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The common pain of surrealism and death:

Acetaminophen reduces compensatory affirmation following meaning threats

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ABSTRACT

The meaning maintenance model argues 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 it inhibits physical pain or the distress caused by social rejection. Across 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 either wrote about their death or a control topic. In Study 2, participants either watched 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 towards law-breakers, while 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 it's the 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 are recognized for their ability to "disturb, offend or mystify" (Rodley, 2005, pg. 245). Insofar as it "hurts" to watch some of Lynch's films, as it arguably does whenever we are assaulted by thoughts and experiences that are at odds with our expectations and values, we might question how this uncomfortable feeling is represented in the brain. In this paper 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, to suggest that any unexpected event, not just those with a physical or social component, produces the same initial neural and subjective experience of distress. Based on this, we argue that acetaminophen, shown to reduce both physical and social pain, will also prevent typical meaning maintenance responses.

Pain and rejection

Both physical pain and social rejection share a neural process and subjective component that is experienced as distress (Eisenberger & Lieberman, 2004; MacDonald, & Leary, 2005). While there are experiences unique to each 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 experiencing more or less of one type of pain, 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, anti-depressants, 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 events is the dorsal anterior cingulate cortex (dACC). The dACC responds to physical and social pain (Eisenberger, Lieberman, & Williams, 2003) and its activation is correlated with subjective reports of felt unpleasantness after physical pain (Tölle et al., 1999) and 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 those that relate directly to physical damage or social rejection (Eisenberger & Lieberman, 2004; Inzlicht, McGregor, Hirsh, & Nash, 2009; Shackman et al., 2011). While it is true then, that an individual will likely not 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 anomaly, share much in common and require additional context 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 argues that any perceived meaning threat produces unpleasant arousal that often lies outside of awareness, and is non-specific 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, accommodate to the unexpected event. For example, upon observing oneself freely choose to write an essay in favor of a tuition increase at one's university, a participant might accommodate to this by changing their attitudes towards tuition increases. In many cases, however, it is not possible to resolve the violation, either because the problem is too complex, or the person has failed to correctly identify the source of their arousal. 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), down to 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, such as 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 (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 pain or social distress. However, when participants are given an explanation for their unpleasant arousal (e.g., being told that it is due to a supplement they have taken) they attribute their distress to this other source and fail to show compensatory responses (Kay, Moscovitch, & Laurin, 2010; Proulx & Heine, 2008; Zanna & Cooper, 1974), suggesting that they are in fact experiencing some form of distress or negative affect. Given that many types of anomalous experiences can elicit the same affirmation response, and that the resultant arousal can be misattributed, it suggests that the distress is general enough that the source of arousal can be confounded in the person's mind.

The present research is predicated on four key findings of the literature: 1) both physical and social pain are associated with activation in the dACC (e.g., Eisenberger et al., 2003); 2) the dACC is activated in response to anomalies (e.g., Botvinick et al., 2004); 3) social rejection can produce the same compensatory

affirmation as other meaning threats (e.g., Nash et al., 2011); and, 4) acetaminophen has been shown to reduce physical and social pain and 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 not show the kinds of compensatory affirmation identified in previous research. Towards this end we conducted two studies with different meaning threats and affirmations.

METHOD

Participants and procedure

We recruited 121 participants (81 women). 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 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 three weeks), participants in the present study received a single acute dose of acetaminophen, which was active in their system while they experienced the threat. Participants were randomly assigned to receive either 1000mg of Tylenol brand acetaminophen (Rapid Release™ formula) or 1000mg of sugar (a placebo), packed in two opaque gel capsules. The researcher was blind to both the type of capsules administered (using coded bottles) and the version of the materials that participants completed.

The effects of acetaminophen are difficult to detect if one is not already in pain, making it hard to identify if one has taken a drug or placebo. When taken orally, Tylenol's expected time to reach peak absorption is 45-60 minutes, and its ceiling effectiveness in adults occurs at 1000mg (Bertolini et al., 2006; Gibb & Anderson, 2008); this is also the maximum recommended single dose.

After receiving the capsules to ingest, participants were given free time for 30 minutes prior to working on filler tasks, which took approximately 25 minutes to complete. They then completed the mortality salience or dental pain paragraphs, followed by the Positive and Negative Affect Schedule (PANAS) and the prostitution bond scenario (all materials described below). Our expectation was that participants in the placebo condition who received the mortality salience manipulation would show typical compensatory affirmation, while those who had taken Tylenol would not show this reaction.

Materials

Filler tasks. We asked participants to complete a number of materials not relevant to the task, to mask our specific hypothesis of interest. These included a page of Sudoku puzzles, a memory task 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. Participants completed the standard mortality salience manipulation: they either wrote 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 produced 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; 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, where mortality salience has been shown to lead to the same compensatory affirmation as viewing surreal art (Proulx, Heine, & Vohs, 2010), perceiving a visual anomaly (Proulx & Heine, 2008) or viewing subliminally-presented incongruous word-pairs (e.g. role-fork; Randles et al., 2011).

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

Positive and Negative Affect Schedule. This measure identifies the state of affect an individual is experiencing, based on twenty different affect descriptors. Participants are asked how they are feeling at the moment (Watson, Clark, & Tellegen, 1988). This scale is often used as a delay between the mortality salience manipulation and the dependent variable, and typically reveals that the manipulation does not influence either positive or negative affect (Burke et al., 2010).

Social judgment survey. Participants read a hypothetical arrest report about a prostitute and were asked to set the amount of the bail (from \$0-\$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 value after a threat, because trading sex for money is both at odds with commonly held cultural views of relationships, as well as being against the law. Increasing the bond assessment provides participants an opportunity to affirm their belief that prostitution is wrong.

RESULTS

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

Planned orthogonal contrasts were used to test our hypothesis. We chose this analysis because we were expecting one particular pattern of effects: namely that the threatened group that received a placebo would show higher compensatory affirmation compared to 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 threat/placebo group punished the norm violator by a significantly larger amount than the other three groups, $t_{112}=2.33$,

$p=.02$, $d=.52 \pm .44$ CI_{.975} (See Figure 1)¹. Participants in the threat/acetaminophen group showed no compensatory affirmation compared to the two control groups, $t_{112}<1$, $d=.09 \pm .45$ CI_{.975}. The two control groups did not differ, $t_{112}<1$, $d=.09 \pm .50$ CI_{.975}. As with previous meaning threat studies, no differences between conditions emerged for self-reported positive or negative affect (all $ts<1$).

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

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. We turned to an artistic tradition which 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; p. x) noted, “the

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

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.’”

METHODS

Students were recruited through the same methods as Study 1. Of the 236 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 guessed that we were interested in their responses to the Lynch film. The key effects still remain significant if these 21 participants are included in the analyses. This left 207 participants (124 women), who were predominantly of European (52%), East Asian (25%), and South Asian (7%) descent.

The paradigm was identical to Study 1, with two differences. First, the meaning threat was changed. Participants in the meaning threat condition watched 3 films. First, was a 2-minute clip from a *Donald Duck* cartoon, designed to ease participants into the task. They then watched a 4-minute clip from the short film, *Rabbits*, created by David Lynch. The film, which at first resembles a sit-com, consists of a series of non-sequiturs, 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 then watched a 2-minute clip from *Snoopy*, designed to serve as a distraction/delay, followed by the PANAS. As we were concerned that participants would identify *Rabbits* as critical to the study, adding an

additional distractor beyond the PANAS was expected to help reduce suspicion. Participants in the control condition saw the same videos except the *Rabbits* clip was replaced with a 4-minute clip from a *Simpsons* episode (all clips available upon request).

We also changed the dependent affirmation measure. This study was conducted 3-6 months after a well-publicized local riot that followed the loss of the Vancouver Canucks bid for the Stanley Cup, and we expected that most students held a negative view of this event. Thus, after a threat, participants should affirm this view by calling for stronger punishment for the rioters. Participants were informed that people were debating whether the rioters should be given more lenient sentences than comparable individual acts of vandalism, because they acted impulsively, or stiffer sentences because they took advantage of the city while it was vulnerable. Participants then marked a spot on a line connecting the endpoints, indicating that rioters should not be fined or jailed (0%) to a doubled fine or sentence (200%), with a normal fine or sentence (100%) lying at the midpoint. (See Appendix A in the Supplementary Materials online for measure).

RESULTS

Participants were unable to correctly identify whether they had taken acetaminophen or a placebo: 53% claimed 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 rioter at a higher value than the court would normally set (all $ps<.001$), which confirms our expectations that most students in our sample found the behaviors unacceptable.

As in Study 1 we used planned orthogonal contrasts to test whether the placebo-threat condition showed more compensatory affirmation than the other conditions. Again, only participants who had experienced a meaning threat and had taken the placebo showed evidence of increased affirmation. Participants in the threat/placebo group punished the norm violator by a significantly larger amount than the other three groups, $t_{203}=2.64$ $p<.01$, $d=.43 \pm .32$ CI_{.975} (See Figure 2). Participants in the threat/acetaminophen group showed no compensatory affirmation compared to the two control groups, $t_{203}<1$, $d=.05 \pm .34$ CI_{.975}. There was no difference between the acetaminophen and placebo groups for the control manipulation, $t_{203}<1$, $d=.09 \pm .35$. Again, there was no difference between 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 identified a typical mortality salience reaction in the placebo group, but those who had taken acetaminophen responded in ways similar to those who did not contemplate their mortality. In the second study, these findings were replicated using a surreal video clip and a novel dependent measure, showing that participants who watched the David Lynch clip and took a placebo were more punitive than those who had consumed acetaminophen or who had watched the control video. In neither study were there any differences in self-reported positive or negative affect, which renders it unlikely that the effects were simply a function of 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 lead 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 how 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 them both triggering something akin to pain, but rather that they both typically involve a violation of expectations. This is not to say that uncertainty is a necessary feature of pain, but that pain (as with social failures) is often brought about by unexpected consequences to behaviors or actions. In reviewing the literature on the ACC, Shackman et al. (2011) argue that the “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 our results, and 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 produced 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 multiple possibilities for this disconnect. It could be that a) the PANAS does not tap into the kinds of negative affect associated with expectancy violations, b) asking participants about how they feel right now is less effective than asking how they felt *about the threat* (as Spunt et al. (2012) did), or c) people might not always have conscious access to the arousal elicited from expectancy violations.

These 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. Research on terror management theory finds effects of 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 obtained here would also be of the same direction yet weaker in magnitude in other samples. A second limitation is that acetaminophen affects a number of brain regions, some not directly related to physical or social distress (Toussaint et al., 2010). Thus, there are several possible explanations for our findings. First, acetaminophen might reduce felt arousal upon witnessing violations. Second, participants may experience the same arousal, but the trigger for the affirmational response may be interrupted by the drug. Third, the presence of the drug may make participants less attentive so they never notice the violation to begin with. Fourth, acetaminophen could potentially affect some of the cognitive

processes involved in completing the dependent measures. Although our studies were inspired by the neurological link between 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 kinds of inhibiting effects. Given the past work that inspired this research (see introduction) it seems possible that any drug that inhibits pain via the central nervous system might be effective, but this 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 not only reduce felt uncertainty during unexpected negative events, but also positive ones (such as receiving a surprise promotion at work). Consistent with this hypothesis are findings that fluid compensation also emerges from positive expectancy violations, such as participants seeing a doctored photo of themselves that makes them look more attractive (Proulx & Randles, 2010) and evidence that the ACC does respond to positive feedback, if negative feedback was expected (Oliveira, McDonald & Goodman, 2007)

The findings raise several questions, and a fuller understanding could be achieved through employing alternative measures of distress (e.g., psychophysiological measures, fMRI), 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 far more reaching psychological consequences than previously realized, and that a single pill can serve as an effective manipulation in the lab.

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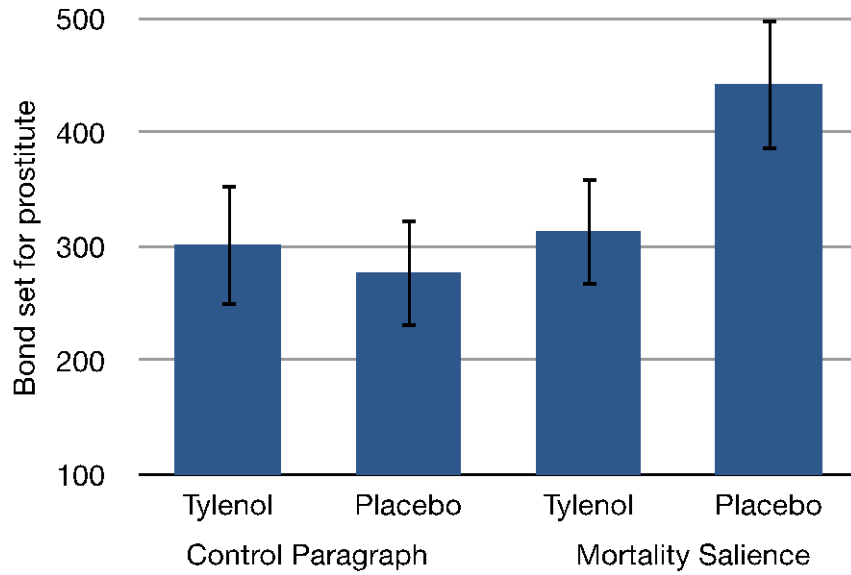
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Figure 1

Bond values set for prostitute described in the social judgment

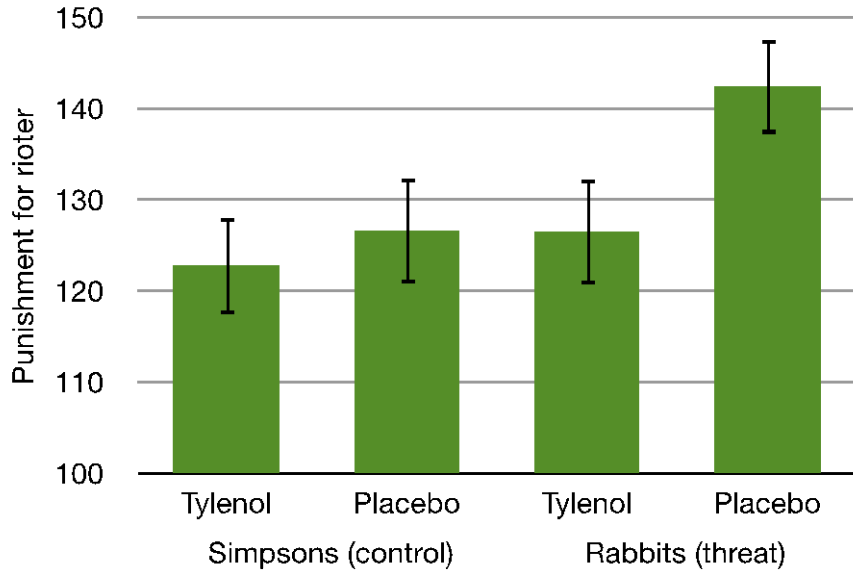


survey

Note: Scale ranged from \$0 – \$999. Error bars represent the standard error for each group.

Figure 2

Increased penalty percentage (fine or jail time) for someone convicted of vandalism or theft during the Vancouver hockey riot.



Note: Scale ranged from 0% (no fine or jail time for a conviction, through 100% (a normal fine or jail time is appropriate) to 200% (the normal penalty should be doubled). Bars represent the standard error for each group.