindale and Greenough 1973; Toplyn and Maguire 1991) and pink noise (Kasof 1997). In our research we therefore focus on ambient noises that are much more common in daily life (e.g., background noise in a restaurant). Finally, existing research is silent on how noise may influence individuals' acceptance of creative ideas. We examine this question in one of our studies by looking at how noise affects consumers' responses to innovative products.

The Proposed Process through Which Noise Can Affect Creativity

We argue that noise distracts people but that the degree of distraction induced by various noise levels will affect creativity differently. A high level of noise may cause a great deal of distraction, causing individuals to process information to a lesser extent and therefore to exhibit lower creativity. A moderate (vs. low) level of noise, however, is expected to distract people without significantly affecting the extent of processing. Further, we reason that such a moderate distraction, which induces processing difficulty, enhances creativity by prompting abstract thinking. We predict, in sum, that a moderate level of noise will enhance creativity relative to both high and low levels of noise.

To elaborate, we theorize that the distraction caused by a moderate level of noise will lead to processing difficulty or disfluency (we use these terms interchangeably in this paper). *Processing disfluency* has been defined as the lack of "the subjective experience of ease or speed in processing information" (Oppenheimer 2008, 237). Of particular relevance to our research is the finding that processing disfluency induces a higher construal level, such that individuals engage in abstract thinking (Alter and Oppenheimer 2008). Alter and Oppenheimer (2008) presented participants with city names (e.g., New York) in either hard-to-read (i.e., disfluent) or easy-to-read (i.e., fluent) fonts, asking them to judge how far away the target city was relative to their current location and to describe the target city. People who saw disfluent fonts adopted a higher construal level, judging the city to be farther away and describing it using more abstract terms than those who saw fluent fonts.

Further, there is evidence relating a higher construal level (or abstract thinking) to greater creativity. Smith (1995) suggests that when people are thinking abstractly, they are less likely to fixate, and thus more creative, than those who are thinking concretely. Echoing this idea, Smith, Ward, and Schumacher (1993) had participants generate new product ideas (e.g., a spill-proof coffee cup or a new toy) and found that fixating people with a few examples before the idea-generation task decreased the abstraction and the creativity level of the generated ideas. Similarly, Forster, Friedman, and Liberman (2004) find that priming people with a distant-future time perspective, which prompts a higher construal level and increased abstraction, enhances creativity.

Based on the above research, we predict that the distraction caused by a moderate (vs. low) level of noise will induce processing difficulty, leading to abstract processing and, consequently, to greater creativity. A different mechanism, however, is proposed for the high noise level. Although we expect that a high (vs. moderate) noise level will also lead to reduced creativity, we argue that this reduction is driven largely by the reduced extent of information processing. Specifically, while a high noise level should also prompt a higher construal level, this positive effect on creativity is likely to be counteracted by the reduced information processing that is simultaneously induced by high (but not moderate) levels of noise. This reduced processing can prevent individuals from thinking divergently, for example, creating new links, which is necessary for creative thinking (Woodman, Sawyer, and Griffin 1993). In fact, brain-imaging studies have shown that the brain areas responsible for attentional processes, which indicate the extent of information processing, are also responsible for cognitive processes that lead to higher creativity (Fink et al. 2010). On the basis of the above arguments, we hypothesize that a high (vs. moderate) level of noise will lead to a lower creativity level due to reduced information processing.

Finally, we posit that the effects hypothesized above will apply not only to the generation of creative ideas but also to the adoption of innovations. Prior research suggests that innovative consumers are more likely to adopt novel products (Hirschman 1980; Houston and Mednick 1963; Im, Bayus, and Mason 2003). If a moderate level of noise can enhance creativity, it should also enhance consumers' appreciation for novel products (Thompson, Hamilton, and Rust 2005). Thus, we expect that a moderate (vs. high or low) level of noise should increase the adoption of innovative products.

We test the above hypotheses in five experiments. The first experiment demonstrates the basic effect that a moderate level of noise enhances creativity relative to both high and low levels of noise. Experiments 2 and 3 provide evidence that construal level and process disfluency independently mediate the noise-creativity relationship, and at the same time rule out a number of alternative explanations. Experiment 4 tests for the complete process mechanism through which a moderate (vs. low) level of noise enhances creativity. The final experiment, a field study, examines the effect of ambient noise on the adoption of innovative products and also examines an important moderator of this effect, namely, individuals' baseline level of innovativeness.

EXPERIMENT 1

Method

Stimuli. To create ambient noise reflecting typical consumption contexts, we blended a combination of multi-talker noise in a cafeteria, roadside traffic, and distant construction noise to create a soundtrack of constantly varying background noise. All noises were first independently recorded at real-life venues (e.g., in a cafeteria, near a construction site) and then superimposed electronically to create the final digital soundtrack. Noise manipulation was accomplished by playing this digital soundtrack on an MP3 player plugged into two stereophonic speakers while participants were completing the task. The volume of the speakers was adjusted as needed to generate low (50 dB), moderate (70 dB), and high (85 dB) levels of noise (Nagar and Pandey 1987). To add a baseline for comparison purposes, we also included a control condition in this experiment, in which about one-fourth of participants completed the focal task while the soundtrack was not played. In this condition, the average ambient noise level for each session in our lab setting varied between 39 dB and 44 dB, with an overall average of 42 dB.

To assess creative performance, we used the Remote Associates Test (RAT; Mednick 1962), which has been widely used to assess creative thinking in both psychology and marketing research (Griskevicius, Cialdini, and Kenrick 2006, 2007; Van den Bergh, Dewitte, and Warlop 2008). Each RAT item consists of three or four stimulus words that are in some way related to a fourth or fifth unreported target word. Participants are given the stimulus words, and their task is to determine the target word. For example, for the stimulus words "Shelf," "Read," and "End," the correct response is "Book." We included eight RAT items in this experiment. We expected that participants in the moderate-noise condition would perform better on this test than those in all other conditions (i.e., high-noise, low-noise, and control conditions).

Procedure. Sixty-five undergraduate students (46 women) from the University of British Columbia participated in the "Restaurant Experience Study" in exchange for a course credit. The experiment was run in small groups of no more than four people per session. Each session was randomly assigned to one of the four noise conditions. Upon arrival, participants were asked to take one of the four available desks, which were strategically placed on the arc of a semicircle. Two stereophonic speakers on stands were positioned in the center of the circle, so that all desks were equidistant to the speakers. For the high-, moderate-, and low-noise conditions, the noise level was measured using a sound-level meter before each session and was kept constant (≈85 dB, 70 dB, or 50 dB; variation due to changes in noise content was approximately ±3 dB) at each desk. The setup was identical for the control condition, except that no noise soundtrack was played.

All experiments were computer based. In experiment 1, the instruction screen explained that the researchers were studying people's experiences in different kinds of restaurants and therefore, to create an appropriate ambience, background noise such as one would usually hear while dining at a roadside restaurant might be present during the experimental session. The speakers were then either turned on at the 85 dB, 70 dB, or 50 dB level or left turned off, depending on the condition. All participants then completed eight RAT items, presented one at a time on the computer screen. The program recorded each participant's responses and his or her response time for each RAT item.

Next, participants rated their current feelings in response to six adjectives, using a 7-point scale (1 = not at all, 7 = very much). Three were positive mood items (happy, cheerful, joyful) and three were negative mood items (sad, depressed, glum); the presentation order of the six items was randomized. The experiment concluded with some demographic questions.

Results

As anticipated, an analysis of variance (ANOVA) revealed a significant main effect of noise level on RAT performance ($F(3, 61) = 3.21$, $p < .05$), such that respondents in the moderate-noise condition ($M = 5.80$) generated more correct answers than those in the low-noise ($M = 4.29$, $t(61) = -2.34$, $p < .05$), high-noise ($M = 3.88$; $t(61) = 2.94$, $p < .01$), or control conditions ($M = 4.48$, $t(61) = -2.06$, $p < .05$). The differences among the latter three conditions were not significant (all $t < 1$).

We then analyzed the average response time for each RAT item, and again found a significant main effect of noise level ($F(3, 61) = 3.48$, $p < .05$). Although there was no significant difference among the participants in moderate-noise ($M = 14.09$ seconds), low-noise ($M = 14.94$ seconds), and control ($M = 13.29$ seconds) conditions (all $t < 1$), those in the high-noise condition ($M = 9.51$ seconds) spent significantly less time on each item than participants in each of the other three conditions (moderate noise: $t(61) = 2.47$, $p < .05$; low noise: $t(61) = 3.02$, $p < .01$; control: $t(61) = 2.10$, $p < .05$). This finding is consistent with our theorizing that a high level of noise reduces the extent of information processing.

Next, we analyzed participants' responses on the mood items. The positive and negative items were averaged to create a positive mood index ($\alpha = .90$) and a negative mood index ($\alpha = .75$). There were no significant mood effects across conditions (positive: $M_{High} = 2.96$, $M_{Moderate} = 2.62$, $M_{Low} = 2.78$, $M_{Control} = 2.88$; negative: $M_{High} = 1.54$, $M_{Moderate} = 1.91$, $M_{Low} = 1.78$, $M_{Control} = 1.59$; all $F < 1$).

Discussion

Results from experiment 1 provide support for our basic proposition that a moderate level of background noise enhances creativity relative to high-, low-, and no-noise conditions. As noted above, although the control condition did not include any active manipulation of noise, there was always some ambient noise present; the average ambient noise across all control-condition sessions was measured as 42 dB, which is close to our manipulated low-noise condition (50 dB). Therefore, it is not surprising that there was no significant difference in respondents' creativity levels between these two conditions. In addition, the nonsignificant results from the mood measures rule out a potential explanation, that is, that mood might have contributed to our findings. Finally, we observed that the time spent on the focal task was lower in the high-noise condition than the other three conditions, indicating reduced information processing under the high noise condition. While we believe this finding supports our theorizing that a high level of noise leads to reduced cognitive capacity to process, it may also imply a motivation account, such that a high level of noise reduces processing motivation. In the next experiment we try to tease apart these two competing accounts and provide further evidence for the reduced cognitive capacity account.

EXPERIMENT 2

This experiment aims to provide theoretical replication of the results of experiment 1. In addition, it is intended to (1) test whether construal level underlies the beneficial effect of moderate (vs. low) levels of noise on creativity and (2) test whether reduced capacity of processing, rather than reduced processing motivation, is responsible for the impaired creativity in the high- (vs. moderate-) noise condition.

Method

Stimuli. We used the same noise manipulation as employed in experiment 1, except that the control condition (i.e., no noise) was dropped from this and all subsequent experiments because it was similar to the low-noise condition (42 dB vs. 50 dB) and the two did not produce any statistically significant difference in results, as shown in experiment 1.

An idea-generation task was used as the focal task in this study. Participants were asked to imagine themselves as a mattress manufacturer looking for creative ideas for a new kind of a mattress; that is, their task was to come up with creative ideas for a new mattress. They were also told that the ideas could be geared toward either new features or a completely new product. We recorded both the ideas generated by each participant and the amount of time spent by him/her on this task. The quality of ideas was used to measure creativity, whereas the number of ideas and the time spent on the task were used to measure the extent of processing.

We also measured participants' construal level in order to test whether this variable can explain our results. The 25-item Behavioral Identification Form (BIF; Vallacher and Wegner 1987) was used to measure individuals' situational construal level. The BIF presents individuals with a series of behaviors and offers two different ways of identifying each behavior; for example, "making a list" could be identified as "getting organized" (an abstract, high-level identification) or as "writing things down" (a concrete, low-level identification). Individuals must select which of the two identifications best describes the behavior for them at the current moment. Participants' responses to all 25 behaviors are summed to create a construal-level index; higher values indicate a higher construal level.

Finally, to measure participants' processing motivation, we asked three questions. Specifically, participants indicated on a 7-point scale (1 = not at all, 7 = very much) the extent to which they were motivated to complete the study, enjoyed doing the task, and thought the study was interesting.

Procedure. Sixty undergraduate students (36 women) at the University of British Columbia participated in the experiment in exchange for $10. Experimental sessions were run in groups of no more than four people per session. Each group of participants was randomly assigned to the high-, moderate-, or low-noise condition. The cover story, seating arrangement, and equipment setup were exactly the same as in experiment 1. Once participants had settled down and after the noise was started, they first answered some demographic questions, which took no more than 2 minutes to complete. Then all participants were presented with the BIF items. Next they completed the idea-generation task, which asked them to generate as many creative ideas as they could think of for a new kind of a mattress and type them into the computer. No time limit was imposed for this task. The computer program recorded the ideas generated by each participant and the time taken to generate these ideas. Finally, participants answered the three questions assessing their processing motivation. The experiment concluded with some demographic questions.

Results

Number of Ideas Generated. Participants generated a total of 211 ideas, for an average of 3.52 ideas per participant (SD = 2.44). Noise level had a marginally significant effect on this measure ($F(2, 57) = 2.41$, $p = .10$): those in the high-noise condition ($M = 2.5$) generated fewer ideas than those in the low-noise ($M = 4.10$; $t(57) = 2.07$, $p < .05$) and moderate-noise ($M = 3.82$, $t(57) = 1.74$, $p = .09$) conditions. The difference between the latter two conditions was not significant ($t < 1$).

Time Spent on Generating the Ideas. To further assess the extent of processing, we next analyzed the time taken by participants to generate their ideas. One-way ANOVA revealed a significant main effect of noise level ($F(2, 59) = 3.70$, $p < .05$). Participants in the high-noise condition ($M = 98.06$) spent significantly less time on this task than both those in the low- ($M = 140.04$; $t(57) = -2.32$, $p < .05$) and moderate-noise ($M = 141.24$; $t(57) = 2.44$, $p < .05$) conditions. Again, the difference between the latter two conditions was not significant ($t < 1$).

Processing Motivation. To test whether our noise manipulation changed participants' processing motivation, we averaged each participant's responses to the three motivation questions detailed above ($\alpha = .77$). A one-way ANOVA revealed no significant treatment effect of noise level on participants' processing motivation ($M_{High} = 4.22$, $M_{Moderate} = 4.18$, $M_{Low} = 4.02$; $F < 1$).

Creativity of the Ideas Generated. To assess the creativity of participants' ideas, we first identified all unique ideas generated. A total of 122 unique ideas were identified in the set of all 211 ideas. Next, 12 independent judges, hired from the same population as the study participants, rated how creative they thought each of the 122 unique ideas was on a 7-point scale (1 = not at all, 7 = very much; Dahl, Chattopadhyay, and Gorn 1999; Goldenberg et al. 1999). The judges were shown only the unique ideas, rather than all ideas, to control for frequency effects (i.e., more frequently presented ideas might be judged as more or less creative). Ratings from 12 judges were then averaged for each unique idea ($\alpha = .81$) to obtain the average judge rating for that idea. These average ratings for all ideas generated by each participant were then averaged (i.e., summed and then divided by the total number of ideas generated by that participant) to obtain a mean creativity score for each participant.

Replicating the results from experiment 1, one-way ANOVA revealed a significant main effect of noise level on mean creativity score ($F(2, 57) = 3.59$, $p < .05$), such that participants in the moderate-noise condition ($M = 4.01$) generated ideas that were more creative than those generated in either the low-noise condition ($M = 3.57$; $t(57) = -2.33$, $p < .05$) or the high-noise condition ($M = 3.58$; $t(57) = -2.25$, $p < .05$). No difference was observed between high- and low-noise conditions (all $t < 1$).

Construal Level. We created a construal-level index ($\alpha = .75$) by summing each participant's responses to the 25 BIF items. One-way ANOVA with the construal-level index as the dependent variable revealed a significant main effect of noise level ($F(2, 57) = 3.65$, $p < .05$). Specifically, participants in the moderate-noise condition ($M = 42.32$) were operating at a higher construal level than those in the low-noise condition ($M = 39.60$; $t(57) = -2.18$, $p < .05$), and participants in the high-noise condition were also operating at a higher construal level ($M = 42.83$) than those in the low-noise condition ($M = 39.60$; $t(57) = -2.47$, $p < .05$). However, no difference in construal levels was observed between those in the moderate- and those in the high-noise condition ($t < 1$).

Mediation Analyses. Two sets of analyses were conducted in order to test whether (1) construal level mediates the beneficial effect of moderate (vs. low) levels of noise on creativity and (2) the reduced capacity of processing is responsible for the lower creativity observed in high (vs. moderate) levels of noise.

For the first analysis, following the procedure recommended by MacKinnon, Lockwood, and Williams (2004), we used the bootstrapping approach to assess the mediation effect. The 95% bias-corrected bootstrap confidence intervals (CIs) were obtained for each of the two contrasts (moderate- vs. low-noise conditions and moderate- vs. high-noise conditions) using 5,000 bootstrap samples. The results support our proposition, demonstrating that the 95% confidence interval for the moderate-low noise contrast ($-.42$ to $-.02$) did not include zero, which indicates that construal level indeed mediates the effect of moderate (vs. low) noise levels on creativity. However, the 95% CI obtained for moderate-high noise contrast ($-.15$ to $.27$) did include zero, which suggests that the indirect effect of construal level was absent for this contrast.

The second analysis examined whether the capacity of processing underlies the impaired creativity observed at high (vs. moderate) levels of noise. The bootstrap approach was again used to test the mediation model. Time spent on the creative task was used as the measure of processing capacity, such that less time spent meant reduced capacity to process information. The 95% bias-corrected bootstrap CI was obtained using 5,000 bootstrap samples for the moderate-high noise contrast. The mediation was tested only for this contrast, as the capacity-of-processing measure did not differ between the moderate- and low-noise conditions. As hypothesized, we observed a significant indirect effect of the processing capacity on the reduction in creativity from the moderate to the high noise level; that is, a 95% bias-corrected CI did not include zero ($-.51$ to $-.06$).

Discussion

Results from experiment 2 theoretically replicated those of experiment 1, that is, that a moderate level of noise leads to higher creativity than either a low or a high level of noise. In addition, experiment 2 provides evidence that construal level underlies the beneficial effect of a moderate (vs. low) level of noise on creativity. Although a high level of noise also leads to a higher construal level, relative to a low level of noise, comparable to the high construal level induced by a moderate level of noise, this positive influence on creativity is counteracted by the reduced capacity of processing also induced by the high, but not by the moderate, level of noise. Thus, experiment 2 shows that the reduced processing capacity was responsible for the impaired creativity observed at high (vs. moderate) noise level. Finally, results on the measure of processing motivation confirmed our expectation that while a high (vs. moderate) level of noise led to reduced capacity of processing, it did not affect the motivation to process.

Up to this point, we have argued that a moderate level of noise induces processing disfluency, leading to abstract processing and thus to higher creativity. Yet an alternative argument, as speculated by Toplyn and Maguire (1991), is that a moderate level of noise induces a moderate level of arousal, thus enhancing creativity. In fact, it is plausible that a moderate (vs. low) level of noise may induce both processing disfluency and arousal. We argue, however, that if noise is present for a longer period, people become accustomed to it physiologically (i.e., their arousal level will normalize) but not cognitively (i.e., their level of distraction, and hence of processing disfluency, will remain high). Thus, if our theorizing is correct, we should observe that a moderate level of noise leads to greater creativity regardless of whether the task is administered at the beginning of the experiment or later on (i.e., whether noise has just begun or has been present for a while). If, on the other hand, arousal underlies the effect, we should observe the beneficial effect of a moderate level of noise only at the beginning of the study. Our next experiment tests these competing hypotheses and examines the role of processing disfluency in the noise-creativity relationship.

EXPERIMENT 3

Method

Stimuli and Design. Experiment 3 used the same noise manipulation as before. However, as we were particularly interested in the process mechanism underlying the beneficial effect of a moderate (vs. low) level of noise on creativity, we dropped the high-noise condition. The focal task asked participants to list as many creative uses of a brick as they could think of (Friedman and Forster 2001). Participants completed this task either shortly after the background noise started to play or after a delay. Thus, this experiment used a 2 (noise level: low vs. moderate) × 2 (timing of task: immediate vs. delayed) between-subjects design. To assess arousal level, we took two physiological measures: heart rate and blood pressure.

To assess processing disfluency, we measured the extent to which participants felt distracted during the study. Past research has measured processing fluency by simply asking participants about the difficulty they experienced in completing a given task. However, most of this research has manipulated processing fluency by varying the difficulty level of the focal task, for example, by employing easy or difficult to read fonts in a reading task (Oppenheimer 2008; Song and Schwarz 2008). In contrast, because the focal task in experiment 3 involved generating unusual ideas, we deliberately refrained from using the difficulty of completing the task as a measure of processing fluency. This is because, in our context, the perceived difficulty of the focal task could represent either processing disfluency induced by the noise manipulation or ease of retrieval in completing the idea-generation task (Tsai and McGill 2011). For example, a person who was able to generate more ideas might perceive the task as easy to complete; this is not the kind of noise-induced processing disfluency that we are trying to assess. To avoid such a potentially confounding measure, we measured processing disfluency indirectly, by assessing the level of distraction, which has been shown to affect processing difficulty (Jacoby et al. 1988; Schwarz 2004). Specifically, we measured participants' level of distraction via three items, each rated on a 7-point scale (1 = not at all, 7 = very much): (1) How distracting did you find the room ambience while completing the study? (2) How well were you able to concentrate while completing the study? (reverse coded); and (3) How comfortable was the experimental room to complete the study? (reverse coded). Measures of both arousal and processing disfluency were taken immediately after participants completed the focal task.

Procedure. Ninety-five undergraduate students (60 women) from the University of British Columbia participated in this experiment, one person at a time, in exchange for course credit. The study setup and noise manipulations were identical to those described in experiment 1, except that only low (50 dB) or moderate (70 dB) levels of noise were played. After the participant had settled down and the background noise had started, s/he first answered some demographic questions that took about 2 minutes. Upon completing the demographic questions, half the participants were presented with the brick task: they were told to generate as many creative uses for a brick as they could think of, but to refrain from listing both typical uses and uses that are virtually impossible. Following Friedman and Forster (2001), participants were given 2 minutes to generate their list. Once the participants completed the brick task, they answered the three disfluency questions. Next, the study administrator measured the participant's heart rate and blood pressure. The sequence of taking physiological measures and answering disfluency questions for all the participants was counterbalanced.

The other half of the participants, upon finishing the demographic questions, worked on some unrelated tasks for about 12–15 minutes before doing the brick task. The unrelated task included answering various but unrelated individual difference scales. After completing the brick task, participants answered the disfluency questions and their physiological measures were taken, with the order of these two measures counterbalanced.

Results

Number of Ideas Generated. A total of 480 ideas were generated by all participants, for an average of 5.05 (SD = 2.50) per person. Neither the interaction between noise level and timing of the idea-generation task ($F(1, 91) = 1.09$, $p = .30$) nor the main effects were found to be statistically significant (all $F < 1$).

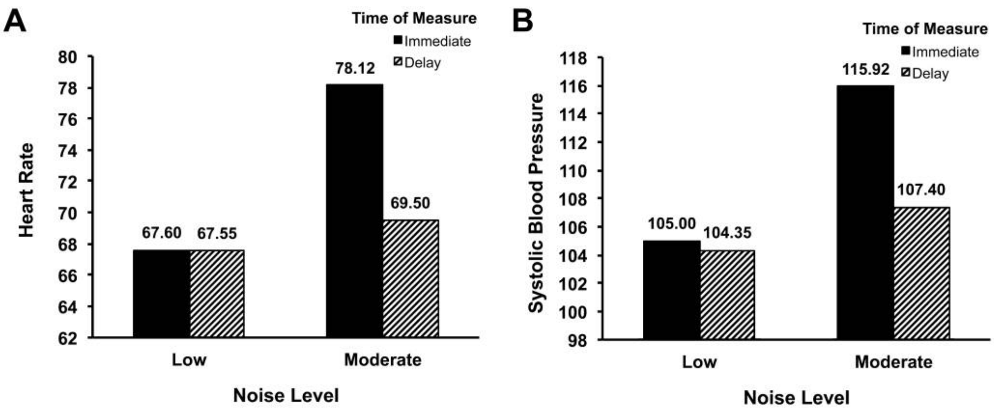
Arousal Level. Arousal level was assessed through noninvasive measures of participants' heart rate and blood pressure. For the heart-rate measure, the main effects of noise level ($F(1, 91) = 11.34$, $p < .01$) and timing of task ($F(1, 91) = 5.44$, $p < .05$) were both significant, along with a significant two-way interaction ($F(1, 91) = 5.31$, $p < .05$). Contrast analysis revealed that in the moderate-noise condition, heart rate was significantly higher when taken shortly after the experiment began than when taken after a delay ($M = 78.12$ vs. 69.5; $t(91) = 3.38$, $p < .01$). No such difference was observed in the low-noise condition ($M_{\text{immediate}} = 67.60$, $M_{\text{delay}} = 67.55$; $t < 1$; see fig. 1*A*). Analysis of the other two contrasts revealed that when heart rate was measured shortly after the experiment began, it was significantly higher in the moderate-noise than in the low-noise condition ($t(91) = -4.14$, $p < .001$). No such difference was observed when heart rate was measured later on in the experiment ($t < 1$).

Similar results were observed for the blood-pressure measure. ANOVA revealed significant main effects of noise level ($F(1, 91) = 9.96$, $p < .01$) and timing of task ($F(1, 91) = 4.29$, $p < .05$), which were qualified by a marginally significant two-way interaction ($F(1, 91) = 3.16$, $p = .08$). Further contrast analysis indicated that in the moderate-noise condition, blood pressure was higher when taken shortly after the experiment began than when taken after a delay ($M = 115.92$ vs. 107.40; $t(91) = 2.81$, $p < .01$). No such difference was observed in the low-noise condition ($M_{\text{immediate}} = 105.00$, $M_{\text{delay}} = 104.35$; $t < 1$; see fig. 1*B*). Examination of the other set of contrasts revealed that when blood pressure was measured shortly after the experiment began, it was significantly higher in the moderate- than in the low-noise condition ($t(91) = -3.60$, $p < .01$); no such difference was observed when blood pressure was measured later on in the experiment ($t < 1$).

Processing Disfluency. Each participant's responses to the three questions assessing processing disfluency were av-

FIGURE 1

EXPERIMENT 3: *A*, HEART RATE AS A FUNCTION OF NOISE LEVEL AND TIMING OF TASK. *B*, BLOOD PRESSURE AS A FUNCTION OF NOISE LEVEL AND TIMING OF TASK



eraged to create an index ($\alpha = .78$). For this measure, as expected, the two-way ANOVA revealed only a significant main effect of noise level ($F(1, 91) = 19.12$, $p < .001$; see fig. 2). The two-way interaction ($F(1, 91) = 1.46$, $p = .23$) and the main effect of task timing were nonsignificant (all $F < 1$). We therefore collapsed the data across the timing-of-task variable and ran a one-way ANOVA. As hypothesized, we found that the moderate (vs. low) level of noise led to greater processing disfluency ($M = 5.37$ vs. 4.29; $F(1, 93) = 20.26$, $p < .001$).

Creativity of the Ideas Generated. To assess the creativity of the ideas generated by participants, we used the same procedure described in experiment 2. We first screened all 480 ideas and identified 198 unique ideas. Next, we hired 12 judges from the same population as our study participants and asked them to rate the creativity of each unique idea on a 7-point scale (1 = not at all, 7 = very much). We then used these ratings to create a mean creativity score for each participant, as detailed in experiment 2. A two-way ANOVA revealed only a significant main effect of noise level ($F(1, 91) = 13.8$, $p < .001$; see fig. 3). We therefore collapsed the data across the timing-of-task variable and ran a one-way ANOVA. We found that the moderate (vs. low) level of noise prompted participants to generate ideas that were rated as more creative ($M = 4.70$ vs. 4.16; $F(1, 93) = 14.48$, $p < .001$).

Discussion

Results from this experiment show that a moderate (vs. low) level of noise induces both higher arousal (as indicated by higher heart rate and blood pressure) and processing disfluency. With the passage of time, however, people seem to become physiologically accustomed to the moderate noise level (i.e., their arousal level normalizes). On the other hand, the high processing disfluency level induced by moderate noise appeared to persist over the course of the experiment. Importantly, we found that a moderate level of noise enhances creativity regardless of the timing of the task, which suggests that processing disfluency, as opposed to arousal, drives this effect. To further test this proposition, we ran a mediation test using the bootstrap approach, with noise level as independent variable, mean creativity score as dependent variable, and disfluency as the mediator in the model. We obtained a 99% CI of (−4.06 to −.014), indicating that disfluency did indeed mediate the noise-creativity relationship.

Up to this point, we have shown that both processing dis-

FIGURE 2

EXPERIMENT 3: PROCESSING DISFLUENCY AS A FUNCTION OF NOISE LEVEL AND TIMING OF TASK

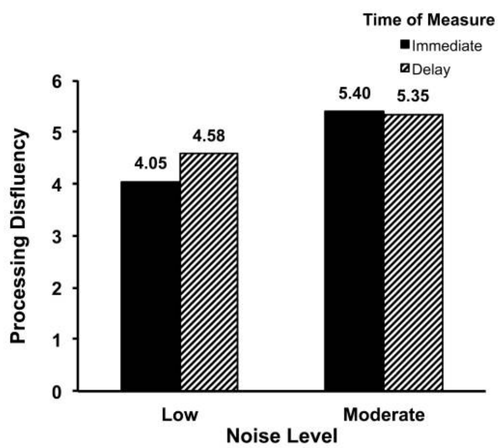
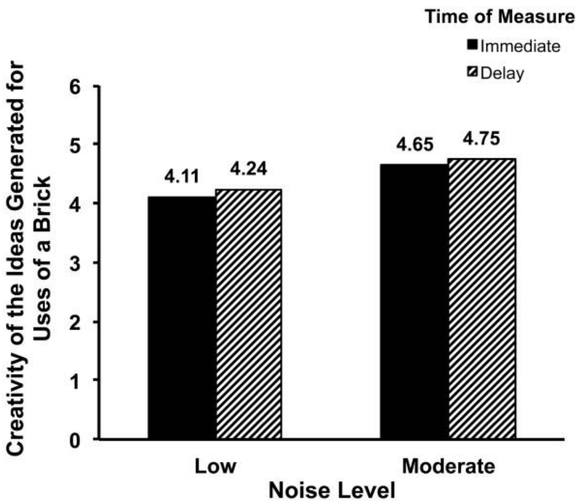


FIGURE 3

EXPERIMENT 3: CREATIVITY MEASURE AS A FUNCTION OF NOISE LEVEL AND TIMING OF TASK



fluency and construal level independently mediate the noise-creativity relationship. However, as theorized earlier, we propose that processing disfluency and construal level should simultaneously mediate the relationship between ambient noise and creativity, such that a moderate (vs. low) level of noise induces higher processing disfluency, which further prompts a high construal level, thus leading to higher creativity. We test this chain of process mechanism in the next experiment.

Furthermore, all our previous experiments have examined creativity as a one-dimensional construct. However, extant research on creativity suggests that creativity may be treated as a multidimensional concept with two main components: originality and appropriateness (Burroughs et al. 2008; Moreau and Dahl 2005). To be creative, an idea must be different from what is already known (the originality dimension) and must also be appropriate in solving the problem at hand (the appropriateness dimension). In other words, an original but bizarre idea is not a creative idea (Lubart 1994). In experiment 4, therefore, we examined both the originality and the appropriateness dimensions of creativity.

EXPERIMENT 4

Method

Stimuli. Experiment 4 used the same noise manipulation described in experiment 3. We used the shoe-polish problem-solving task from Burroughs and Mick (2004), as the focal task in this experiment. Participants were told to imagine the following scenario:

> You are going out to a banquet held by your new employer and will probably be called up front and introduced to the rest of the company. You put on a black outfit and are all ready to leave for the dinner when you realize that your shoes are all scuffed up and the scuffs are definitely noticeable. You have completely run out of polish and these shoes are the only ones that can go with your outfit, and there is really no other outfit you can wear. You have to leave in the next 2 minutes if you want to be on time. All the stores in your part of the town are closed for the evening. Although there is one shopping mall that is still open, it would mean an extra 5 miles of freeway driving.

After reading the scenario, participants were asked to generate as many solutions as they could think of for the given problem. To assess the underlying process, we measured construal level using the BIF scale, as in experiment 2, and processing disfluency using the same three items as in Experiment 3.

Procedure. Forty-two undergraduate students (27 women) at the University of British Columbia participated in this experiment in exchange for $10. The experiment was run in small groups of no more than four people per session. The study setup and noise manipulation remained identical to experiments 1–3. We presented participants with the shoe-polish problem (Burroughs and Mick 2004) after they had settled down and the background noise had started. Participants were asked to generate as many solutions to the problem as they could think of; once they had finished generating solutions, they completed the 25 BIF items (Vallacher and Wegner 1987) and the processing-disfluency measures.

Results

Number of Ideas Generated. A total of 188 ideas were generated, for an average of 4.48 (SD = 2.09) ideas per person. The noise level did not affect the number of solutions generated ($M_{\text{Moderate}} = 4.30$, $M_{\text{Low}} = 4.64$; $F < 1$), nor was any difference observed in the amount of time (in seconds) taken to complete the focal task ($M_{\text{Moderate}} = 251.61$, $M_{\text{Low}} = 237.73$; $F < 1$).

Originality of the Ideas Generated. We first screened all 188 ideas and identified 61 unique ideas, then hired 12 judges from the same population as our study participants. These 12 judges rated the originality, novelty, and innovativeness of each of the 61 unique ideas on a 7-point scale (1 = not at all, 7 = very much). We then averaged the 12 judges' ratings to obtain the mean judges' originality score ($\alpha = .62$), mean judges' novelty score ($\alpha = .67$), and mean judges' innovativeness score ($\alpha = .66$) for each unique idea. These scores were used to calculate the mean originality, novelty, and innovativeness score for each participant. For example, to obtain the mean novelty score for a participant, we summed the mean judges' novelty scores for each idea generated by that participant, then divided this sum by the total number of ideas generated by that person. The mean originality, novelty, and innovativeness scores loaded on one factor with high reliability ($\alpha = .95$) and were then averaged to create an overall originality index.

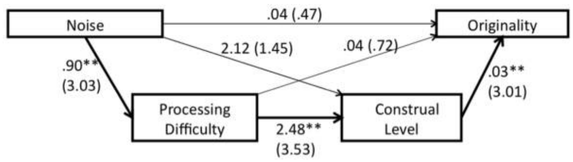
One-way ANOVA revealed a significant effect of noise on this originality index, such that ideas generated by participants in the moderate- (vs. low-) noise condition were rated as more original ($M = 3.87$ vs. 3.66; $F(1, 40) = 4.76$, $p < .05$).

Appropriateness of Ideas. Another set of 14 judges rated each of the 61 unique ideas on its appropriateness ($\alpha = .82$), usefulness ($\alpha = .81$), and practicality ($\alpha = .80$); these ratings were then used to create an overall appropriateness index ($\alpha = .98$), using the same procedure described above. One-way ANOVA also revealed a significant effect of noise on this appropriateness index, such that ideas generated by respondents in the moderate-noise (vs. low-noise) condition were rated as more appropriate ($M = 4.48$ vs. 4.20; $F(1, 40) = 5.34$, $p < .05$).

Processing Disfluency and Construal Level. Participants' responses to the three processing-disfluency questions were averaged to create a processing-disfluency index ($\alpha = .74$). As expected, one-way ANOVA revealed a main effect of noise on processing disfluency, such that moderate noise ($M = 4.02$) led to higher processing disfluency than low noise ($M = 3.12$; $F(1, 40) = 9.16$, $p < .01$). Similarly, participants' responses to the 25 construal-level items were summed to create a construal-level index ($\alpha = .85$). A significant effect of noise level was also observed for this index, such that a moderate noise level induced a higher construal level ($M = 4.02$) relative to a low noise level ($M = 39.41$; $F(1, 40) = 8.46$, $p < .01$).

FIGURE 4

EXPERIMENT 4: MULTISTEP MULTIPLE-MEDIATION MODEL FOR THE ORIGINALITY INDEX



NOTE.—Coefficients are unstandardized and *t*-statistics are in parentheses. ** $p < .01$.

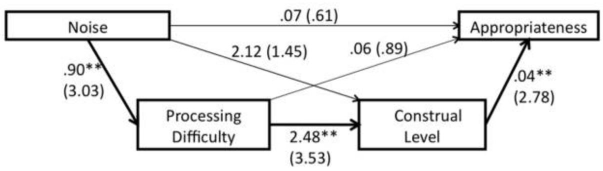
Multiple Mediation. Next, we conducted mediation analysis to examine whether processing disfluency and construal level simultaneously mediate the noise-creativity relationship. Because we hypothesized a causal relationship between processing disfluency and construal level, we conducted a test of multiple mediation using the multiple-step multiple-mediator model (Hayes, Preacher, and Myers 2011; Preacher and Hayes 2008). Using this model, we tested for the presence of a multiple-mediation effect, such that a moderate (vs. low) noise level induces higher processing disfluency, leading to a higher construal level and consequently enhancing both the originality and the appropriateness dimensions of creativity.

We conducted our first set of multiple-mediation analyses to test for a mediating effect of processing disfluency and construal level on the relationship between noise level and originality of ideas generated. We therefore included noise, the processing-disfluency index, the construal-level index, and the mean originality score in the model. A 5,000-resamples bootstrap approach generated a 95% CI of (.010 to .161) for the multiple mediators' indirect effect, indicating a significant multiple-mediation effect at the $p < .05$ level. Analysis of individual paths in the model provided further interesting information about the multiple-mediation effect. A separately run individual set of regressions indicated significant direct effects of noise on the originality of ideas ($\beta = .21$, $t = 2.18$, $p < .05$), processing disfluency ($\beta = .90$, $t = 3.03$, $p < .01$), and construal level ($\beta = 4.34$, $t = 2.91$, $p < .01$). When both processing disfluency and construal level were included in the multistep multiple-mediator model, however, only the individual paths from noise to processing disfluency ($\beta = .90$, $t = 3.03$, $p < .01$), from processing disfluency to construal level ($\beta = 2.48$, $t = 3.53$, $p < .01$), and from construal level to originality ($\beta = .03$, $t = 3.01$, $p < .01$) remained significant, while all other paths became nonsignificant. This result confirms that the moderate level of noise induced higher processing disfluency, which then induced a higher construal level, leading to increasingly original ideas (see fig. 4).

Next, we ran the same multistep multiple-mediator model as described above but replaced the originality index with the appropriateness index. A 5,000-resamples bootstrap approach generated a 95% CI of (.004 to .173) for the multiple mediators' indirect effect, indicating a significant multiple-mediation effect at the $p < .05$ level. Again, further analysis of individual paths in the model demonstrated that although the direct effect of noise on appropriateness was significant initially ($\beta = .29$, $t = 2.31$, $p < .05$), when both processing disfluency and construal level were included in the multiple-mediation model only the individual paths from noise to processing disfluency ($\beta = .90$, $t = 3.03$, $p < .01$), from processing disfluency to construal level ($\beta = 2.48$, $t = 3.53$, $p < .01$), and from construal level to appropriateness ($\beta = .04$, $t = 2.78$, $p < .05$) remained significant, while all other paths became nonsignificant. Thus, the mediation confirms that a moderate level noise led to higher processing disfluency, which then induced a higher construal level, thus producing more appropriate ideas (see fig. 5).

FIGURE 5

EXPERIMENT 4: MULTISTEP MULTIPLE-MEDIATION MODEL FOR THE APPROPRIATENESS INDEX



NOTE.—Coefficients are unstandardized and t-statistics are in parentheses. ** $p < .01$.

Discussion

Results from this experiment provide crucial support for our theory by demonstrating the chain of underlying processes through which noise affects creativity. Specifically, we demonstrate that moderate (vs. low) levels of noise induce higher processing disfluency, which induces a higher construal level and abstract processing, and consequently enhances both the originality and the appropriateness dimensions of creativity.

Our next and final experiment aims to extend earlier studies in three ways. First, although in previous experiments we manipulated noise to a high (85 db), moderate (70 dB), or low (50 dB) level, we recognize that in real life consumers encounter a wide range of noise intensities, from low to high. In our final experiment, therefore, we operationalized the noise factor as a continuous variable by measuring it in a natural setting. Second, we employed innovation adoption as the focal task in this study, as our theorizing suggests that noise should affect not only creative production but also adoption of innovative products. Finally, we explored how individuals' baseline level of innovativeness might moderate the effect of noise on innovation adoption.

EXPERIMENT 5

Method

In this experiment we aimed to study the effect of noise on innovation adoption in a real-life setting. We conducted the experiment in a student lounge area equipped with various appliances (microwave, fridge, water cooler, coffee machine, and oven). This lounge is used by graduate students, and the noise level varies through the day. Typically it is quite noisy during the lunch hour, moderately noisy during coffee breaks, and rather quiet for the rest of the day. We set up a cubicle with a desk and computer in a corner of this lounge, such that the study participant in the cubicle could hear noise but could not see movement in the lounge. A sound-level meter placed near the desk in this cubicle, hidden from the participants, was switched on before each participant began the experimental task and paused as soon as the participant left. The settings of the sound-level meter gave us an average noise level for the period during which it was switched on.

Stimuli. We constructed eight pairs of different products for this experiment. Each product pair offered two options from the same product category, one of which was new and innovative while other was more traditional (see appendix fig. A1 for an example of such a pair). Full-color pictures, along with some product information for the two options in each pair, were presented together on the same screen. Participants indicated their likelihood of buying the innovative option over the traditional one on a 7-point scale (1 = not at all, 7 = very much).

Because the study involved innovative product adoption, individual differences in creativity were measured using a user innovativeness scale (Price and Ridgway 1983). This scale measures individuals' tendency to use products creatively to solve problems and includes items such as "I enjoy thinking of new ways to use old things around the house" and "I take great pleasure in adapting products to new uses that the manufacturer never intended." Participants completed this measure, along with some other individual difference measures, at the beginning of the term. Their responses to this user innovativeness scale were later used for experiment 5 data analysis.

Procedure. Sixty-eight undergraduate students (44 women) at the University of British Columbia participated in this experiment, one at a time. The sessions were run throughout the day, every day for 5 days. Upon arrival, the participant was asked to sit in front of a computer inside the cubicle. Once the participant was ready to begin, the research assistant turned on the hidden sound-level meter and asked the participant to complete the survey at his/her own pace. The focal task involved presenting the participant with eight pairs of traditional-innovative products one at a time. For each pair, the participant rated his/her likelihood of buying the innovative product as compared to the traditional option, as described above. Once the participant completed the task, the research assistant paused the sound meter and noted the noise level for that session.

Results

Average noise levels across all sessions ranged from 38.40 dB to 71.50 dB, with an overall average of 51.35 dB (SD = 7.59 dB). The average noise level for each session was treated as a continuous variable in the subsequent analyses. Note that the highest noise participants were exposed to in this real-life setting corresponds to the moderate-noise condition in experiments 1–4. Thus, based on our theorizing and findings so far, we expected a positive linear relationship between noise and willingness to buy innovative products.

Buying Likelihood. Each participant's buying-likelihood scores for the eight product categories were averaged to create a buying-likelihood index; higher scores indicated a greater likelihood of adopting innovation. A linear regression with the buying-likelihood index as the dependent variable and the continuous noise measure as the independent variable revealed a significant positive coefficient for the noise variable ($\beta = .25$, $t(66) = 2.08$, $p < .05$). As the noise level increased, respondents indicated a higher likelihood of buying the innovative products (buying likelihood at +1 SD of mean noise level = 4.61; buying likelihood at −1 SD of mean noise level = 4.15).

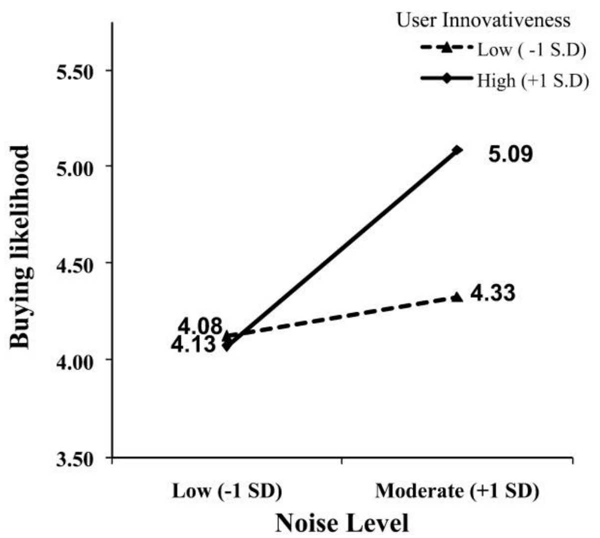
Individual Difference in Creativity. Of the 68 participants who completed this experiment, we were able to match user-innovativeness scale responses for 62 people. Therefore, we used the data for only these 62 participants to examine whether individual differences in creativity moderate the effect of noise on innovation adoption. All data were analyzed in accordance with the Aiken and West (1991) approach. We regressed buying likelihood on noise, mean-centered user-innovativeness scale, and the interaction term. A marginally significant two-way interaction emerged for the measure of participants' buying likelihood ($\beta = .05$, $t = 1.77$, $p = .08$). Next, we plotted the graphs at one standard deviation above and below the mean of the user-innovativeness scale (see fig. 6). Consistent with prior research (Toplyn and Maguire 1991), we found that as noise level increased, buying likelihood for the innovative products increased only for highly creative people (i.e., at +1 SD on the user-innovativeness scale; $M_{-1\text{ SD noise level}} = 4.08$, $M_{+1\text{ SD noise level}} = 5.09$; $\beta = .06$, $t = 3.15$, $p < .01$). For less creative people (i.e., at −1 SD on the user-innovativeness scale), no difference was observed as noise level increased ($M_{-1\text{ SD noise level}} = 4.13$, $M_{+1\text{ SD noise level}} = 4.33$; $\beta = .01$, $t < 1$).

Discussion

Results from this experiment provide convergent evidence for our theory. They support our hypothesis that moderate levels of noise not only lead to higher creative output but also enhance people's adoption of innovative products. These results also support previous findings in the literature

FIGURE 6

EXPERIMENT 5: BUYING LIKELIHOOD AS A FUNCTION OF NOISE LEVEL AND INDIVIDUAL DIFFERENCES IN USER INNOVATIVENESS



to the effect that increasing noise to a moderate level helps highly creative people to be more creative but may not be of value for people whose baseline creativity level is low (Amabile 1983).

GENERAL DISCUSSION

While ambient noise is omnipresent, our understanding of its impact on human cognition, particularly creative cognition, remains limited. In this study, through a series of five experiments, we demonstrate how and why ambient background noise can affect creativity. Specifically, we show that a moderate (vs. low) level of ambient noise induces processing disfluency, which leads to abstract cognition and consequently enhances creativity. A high level of noise, however, impairs creativity by reducing the extent of information processing.

Findings from this research make several theoretical contributions. First, they contribute to the noise literature by providing valuable insights into the noise-creativity relationship. Previous research has reported inconclusive findings with respect to the effect of noise on creativity: while the majority of prior studies suggest that high noise levels hurt creativity, some have found that moderate noise can enhance creativity. In addition, prior research has primarily employed noise stimuli rarely found in consumer environments (e.g., white noise, pink noise). Our study helps to reconcile the mixed findings in the extant literature by demonstrating an inverted-U relationship between noise level and creativity. Using background noise that is commonly present in consumers' lives (in this case, ambient noise in a roadside restaurant), we show that while a moderate level of background noise enhances creativity relative to a low noise level, a rather high level of noise impairs creativity.

Second, we uncover the process through which ambient noise affects creative cognition. We find that increasing levels of noise induce distraction, leading to a higher construal level. That is, both moderate and high noise levels lead to more abstract processing as compared to a low noise level. This higher construal level then induces greater creativity in the moderate-noise condition; however, the very high level of distraction induced by the high-noise condition, although it prompts a higher construal level, also causes reduced information processing, thus impairing creativity. In other words, while a moderate level of noise produces just enough distraction to induce disfluency, leading to higher creativity, a very high level of noise induces too much distraction so as to actually reduce the amount of processing, leading to lower creativity.

As discussed above, a clear understanding of how noise affects creativity is lacking in the extant literature. Different scholars conjecture different mechanisms (e.g., arousal, stress, attention) but do not provide rigorous empirical evidence. For example, Toplyn and Maguire (1991) speculate that a moderate level of background noise induces higher arousal and that this enhances creativity. In our research, however, arousal does not appear to be the driving force underlying the effect of noise on creativity. Consistent with our findings, other researchers have also documented null effects of arousal on creativity. For example, Van den Bergh et al. (2008) demonstrate that the activation of the reward circuitry, not the arousal induced, by exposure to sex cues enhances performance on the RAT task (i.e., a creative task). Although arousal appears to be an intuitive explanation for the effect of noise on creativity, it was not supported by our findings. We believe further research is needed to examine whether in other contexts, such as with different types of noise and among various segments of consumers, arousal might play a role in affecting creativity.

Another interesting finding from our experiment 5 was that the main effect (i.e., a moderate level of noise enhances creativity) was present only among highly creative people. Although these results are in line with prior findings (Toplyn and Maguire 1991), they merit further attention. A logical question that arises, given this proposition, is why we observed similar results for the general population of our participants in experiments 1–4. While a dedicated inquiry is needed to fully address this question, we lay out a possible explanation for this observation. Amabile (1983) suggests that an individual will be incapable of producing work that is considered creative if creativity-relevant skills are lacking. Thus, a person must have certain basic skills before his/her creativity can be enhanced through subtle manipulations such as background noise. This proposition is supported by our results from experiment 5. With respect to the presence of our main effect for the general participant population through experiments 1–4, we draw support from Alba (2000), who points out that college students, who are regularly used as research participants, are preselected on the basis of their cognitive skills. These individuals, on an average, are bound to have above-average innate competence or creativity-relevant skills. In fact, the user-innovativeness measure as obtained in experiment 5 supports this argument, in that the average score of all participants was significantly above the midpoint of the scale ($M = 4.20$, $t(61) = 2.43$, $p < .05$). Hence, it may not be surprising that the manipulation of background noise affected creativity among our overall participant population.

Finally, this research also contributes theoretically to the literature on creativity and innovation adoption. We document that ambient noise, an incidental environmental cue, is an important antecedent of creative cognition. A moderate level of noise not only enhances creative production but also leads to greater adoption of innovative products.

In addition to the preceding theoretical contributions of our study, valuable practical implications also follow for both marketers, who typically strive to increase adoption rates of new and innovative products, and consumers, who look for creative solutions to their everyday problems. For example, in order to encourage adoption of new and innovative products, marketers might consider equipping their showrooms with a moderate level of ambient noise. For individuals looking for creative solutions to daily problems, such as planning a dinner menu based on limited supplies or generating interesting research topics to study, our findings imply that instead of burying oneself in a quiet room trying to figure out a solution, walking out of one's comfort zone and getting into a relatively noisy environment (such as a café) may trigger the brain to think abstractly, and thus generate creative ideas.

While our findings are intriguing, they also offer avenues for future research. First, future research might investigate whether different types of noise will produce similar effects on creativity. For example, does the valence of noise, in addition to its decibel level, influence creativity? The findings from our work confirm that the disfluency or distraction induced by multi-talker noise in the background can enhance creativity. However, what about more pleasant types of noise in the background (e.g., serene music)? Will they affect creativity? And, if so, in what direction? It may be possible that pleasant noise will actually increase processing fluency and thus prompt more concrete processing, consequently hurting creativity.

A second avenue for future research would be to examine the effect of ambient noise on different types of creative tasks. Although we focused on creative tasks of the problem-solving type, our theory can be extended to open-ended or divergent creative tasks, such as art and music.

Third, future research can investigate how background noise might affect consumers' assessment of neutral ideas or products. While we show that a moderate level of noise enhances adoption of innovative products, it seems plausible that even a seemingly ordinary idea might be assessed as more creative/innovative in the context of a moderate (vs. low) noise level.

Finally, future research can examine whether other types of distracting variables, such as background conversations, affect creative cognition in a similar manner as noise. What about whether the conversation takes place in our native language or in a foreign language? We hope that our research will stimulate further investigation in this fascinating domain.

APPENDIX

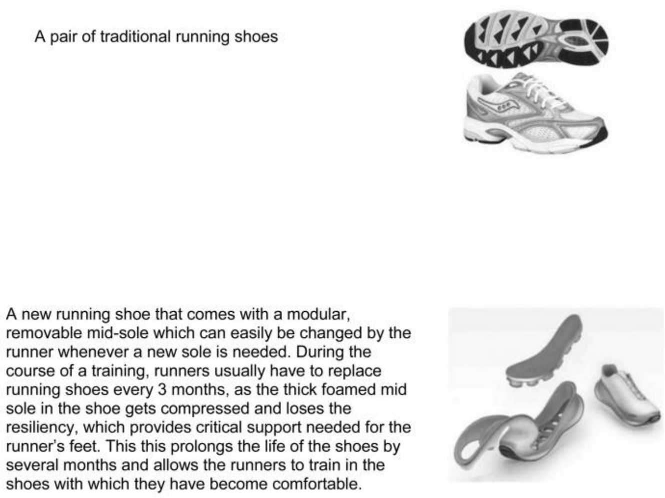
TABLE A1

EXAMPLES OF SOUND SOURCES AND INTENSITY

Sound source	Intensity (dB)
Rocket launch equipment acoustic tests	Approx. 165
Threshold of pain	134
Hearing damage during short-term effect	Approx. 120
Jet engine, 100 m distant	110–40
Jackhammer, 1 m distant/Discotheque	Approx. 100
Hearing damage from long-term exposure	Approx. 85
High noise condition in present studies	*85*
Traffic noise on major road, 10 m distant	80–90
Moderate noise condition in present studies	*70*
Moving automobile, 10 m distant	60–80
TV set at typical home level, 1 m distant	Approx. 60
Low noise condition in present studies	*50*
Normal talking, 1 m distant	40–60
Very calm room	20–30
Quiet rustling leaves, calm human breathing	10
Auditory threshold at 2 kHz for undamaged human ears	0

FIGURE A1

SAMPLE PRODUCT PAIR USED IN EXPERIMENT 4



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