
# Priming for Better Performance in Microtask Crowdsourcing Environments

Although microtask platforms are desirable for their speed, scalability, and low cost, task performance varies greatly. Many researchers have focused on improving the quality of the work performed on such platforms. *Priming* uses implicit mechanisms to induce observable changes in behavior. Although priming has been effective in the laboratory, its use hasn't been explored extensively in software design, perhaps because the effects are often short-lived. In the context of microtask crowdsourcing environments, however, where tasks are short and circumscribed, temporary priming effects can lead to significant performance gains.

**Robert R. Morris**
*Massachusetts Institute of Technology*

**Mira Dontcheva**
*Advanced Technology Labs, Adobe*

**Elizabeth Gerber**
*Northwestern University*

Crowdsourcing is an emerging paradigm that industry, government, and academia employ to harness thousands of individuals' cognitive abilities. *Microtask* crowdsourcing lets users contribute at a time scale of minutes. Typically, such tasks require minimal time and cognitive effort, but combined individual efforts can result in major accomplishments. Although microtask platforms are desirable to employers for their speed, scalability, and low cost, task performance varies greatly. To improve performance, researchers have explored creating games to motivate workers,[1] administering qualification tests to eliminate unqualified workers, incorporating verification tasks to confirm that workers are paying attention,[2] decomposing complex tasks into smaller, simpler subtasks, and duplicating effort across many workers to increase the likelihood of good results.[3] Although this research has inspired new best practices for task design, improvements are still possible. Here, we show how *priming* can help improve performance on microtask crowdsourcing platforms.

## Priming Overview

Psychological literature defines priming as the temporary, implicit activation of behavioral tendencies as a result of exposure to environmental stimuli.[4] Primes might be visible (supraliminal) or hidden (subliminal), and the connection between them and subsequent

 Published by the IEEE Computer Society 1089-7801/12/$31.00 © 2012 IEEE 

behavior is usually outside conscious awareness. Primes can take many forms, such as videos, images, text, and music.

Consider the following experiment from social psychology, in which research participants were asked to pass judgment on a stranger. Before meeting this person, participants briefly held a cup of either hot or iced coffee. Those who held the warm cup judged the stranger as having a "warmer," more generous personality.[5] In another study, researchers primed participants with word puzzles containing stereotypes about the elderly, such as "Florida," "old," and "gray." After completing the puzzles, participants exposed to the stereotype words walked significantly slower down a hallway than those who were given neutral words.[6] Researchers have also found that résumés reviewed on a heavy clipboard were judged as more substantive than those reviewed on a light-weight clipboard.[7] In each of these experiments, simple priming techniques induced significant behavioral changes, all without conscious awareness on the part of research participants.

Outside the laboratory, marketers have successfully used priming techniques to influence consumer behavior and cognition. For example, when shown food advertisements during television viewing, children consumed 45 percent more food during and after viewing than when shown nonfood advertisements.[8] In another example, racial cues in political advertisements primed racial attitudes, influencing preference for a particular political candidate.[9]

These examples notwithstanding, priming is easier said than done and can be difficult to apply in real-world contexts. Designers who wish to embed priming techniques within applied contexts face some limitations: priming effects are transient and don't last very long, and it isn't always practical to embed primes in real-world scenarios. Fortunately, microtask crowdsourcing platforms are largely immune to these shortcomings. We argue that such platforms are extremely well-suited for priming because tasks are brief, and the work environment is highly structured, making it easy to use various priming techniques.

We began our research with *affective priming* — a technique used to induce various affective states (such as happiness or sadness) to influence behavior. For our purposes, we wanted to see whether we could prime positive affect, given that a well-established link exists between positive affective states and performance. For example, when people are happy, they see more connections between ideas and see more ideas as relevant to the problem, thus increasing the probability that they'll find a solution. Additionally, they're more likely to believe that effort will result in good performance, which in turn influences goal commitment, goal setting, and persistence.[10] We can also observe these effects in the context of priming research. In one study, researchers primed positive affect by giving students a bag of candy and then asked them to solve 10 anagrams. The study found that participants induced with positive affect performed better, were more persistent, tried harder, and reported higher levels of motivation than those who didn't receive the candy.[10]

Here, we address two questions:

- Can we apply affective priming in real-world human-computer interaction scenarios?
- Can affective priming enhance performance in microtask crowdsourcing platforms?

Drawing from our recent research,[11,12] we describe two affective priming experiments conducted on Amazon Mechanical Turk (MTurk). Using two priming techniques, we show that we can prime affect on microtask crowdsourcing platforms, thereby enhancing performance.

## Priming with Images

In our first experiment, we studied how affective priming influences creative idea generation on AMT. In microtask markets, motivating creative performance can be difficult. Extrinsic rewards, such as money, can weaken the intrinsic motivations that drive creative achievement. Thus, we wanted to see whether a simple affective prime could improve creative performance in a for-pay microtask market.

### Experiment 1 Details

We can induce affect in several ways, ranging from lengthy (10 minutes or more) mood induction procedures to microsecond subliminal presentations. In this experiment, we used photographs as the affective prime (see Figure 1).

To create a database of images that induce positive, neutral, and negative affect, we used AMT to collect affective ratings for 33 images

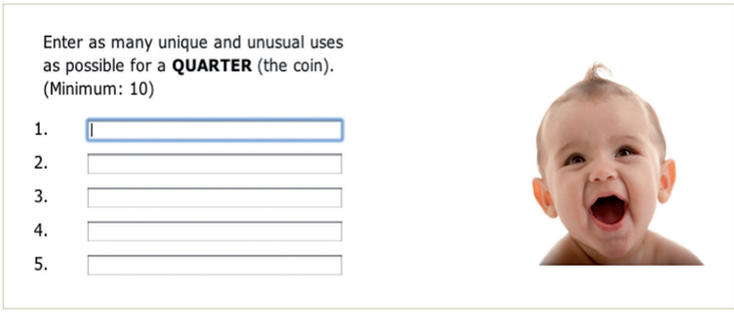


*Figure 1. The crowdsourced microtask in experiment 1. The photograph of the laughing baby acts as a positive affective prime.*

(20 ratings per image). We referenced the International Affective Picture System (IAPS) manual and used the 9-point Self-Assessment Manikin (SAM) scale for affect ratings. A complete list of our dataset and ratings is available elsewhere.[11]

We selected the image with the highest rating (a laughing baby) and the lowest rating (dead bodies after the 2010 earthquake in Haiti) for the positive and negative primes, respectively. For the neutral prime, we selected the image with a rating closest to the median (a hammer).

For our experiment, we recruited 240 participants on AMT and asked them to complete Guilford's "unusual uses" task. This is a standard creativity task that asks participants to generate unusual uses for a common object. We asked participants to think of novel uses for a brick or a quarter. Each participant was also randomly assigned to one of four priming conditions (positive, neutral, negative, and control) and received the following instructions:

> In this task, your goal is to think of as many unique and unusual uses for a common object. For example, using a paper clip as an earring is an unusual and unique use. However, using a paper clip to bind papers is not unique or unusual. Try to think of as many unique and unusual uses as possible. DO NOT use any external sources (e.g., websites, people) to complete this task.

To proceed, the participants clicked a "next" button, which brought them to a webform in which they were required to give between 10 and 20 responses (see Figure 1). Unbeknownst to our participants, the background image on the form was used to prime behavior.

### Results

After excluding individuals who didn't follow our instructions, we had 226 participants in our analyses. To examine our priming conditions' effects, we had three expert raters analyze the quantity and quality of the ideas our participants submitted. These raters assessed quality using a scale from 1 to 5. To calibrate their ratings, they first examined a small subset of the responses and discussed their ratings until they agreed on a strategy. The raters were naïve to our hypotheses and to our experimental conditions.

Our data suggests that although the effect isn't large, positive images can influence idea generation in a crowdsourcing setting. For both the brick and quarter tasks, participants who were primed to feel positive affect generated more original ideas than those primed for neutral affect. Participants primed with positive stimuli generated significantly more original responses (brick: $\mu = 2.76$, $\sigma = 1.31$; quarter: $\mu = 2.76$, $\sigma = 0.96$) than participants primed to feel neutral affect (brick: $\mu = 2.58$, $\sigma = 1.22$, $p < 0.04$; quarter: $\mu = 2.56$, $\sigma = 0.94$, $p < 0.008$). Surprisingly, the responses from participants primed with negative images were also rated as significantly more original (brick: $\mu = 2.85$, $\sigma = 1.30$; quarter: $\mu = 2.71$, $\sigma = 0.87$) than those primed to feel neutral affect (brick: $\mu = 2.58$, $\sigma = 1.22$, $p < 0.05$; quarter: $\mu = 2.56$, $\sigma = 0.94$, $p < 0.02$). We propose an explanation for this finding later in the article. The priming conditions didn't seem to affect the total number of ideas participants gave (good or bad).

## Priming with Music

In our second experiment,[12] we used music to prime affect. We wanted to see whether exposure to a short musical stimulus could significantly enhance performance on a subsequent insight-based problem-solving task. We also wanted to see whether we could deploy the prime before the focal task, rather than directly alongside it. As with our first experiment, we conducted this experiment on AMT because we wanted to see whether we could observe priming effects in a real-world crowdsourcing scenario.

### Experiment 2 Details

For music primes, we chose two instrumental pieces that have been used previously in mood induction research. The positive prime was Bach's "Brandenburg Concerto no.3" (a spirited, up-tempo piece played by jazz flutist Hubert

Laws); the negative prime was Prokofiev's "Alexander Nevsky: Russia under the Mongolian Yoke" (a dreary piece performed by the Los Angeles Philharmonic and played at half-speed). To validate these primes, we asked AMT workers to listen to 30-second excerpts and rate them using the SAM scale. As expected, participants reported feeling significantly happier when listening to the Bach piece than when listening to the Prokofiev piece.

In our experiment, we presented these primes as a part of a supposed verification task. We asked workers to listen to the audio and describe what they heard to prove that they were paying attention. We recruited 176 participants for the experiment, and randomly assigned them to three different conditions. Participants assigned to the positive condition listened to a 30-second excerpt of the Bach piece, whereas those assigned to the negative condition listened to a 30-second excerpt of the Prokofiev piece. Participants assigned to the neutral condition simply wrote down the date. Participants couldn't proceed to the actual task until they completed this preliminary verification task.

Immediately after the priming task, participants were given Mednick's Remote Associates Task (RAT) — a cognitive test that requires insight and creative problem-solving. In a typical RAT, participants are shown three words and asked to generate a fourth that forms a two-word phrase or compound with the other three. For example, if given the words "aid," "rubber," and "wagon," the correct answer would be "band," as in "band-aid," "rubber band," or "bandwagon." In our experiment, we asked participants to complete 20 RAT items, and they had at most 30 seconds to solve each problem (see Figure 2).

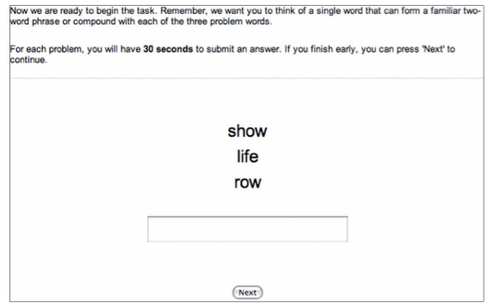


*Figure 2. The Remote Associates Task, as administered on Amazon Mechanical Turk. The correct answer to this problem is "boat."*

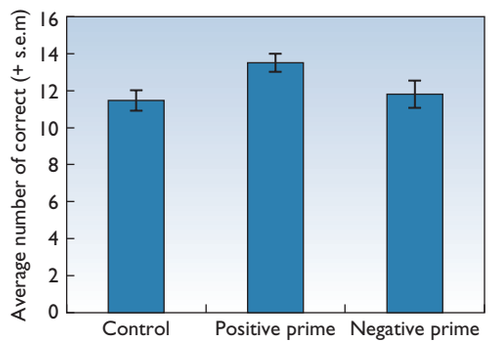


*Figure 3. Experiment 2 results. Positive music primes significantly enhanced performance on the Remote Associates Task — a test for insight and creative problem-solving.*

## Results

As we hypothesized, participants in the positive priming condition significantly outperformed those in the neutral and negative conditions. A one-way analysis of variance between subjects revealed that the priming condition had a significant effect on RAT scores. Post hoc tests showed that performance was significantly better when participants were primed with positive music, relative to the neutral, nonpriming condition. When primed with positive music, they solved 13.5 RAT items out of 20. By comparison, those assigned to the negative and neutral conditions solved only 11.8 and 11.5 items, respectively. Just listening to a 30-second excerpt of happy music boosted performance by 10 percent (see Figure 3).

To our knowledge, these results are the first to show significant affective priming effects from short musical excerpts outside the laboratory. Previous research conducted in the lab used similar methodologies but required participants to listen and reflect on the musical pieces for 10 minutes.[13] Our research shows that we can prime music-evoked affect on a much shorter time scale (just 30 seconds) and use it in a real-world crowdsourcing environment, where we can't control extraneous variables (such as background noise).

## Implications and Limitations

Our two experiments differed in several respects. The methodologies varied with respect to prime type (images versus music) and priming sequence (during the task versus immediately

## Priming Goal Pursuit in Crowdsourcing Environments

Affective priming is one direction we've explored, but we believe other priming techniques might also be applicable to crowdsourcing environments. For example, in addition to priming affect, primes can be used to activate goals related to persistence, attention, and patience, among others. Indeed, various techniques can prime the pursuit of task-relevant goals. For example, in one laboratory study, participants primed with a cooperation goal were more likely to cooperate in a subsequent game involving competition over scarce resources.[1] In another study, words related to achievement goals primed participants to persist longer on puzzles.[1] Applied to crowdsourced microtasks, we can imagine a person reading a passage on persistence as a verification task prior to working on a task requiring patience. Workers who choose to stay on retainer[2] could be primed with game-like primes, such as a word scramble, while they wait for their focal task to begin. To achieve these ends, designers will need to integrate primes in a contextualized way that doesn't detract from the primary task. Fortunately, many existing primes, such as images, video, and music, can be naturally integrated into the interface of a crowdsourcing platform with limited technical expertise.

**References**


1. J. Bargh et al., "The Automated Will: Nonconscious Activation and Pursuit of Behavioral Goals," *J. Personality and Social Psychology*, vol. 81, 2001, pp. 1014–1027.
2. M.S. Bernstein et al., "Crowds in Two Seconds: Enabling Realtime Crowd-Powered Interfaces," *Proc. 24th Symp. User Interface Software and Technology*, ACM, 2011, pp. 33–42.


prior to it). Our dependent measures also differed across the two experiments. We used the unusual uses task (a divergent creative task) in experiment 1 and the RAT (a convergent creative task) in experiment 2. In a third experiment still in progress, we're exploring yet another combination, and we see trends showing that positive images also improve performance on the RAT. Taken together, these experiments show that different affective priming techniques can improve the quality of creative work in microtask crowdsourcing environments. This suggests that crowdsourcing designers have some flexibility in terms of what primes they want to use (images or music) and how they want to use them (before or during the task).

Interestingly, we found that negative primes improved performance in experiment 1. Other researchers have had similar results,[14] but it isn't clear how or when negative affect supports creative work. Possibly, arousal by itself, irrespective of positive or negative valence, can influence creativity in certain domains. If the prime is sufficiently arousing, it might positively influence performance simply by increasing attention and engagement. However, more work is needed to test this hypothesis. Although scholars have described links between arousal levels and performance,[15] less is known about how arousal might specifically affect insight and creative problem solving.

Although our results strongly support the notion that priming techniques can be applied in online crowdsourcing environments, our experiments have some limitations. Most notably, our dependent measures (the RAT and Guilford task) aren't ordinary crowdsourcing tasks and thus lack a certain degree of ecological validity. However, we believe that they make up for this in predictive validity. High performance on these creative tasks is known to correlate with creative achievement in other domains. Thus, we argue that our results with regard to performance should generalize to many different crowdsourcing tasks that require creative problem solving.

Finally, although some employers desire creative performance on microtask crowdsourcing platforms,[16] qualities such as patience, attention, and persistence are also extremely important. In the sidebar "Priming Goal Pursuit in Crowdsourcing Environments," we describe work that looks at how priming might help boost performance in domains beyond creativity.

Based on what we've learned from our experiments and those from psychologists in the lab, we offer a few preliminary design considerations for anyone wanting to apply priming to crowdsourcing platforms.

First, priming mechanisms should be kept outside conscious awareness. Research suggests that priming effects can be diminished, or even reversed, if they're consciously observed.[9] In general, keeping the primes subtle and their actions implicit is best. Moreover, priming effects don't last long, so priming manipulations should immediately precede or co-occur

with the target task. Finally, primes won't improve performance on impossible tasks — priming isn't a substitute for learning. Workers who don't have the knowledge or skills to do a task won't be influenced by primes.

Priming also has implications for interfaces beyond the crowdsourcing context. In experiments with drawing software on a tablet device, we found that those taught to use software with happy images drew a higher number of original drawings than those taught without images or with negative or neutral ones.[11] Although priming outside a microtask crowdsourcing context might be harder to study, the potential impact on user performance could be even greater.

Before we go forth and start designing for particular behavior, however, we must consider the ethics of priming. Just as we've shown that priming can improve worker performance, we must acknowledge that these same techniques could negatively influence behavior and cognition. For instance, primes could potentially cause people to work longer hours without appropriate compensation. In our view, primes should only be employed to help crowdworkers excel at the jobs they willingly signed up to do, and workers should receive compensation for extended effort.

Priming can also be controversial because it runs contrary to our notions of free will. We like to believe that our behavior is solely the product of conscious deliberation. But we must accept that we're influenced by our environment in ways we don't consciously recognize. As hardware, software, and interface designers, we're already influencing the world in this manner. The colors we pick for a device or interface are priming for certain outcomes, whether we explicitly acknowledge this or not.[17] So are the fonts used in this publication — indeed, different font sizes and styles can influence recall, comprehension, and affect. We have the power to build on many years of cognitive science research and make interfaces and systems that leverage our innate human abilities and empower us to be more creative, productive, and successful. We must always use these tools and techniques responsibly.

## References


1. S. Cooper et al., "Predicting protein structures with a multiplayer online game," *Nature*, vol. 466, no. 7307, 2010, pp. 756–760.
2. S. Cooper et al., "Predicting protein structures with a multiplayer online game," *Nature*, vol. 466, no. 7307, 2010, pp. 756–760.
3. M. Bernstein et al., "Soylent: A Word Processor with a Crowd Inside," in *23rd ACM Symposium on UIST*, New York, New York, 2010, pp. 313–322.
4. J. Bargh and T.L. Chartrand, "Studying the Mind in the Middle: A Practical Guide to Priming and Automaticity Research," *Handbook of Research Methods in Social and Personality Psychology*, Cambridge Univ. Press, 2000, pp. 253–285.
5. L.E. Williams and J.A. Bargh, "Experiencing Physical Warmth Promotes Interpersonal Warmth," *Science*, vol. 322, no. 5901, 2008, pp. 606–607.
6. J. Bargh, M. Chen, and L. Burrows, "Automaticity of Social Behavior: Direct Effects of Trait Construct and Stereotype Activation on Action," *J. Personality and Social Psychology*, vol. 71, no. 2, 1996, pp. 230–244.
7. J.M. Ackerman, C.C. Nocera, and J.A. Bargh, "Incidental Haptic Sensations Influence Social Judgments and Decisions," *Science*, vol. 328, no. 5986, 2010, pp. 1712–1715.
8. J.L. Harris, J.A. Bargh, and K.D. Brownell, "Priming Effects of Television Food Advertising on Eating Behavior," *Health Psychology*, vol. 28, no. 4, 2009, pp. 404–413.
9. N. Valentino, V. Hutchings, and I. White, "Cues That Matter: How Political Ads Prime Racial Attitudes During Campaigns," *Am. Political Science Rev.*, vol. 96, no. 1, 2002, pp. 75–90.
10. A. Erez and A. Isen, "The Influence of Positive Affect on the Components of Expectancy Motivation," *J. Applied Psychology*, vol. 87, 2002, pp. 1055–1067.
11. S. Lewis, M. Dontcheva, and E. Gerber, "Affective Computational Priming and Creativity," *Proc. 2011 Ann. Conf. Human Factors in Computing Systems* (CHI 11), ACM, 2011, pp. 735–744.
12. R.R. Morris, M. Dontcheva, and E. Gerber, *Using Music-Evoked Affect to Enhance Performance on Microtask Crowdsourcing Platforms*, tech. report, vol. 002, Segal Design Inst., Northwestern Univ., 2012.
13. G. Rowe, J.B. Hirsh, and K.A. Anderson, "Positive Affect Increases the Breadth of Attentional Selection," *Proc. Nat'l Academy of Sciences of the United States of America*, vol. 104, 2007, pp. 383–388.
14. G. Kauffman and S. Vosburg, "Paradoxical Effects of Mood on Creative Problem Solving," *Cognition and Emotion*, vol. 11, 1997, pp. 151–170.
15. Hebb, D.O. (1955). Drives and the C.N.S. (Conceptual Nervous System). Psychological Review, 62, 243–254.
16. A. Kittur, "Crowdsourcing, Collaboration and Creativity," *XRDS — Crossroads: The ACM Magazine for Students*, vol. 17, no. 2, Dec. 2010, pp. 22–26.

17. N. Mandel and E.J. Johnson, "When Web Pages Influence Choice: Effects of Visual Primes on Experts and Novices," *J. Consumer Research*, vol. 29, no. 2, Sept. 2002, pp. 235–245.

**Robert R. Morris** is a PhD student in the Massachusetts Institute of Technology's Media Lab. His research interests include collective intelligence, affective computing, emotion regulation, and music interfaces. Morris has an MA in media arts and sciences from MIT. He's a member of the ACM. Contact him at rmorris@media.mit.edu.

**Mira Dontcheva** is a senior research scientist at Adobe. Her research interests include learning and creativity. Dontcheva has a PhD in computer science from the University of Washington. She's a member of the ACM. Contact her at mira.dontcheva@adobe.com.

**Elizabeth M. Gerber** is an assistant professor at Northwestern University. Her research interests include crowdsourcing, social computing, motivation, design, and innovation. Gerber has a PhD in management science and engineering from Stanford University. She's a member of the ACM, the Industrial Designers Society of America, the American Society of Mechanical Engineers, and the Design and Research Society. Contact her at egerber@northwestern.edu.