The Common Pain of Surrealism and Death: Acetaminophen Reduces Compensatory Affirmation Following Meaning Threats

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Abstract
The meaning-maintenance model posits that any violation of expectations leads to an affective experience that motivates compensatory affirmation. We explore whether the neural mechanism that responds to meaning threats can be inhibited by acetaminophen, in the same way that acetaminophen inhibits physical pain or the distress caused by social rejection. In two studies, participants received either acetaminophen or a placebo and were provided with either an unsettling experience or a control experience. In Study 1, participants wrote about either their death or a control topic. In Study 2, participants watched either a surrealist film clip or a control film clip. In both studies, participants in the meaning-threat condition who had taken a placebo showed typical compensatory affirmations by becoming more punitive toward lawbreakers, whereas those who had taken acetaminophen, and those in the control conditions, did not.

It does not take long after the opening credits of a David Lynch film for the viewer to sense that something is awry. Whether because of nonlinear dream imagery, the unsettling juxtaposition of the beautiful alongside the horrifying, or the surreal disconnect between the events and characters' reactions, Lynch's films have the ability to "disturb, offend or mystify" (Rodley, 2005, p. 245). Insofar as it "hurts" to watch some of Lynch's films, as it arguably hurts whenever one is assaulted by thoughts and experiences that are at odds with one's expectations and values, the question arises as to how this uncomfortable feeling is represented in the brain. In this article, we explore the common foundation that underlies people's reactions to various kinds of events that cause anxiety, unease, and pain.

The meaning-maintenance model (MMM) proposes that domain-general arousal is triggered by any experience that is surprising, confusing, or in violation of expectations (Heine, Proulx, & Vohs, 2006). In this article, we extend recent work on the common neural pathway for physical and social pain, suggesting that any unexpected event, not just events with a physical or

social component, produces the same initial neural and subjective experience of distress. On this basis, we argue that acetaminophen, which has been shown to reduce both physical and social pain, will also prevent typical meaning-maintenance responses.

Pain and Rejection

Physical pain and social rejection share a neural process and subjective component that are experienced as distress (Eisenberger & Lieberman, 2004; MacDonald & Leary, 2005). Although there are experiences unique to each type of event, such as the sensory awareness of specific pain, there are many subjective and neurological similarities that lead to the same general felt unpleasantness (Price, 2000). For instance, there is evidence that

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experiencing more or less of one type of pain (physical or social) influences sensitivity to the other (Asmundson, Norton, & Jacobson, 1996; MacDonald, Kingsbury, & Shaw, 2005). Likewise, social support has been found to reduce physical pain (Hoogendoorn, van Poppel, Bongers, Koes, & Bouter, 2000), and a number of drugs (including opiate-based drugs, antidepressants, and acetaminophen) have been shown to reduce both physical and social pain (e.g., DeWall et al., 2010; Panksepp, 2004).

One brain region that responds to both physical and social pain is the dorsal anterior cingulate cortex (dACC; Eisenberger, Lieberman, & Williams, 2003). Its activation is correlated with subjective reports of felt unpleasantness after physical pain (Tölle et al., 1999) and social exclusion (Eisenberger et al., 2003). However, there is evidence that the dACC reacts to all conflicts and errors in general (Botvinick, Cohen, & Carter, 2004). The dACC has been described as a cortical alarm system, sensitive to any discrepancy in the environment, not just to discrepancies that relate directly to physical damage or social rejection (Eisenberger & Lieberman, 2004; Inzlicht, McGregor, Hirsh, & Nash, 2009; Shackman et al., 2011). Although it is true that an individual will not likely confuse a stubbed toe with being picked last for a soccer team, we suggest that the early-stage neural mechanisms for both these events, or for any perceived anomalies, share much in common, and that additional context is required to give them specificity.

The Meaning-Maintenance Model

The MMM focuses on people's compensatory responses to violations of expectations, termed meaning threats. The model posits that any perceived meaning threat produces unpleasant arousal that often lies outside of awareness, and is nonspecific to the causal stimulus. This arousal arguably serves to prompt people to identify the source of the perceived discrepancy and, if time and cognitive resources are sufficiently available, to accommodate to the unexpected event. For example, upon observing themselves freely choose to write an essay in favor of a tuition increase at their university, participants in an experiment might accommodate to this anomaly by changing their attitudes toward tuition increases.

In many cases, however, it is not possible to resolve the violation, either because the problem is too complex or because the source of the arousal has not been identified correctly. When this occurs, people may respond to the arousal by affirming any available unrelated schema to which they are committed. These affirmations of intact meaning frameworks serve to dispel the unpleasant sense that something is wrong. Consequently, disturbing experiences that are as explicit and complex as writing about

one's own death (Burke, Martens, & Faucher, 2010) or dealing with social rejection (Nash, McGregor, & Prentice, 2011), as well as experiences that are relatively implicit and benign, such as subliminally seeing incoherent word pairs (e.g., "quickly-blueberry"; Randles, Proulx, & Heine, 2011) or being presented with a change-blindness manipulation (Proulx & Heine, 2008), all lead to increased motivation to affirm unrelated beliefs. These kinds of affirmation responses have been identified in a number of different research paradigms, including work on terror management theory, self-affirmation, and uncertainty management (for reviews, see Heine et al., 2006; Proulx, Inzlicht, & Harmon-Jones, 2012).

The dACC has been theorized to be the source of the unpleasant arousal associated with uncertainty and violations of expectations (I. McGregor, Nash, Mann, & Phills, 2010), and strong adherence to belief systems that serve as affirmations, such as religion and political conservatism, inhibit activity throughout the ACC (Amodio, Jost, Master, & Yee, 2007; Inzlicht et al., 2009). The arousal caused by meaning threats is not always consciously accessible, which is a clear departure from the experience of physical pain or social distress. However, when participants are given an explanation for their unpleasant arousal (e.g., when they are told that it is due to a dietary supplement they have taken), they fail to show compensatory responses (Kay, Moscovitch, & Laurin, 2010; Proulx & Heine, 2008; Zanna & Cooper, 1974), which suggests that they are in fact experiencing some form of distress or negative affect that they have attributed to this other source. Given that many types of anomalous experiences can elicit the same affirmation response, and that the resultant arousal can be misattributed, the distress appears to be general enough that the source of arousal can be confounded in a person's mind.

The present research is predicated on four key findings in the literature: (a) Both physical and social pain are associated with activation in the dACC (e.g., Eisenberger et al., 2003), (b) the dACC is activated in response to anomalies (e.g., Botvinick et al., 2004), (c) social rejection can produce the same compensatory affirmation as other meaning threats (e.g., Nash et al., 2011), and (d) acetaminophen has been shown to reduce physical and social pain, as well as activation in the dACC (DeWall et al., 2010). These findings led us to predict that acetaminophen may also inhibit compensatory affirmation following meaning threats. We reasoned that participants who experienced a meaning threat after having consumed acetaminophen would fail to detect any increase in arousal and thus would not show the kinds of compensatory affirmation identified in previous research. Toward this end, we conducted two studies with different meaning threats and affirmations.

Study 1

Method

We recruited 121 participants (81 women, 40 men). The sample was predominantly of East Asian (45%), European (29%), and South Asian (12%) descent. Participants were offered $15 through flyers posted on campus or received partial course credit in psychology classes. The study was advertised as a general assessment of the cognitive and emotional impacts of acetaminophen.

In contrast to the procedure of DeWall et al. (2010; in which participants took acetaminophen multiple times a day for 3 weeks), our procedure called for participants to receive a single acute dose of acetaminophen, which was active in their system while they experienced the threat. Participants were randomly assigned to receive either 1,000 mg of Tylenol-brand acetaminophen (Rapid Release formula) or 1,000 mg of sugar (a placebo), packed in two opaque gel capsules. The experimenter was blind to both the type of capsules administered (coded bottles were used) and the version of the materials that participants completed.

The effects of acetaminophen are difficult to detect if one is not already in pain, so it was hard for participants to determine if they had taken the drug or a placebo. When taken orally, Tylenol's expected time to reach peak absorption is 45 to 60 min, and its ceiling effectiveness in adults occurs at 1,000 mg (Bertolini et al., 2006; Gibb & Anderson, 2008); this is also the maximum recommended single dose.

After receiving the capsules to ingest, participants were given 30 min of free time prior to working on filler tasks, which took approximately 25 min to complete. They then completed a writing task (mortality-salience manipulation), followed by measures of affect and social judgment (our index of compensatory affirmation). Our expectation was that among participants in the mortality-salience condition, those who had taken the placebo would show typical compensatory affirmation, whereas those who had taken Tylenol would not show this reaction.

Filler tasks. First, we asked participants to complete a number of materials not relevant to the task, to mask our specific hypothesis of interest. These tasks included a page of Sudoku puzzles, a memory task involving matching faces of individuals to their biographies, and a series of personality questionnaires that were not analyzed as part of the study.

Mortality-salience manipulation. Next, participants completed the standard-mortality salience manipulation: They wrote either two paragraphs about what will happen to their body after they die and how they feel about it or two paragraphs about dental pain (Burke et al., 2010). Terror management theorists have argued that thoughts about death produce a unique type of anxiety (Greenberg, Solomon, & Pyszczynski, 1997). Recently, however, a number of other theorists have argued that thinking about death is incompatible with everyday thoughts about relationships, plans, and ambitions (Heine et al., 2006; I. McGregor, Zanna, Holmes, & Spencer, 2001; Proulx et al., 2012), and that it leads to the same anxiety associated with other violations of expectations, such as frustrated social interactions or perceived incongruities. These arguments have been supported empirically, as viewing surreal art (Proulx, Heine, & Vohs, 2010), perceiving a visual anomaly (Proulx & Heine, 2008), and viewing subliminally presented incongruous word pairs (e.g., "role-fork"; Randles et al., 2011) have been shown to lead to the same compensatory affirmation as mortality salience.

The rationale behind using dental pain as a control is that it should be aversive, but should not create an experience of violated expectations or uncertainty, and thus should not lead to affirmation responses (H. A. McGregor et al., 1998). This control condition thus helps to rule out negative mood as an explanation for compensatory affirmation, which is why it is used as a standard control in mortality-salience paradigms (Burke et al., 2010).

Positive and Negative Affect Schedule. After the mortality-salience manipulation, participants completed the Positive and Negative Affect Schedule (PANAS; Watson, Clark, & Tellegen, 1988). This measure identifies the state of affect an individual is experiencing, using 20 different affect descriptors. Participants are asked to report how well each descriptor matches how they are feeling at the moment. This scale is often used to create a delay between the mortality-salience manipulation and the task assessing the dependent variable, and it typically reveals that the manipulation does not influence either positive or negative affect (Burke et al., 2010).

Social judgment survey. Finally, participants read a hypothetical arrest report about a prostitute and were asked to set the amount of the bail (on a scale from $0 to $999). This measure has been used in a number of other meaning-threat studies (Proulx & Heine, 2008; Proulx et al., 2010; Randles et al., 2011; Rosenblatt, Greenberg, Solomon, Pyszczynski, & Lyon, 1989). Participants are expected to increase the bond amount after experiencing a threat, because trading sex for money is both at odds with commonly held cultural views of relationships and against the law. Increasing the bond assessment provides participants an opportunity to affirm their belief that prostitution is wrong.

Results

During debriefing, participants were asked to guess which capsules they had consumed. Fifty-five percent claimed that they had no idea; of those who guessed, 57% were correct (not different from chance, p = .17). Data from 5 participants who did not complete the materials were removed from analysis.

Planned orthogonal contrasts were used to test our hypothesis. We chose this analysis because we were expecting one particular pattern of effects: that participants in the mortality-salience/placebo group would show higher compensatory affirmation compared with participants in the other three groups. As predicted, only participants who had experienced a meaning threat and had taken the placebo showed evidence of increased affirmation. Participants in the mortality-salience/placebo group (M = 443.19, SD = 299.15) punished the norm violator by a significantly larger amount than the other three groups did (control/placebo: M = 277.61, SD = 268.46; control/acetaminophen: M = 301.87, SD = 298.26; mortality-salience/acetaminophen: M = 313.89, SD = 253.66; see Fig. 1), $t(112)$ = 2.33, p = .02, d = 0.52 (97.5% confidence interval, CI = ±0.44[1]). Participants in the mortality-salience/acetaminophen group showed no compensatory affirmation compared with those in the two control groups, $t(112) < 1$, d = 0.09 (97.5% CI = ±0.45). The two control groups did not differ from each other, $t(112) < 1$, d = 0.09 (97.5% CI = ±0.50). As in previous meaning-threat studies, self-reported positive and negative affect did not differ between conditions (all ts < 1).

These results suggest that a drug that can alleviate mild pain, headaches, or hurt feelings (DeWall et al., 2010) can also reduce the affirmation responses that are generated when people consider their own mortality, which some theorists have argued threatens meaning (Heine et al., 2006; Proulx et al., 2012).
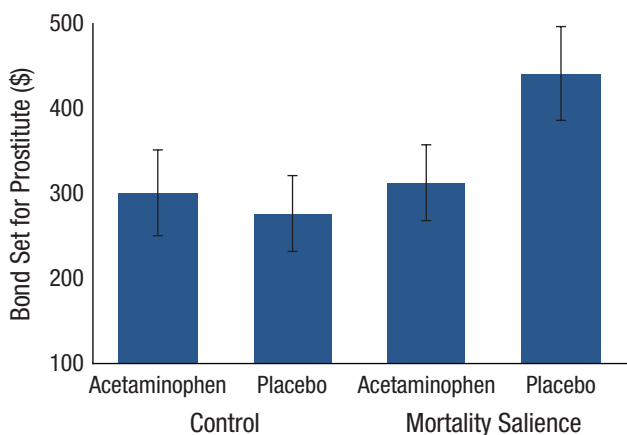

Fig. 1. Results from Study 1: mean bond value set for the prostitute as a function of group (mortality-salience vs. control condition crossed with placebo vs. acetaminophen condition). The scale ranged from $0 to $999. Error bars represent the standard error for each group.

Study 2

In Study 1, we employed the most commonly used manipulation of existential anxiety, mortality salience. To test whether acetaminophen affects uncertainty more broadly defined, we turned to a very different and novel manipulation in Study 2. Specifically, we turned to an artistic tradition that is known precisely for its ability to provoke feelings of discomfort and unease: surrealism. The surrealist tradition involves the juxtaposition of unfamiliar elements in familiar settings. Past research has found that surrealist art forms, including literature, paintings, and humor, lead to compensatory responses (Proulx & Heine, 2009; Proulx et al., 2010). The work of surrealist filmmaker David Lynch seemed especially apt for our needs. As his biographer Rodley (2005) noted, "the indefinable 'mood' or 'feeling' Lynch seeks to convey is linked to a form of intellectual uncertainty—what he calls being 'lost in darkness and confusion'" (p. x).

Method

Students were recruited through the same methods as in Study 1. Of the 236 who were recruited, 8 failed to complete the study because of technical problems, and the data from 21 participants were removed because they reported during an open-ended debriefing that they had participated in previous MMM experiments or had guessed that we were interested in their responses to Lynch's film. (The key effects still remained significant when these 21 participants were included in the analyses.) This left 207 participants (124 women, 83 men), who were predominantly of European (52%), East Asian (25%), and South Asian (7%) descent.

The procedure was identical to that in Study 1, with two differences. First, the meaning threat was changed. Participants in the meaning-threat condition watched three films. The first was a 2-min clip from a Donald Duck cartoon, designed to ease participants into the task. They then watched a 4-min clip from the short film *Rabbits*, created by David Lynch (2002). The film, which at first resembles a sitcom, consists of a series of non sequiturs, with seemingly random laugh and applause tracks separated by long portentous pauses, an eerie soundscape, a complete absence of a narrative, and characters inexplicably dressed in rabbit costumes. The clip is ominous, although it contains no reference to disturbing or unpleasant topics. After the *Rabbits* clip, participants watched a 2-min clip from a Snoopy cartoon, designed to serve as a distraction, or delay. As we were concerned that participants would identify *Rabbits* as critical to the study, we included an additional distractor beyond the PANAS to help reduce suspicion. Participants in the control condition saw the same videos except that the *Rabbits* clip was replaced with a 4-min clip from an episode of "The Simpsons" (all clips are available upon request).

We also changed the dependent measure. This study was conducted 3 to 6 months after a well-publicized local riot that followed the Vancouver Canucks' loss in their bid for the Stanley Cup, and we expected that most students held a negative view of the riot. Thus, we expected that after a threat, participants would affirm this view by calling for stronger punishment for the rioters. Participants were informed that people were debating whether the rioters should be given sentences more lenient than those for comparable individual acts of vandalism, because the rioters had acted impulsively, or should be given stiffer sentences, because they had taken advantage of the city while it was vulnerable. Participants then marked a spot on a line from 0% to 200%. They were told that 0% indicated that rioters should not be fined, that 100% indicated that rioters should receive a normal fine, and that 200% indicated that rioters should receive a doubled fine. (See Appendix A in the Supplemental Material available online for the materials used.)

Fig. 2. Results from Study 2: mean preference for the penalty to be given individuals convicted of vandalism or theft during the Vancouver hockey riot as a function of group (threat vs. control condition crossed with placebo vs. acetaminophen condition). The rating scale ranged from 0% (no fine for a conviction), through 100% (a normal fine), to 200% (a doubled penalty). Error bars represent the standard error for each group.

Results

Participants were unable to correctly identify whether they had taken acetaminophen or a placebo. Fifty-three percent claimed that they had no idea; of those who guessed, 45% were correct (not different from chance, $p = .29$). Participants in all conditions set the fine for the rioters at a higher value than the court would normally set (all ps < .001), which confirms our expectation that most students in our sample found the behaviors unacceptable.

As in Study 1, we used planned orthogonal contrasts to test whether participants in the threat-placebo group showed more compensatory affirmation than participants in the other three groups. Again, only participants who had experienced a meaning threat and had taken the placebo showed evidence of increased affirmation (see Fig. 2). Participants in that group wanted to punish the norm violators by a significantly larger amount than those in the other three groups did, $t(203) = 2.64$ $p < .01$, $d = 0.43$ (97.5% CI = ±0.32). Participants in the threat-acetaminophen group showed no compensatory affirmation compared with those in the two control groups, $t(203) < 1$, $d = 0.05$ (97.5% CI = ±0.34). There was no difference between the two control groups, $t(203) < 1$, $d = 0.09$ (97.5% CI = ±0.35). Again, there was no difference among the groups in self-reported positive or negative affect (all ts < 1.2, ps > .23).

Discussion

Two studies show that acetaminophen interrupts the typical compensatory responses to meaning threats. In the first study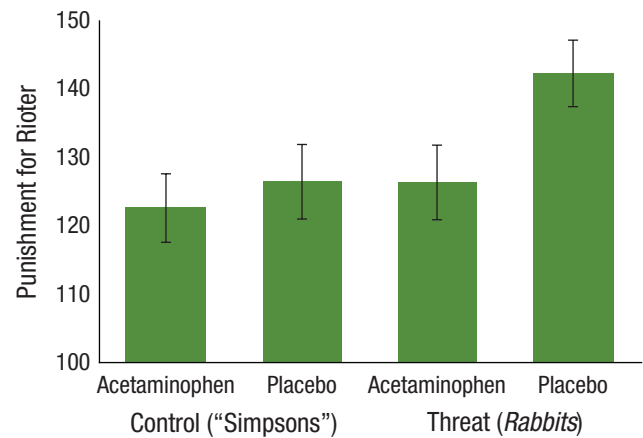, we found a typical mortality-salience reaction in the placebo condition, but participants in the mortality-salience condition who had taken acetaminophen responded in ways similar to those who had not contemplated their mortality. In the second study, this pattern of findings was replicated using a surreal video clip and a novel dependent measure; participants who had watched the David Lynch clip and taken a placebo were more punitive than those who had watched the same clip but consumed acetaminophen or who had watched the control video. In neither study were there any group differences in self-reported positive or negative affect, which renders it unlikely that the effects were simply due to people becoming more punitive because they were in a bad mood. Rather, we argue that a particular type of distress associated with expectancy violation (originating from the dACC) and a failure to correctly identify or be able to accommodate to the source of that distress led to this affirmation.

These results are consistent with the notion of a domain-general process for expectancy violation. Although there is some evidence that domain-specific responses to certain types of uncertainty or threat can occur (e.g., Burke et al., 2010; Rutjens & Loseman, 2010), a recent review of the threat-compensation literature underscored that similar psychological processes are implicated across different threats (Proulx et al., 2012).

Our findings imply that the similarities between physical pain and belongingness threats may not be specifically due to both kinds of threat triggering something akin to pain; rather, the similarities may arise because both typically involve a violation of expectations. This is not to say that uncertainty is a necessary feature of pain, but we are arguing that pain (and social failure) is often

brought about by unexpected consequences to behaviors or actions. In reviewing the literature on the dACC, Shackman et al. (2011) argued that "the core function common to negative affect, pain and cognitive control is the need to determine an optimal course of action in the face of uncertainty" (p. 160).

However, one disconnect between the present findings and current data on the dACC is that the manipulations we used, and indeed many manipulations of uncertainty or existential anxiety (e.g., Burke et al., 2010), do not lead to changes in self-reported affect as measured by the PANAS. Studies that have measured dACC activation following physical pain, social pain, and frustration have found an association with self-reported negative affect (e.g., DeWall et al., 2010; Eisenberger & Lieberman, 2004; Spunt, Lieberman, Cohen, & Eisenberger, 2012), and a recent meta-analysis of brain-imaging studies found that the dACC was activated in response to manipulations that induced fear, anger, or disgust (Shackman et al., 2011). There are several possible reasons for this disconnect. It could be (a) that the PANAS does not tap into the kinds of negative affect associated with expectancy violations, (b) that asking participants about how they are generally feeling at the moment is less likely to reveal measurable differences between conditions compared with asking how they felt about the threat in particular (as Spunt et al., 2012, did), or (c) that people do not always have conscious access to the arousal elicited from expectancy violations.

Our studies have a number of limitations and suggest several future research directions. First, it is unclear how well our findings would generalize to other samples. However, research on terror management theory finds effects in the same direction across a broad array of samples, although Americans and college students show stronger effects than other samples (Burke et al., 2010). We therefore anticipate that the findings we obtained would also be obtained, with a weaker magnitude, in other samples. Second, acetaminophen affects a number of brain regions, some of which are not directly related to physical or social distress (Toussaint et al., 2010). Therefore, our findings could have been due to acetaminophen (a) reducing participants' felt arousal when they witnessed violations, (b) interrupting the trigger for the affirmational response without affecting participants' experience of arousal, (c) making participants less attentive so they never noticed the violation to begin with, or (d) affecting some of the cognitive processes involved in completing the dependent measures. Although our studies were inspired by the neurological links among physical pain, social pain, and expectancy violation, further work will be needed to confirm that overlapping neurological structures are involved.

We also do not know whether other pain relievers would have the same kind of inhibiting effects. Given the past work that inspired this research (see the introduction), it seems possible that any drug that inhibits pain via the central nervous system might be effective, but this possibility has yet to be tested, two exceptions being that marijuana has also been found to reduce both physical pain and social pain (Deckman, DeWall, Way, Gilman, & Richman, 2012) and that the tranquilizer phenobarbital reduces attitude change following induced compliance (Cooper, Zanna, & Taves, 1978).

An additional hypothesis that emerges from these findings is that acetaminophen may reduce felt uncertainty not only during unexpected negative events, but also during positive ones (e.g., receiving a surprise promotion at work). Consistent with this hypothesis are findings that fluid compensation emerges from positive expectancy violations, such as seeing a doctored photo of oneself that increases one's attractiveness (Proulx & Randles, 2010), and evidence that the ACC does respond to positive feedback if negative feedback was expected (Oliveira, McDonald, & Goodman, 2007)

Our findings raise several questions, and a fuller understanding could be achieved through employing alternative measures of distress (e.g., psychophysiological measures, functional MRI), painkillers (e.g., acetylsalicylic acid), kinds of meaning violations (e.g., cognitive dissonance), compensatory measures (e.g., pattern learning, increased beliefs in God), and samples (e.g., young children). Despite the many questions that these findings raise, they do demonstrate that acetaminophen has more far-reaching psychological consequences than previously realized, and that a single pill can serve as an effective manipulation in the lab.

Declaration of Conflicting Interests

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Supplemental Material

Additional supporting information may be found at http://pss.sagepub.com/content/by/supplemental-data

Note

1. Point and interval estimates for Cohen's *d* are based on recommendations in Robey (2004).

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