

2012

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### Repository Citation

Gailliot, Matthew T., "Mortality Salience and Metabolism: Glucose Drinks Reduce Worldview Defense Caused by Mortality Salience" (2012). *Faculty Publications*. 7.  
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# Mortality Salience and Metabolism: Glucose Drinks Reduce Worldview Defense Caused by Mortality Salience

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Received August 23<sup>rd</sup>, 2012; revised September 23<sup>rd</sup>, 2012; accepted October 21<sup>st</sup>, 2012

The current work tested the hypothesis that a glucose drink would reduce worldview defense following mortality salience. Participants consumed either a glucose drink or placebo, wrote about either death or dental pain, and then completed a measure of worldview defense (viewing positively someone with pro-US views and viewing negatively someone with anti-US views). Mortality salience increased worldview defense among participants who consumed a placebo but not among participants who consumed a glucose drink. Glucose might reduce defensiveness after mortality salience by increasing the effectiveness of the self-controlled suppression of death-related thought, by providing resources to cope with mortality salience and reducing its threatening nature, or by distancing the individual from actual physical death.

*Keywords:* Mortality Salience; Glucose; Metabolism; Worldview Defense

## Introduction

Reminders of mortality are commonplace, yet people often avoid thinking about death because thoughts of dying can be personally threatening (e.g., Aries, 1981; Becker, 1973). The threatening nature of mortality triggers defensive reactions that function to reduce awareness of death (e.g., Florian & Mikulincer, 1997; Greenberg et al., 1990; Heine, Harihara, & Niiya, 2002; Landau et al., 2004; Ochsman & Mathey, 1994). The current work focused on the biology of responses to death reminders. It is posited that avoiding thoughts of death is demanding, psychological work that requires additional metabolic energy. When metabolic energy is low, death should be more threatening. The prediction therefore was that lower glucose—the primary energy for the brain—would increase defensive responding to mortality reminders.

There are at least three reasons why low glucose should be linked with increased defensiveness after mortality salience. One is that low glucose might impair the effortful, controlled suppression of death thoughts and thus increase defensive reactions to death reminders. Thoughts of death are avoided and suppressed (e.g., Aries, 1981; Becker, 1973; Feifel & Branscomb, 1973; Greenberg, Pyszczynski, Solomon, Simon, & Breus, 1994; Harmon-Jones, Simon, Greenberg, Pyszczynski, Solomon, & McGregor, 1997; Pollak, 1979, 1980). The avoidance or suppression of death thoughts is effortful and demanding (Arndt et al., 1997; Greenberg et al., 2001), and requires controlled or executive processes (Greenberg et al., 1994; Harmon-Jones et al., 1997; Pyszczynski, Greenberg, & Solomon, 1999; Wegner, 1994). For instance, after thinking about mortality, death thoughts are suppressed and less accessible to awareness (e.g., Arndt, Greenberg, Solomon, Pyszczynski, & Simon, 1997; Greenberg et al., 1994; Harmon-Jones et al., 1997). Factors that impair controlled or executive processing (e.g., a cognitive load) undermine such suppression, however, and increase the accessibility of death thoughts (Arndt et al., 1997; Greenberg, Arndt, Schimel, Pyszczynski, & Solomon,

2001; Smart & Wegner, 1999; Wegner & Zanakos, 1994; Wenzlaff & Wegner, 2000).

In particular, thought suppression requires self-control (e.g., Baumeister, Tice, & Heatherton, 1994; Wegner, 1994). Thus, people with good (v. poor) trait self-control appear less susceptible to thinking about death (Gailliot, Schmeichel, & Baumeister, 2006). Ample evidence indicates that exerting self-control impairs subsequent self-control (for reviews, see Baumeister, Vohs, & Tice, 2007; Muraven & Baumeister, 2000; Gailliot, 2009). Consistent with these findings, suppressing thoughts impairs subsequent self-control (e.g., Gordijn, Hendriks, Koomen, Dijksterhuis, & Van Knippenberg, 2004; Muraven et al., 1998), as does mortality salience. Mortality Salience has been found to impair performance on tasks requiring self-control, such as the Stroop task, solving anagrams, and effortful persistence tasks (Gailliot et al., 2006; Gailliot et al., 2007). The idea is that, after thinking about death, people use self-control to suppress thought related to death, and this impairs subsequent self-control. One study found that regulating emotions increased death thoughts among participants with poor trait self-control but not among participants with good trait self-control (Gailliot, Schmeichel, & Maner, 2007). Regulating emotions weakened self-control, thereby increasing the accessibility of death-related thought, except among people with dispositionally good self-control. These findings indicate that self-control allows for the suppression of death related thought.

Self-control, controlled processing, and effortful exertion use a relatively large amount of glucose, are better with optimal glucose levels in the bloodstream, and are impaired by low glucose or other metabolic problems (DeWall, Baumeister, Gailliot, & Maner, 2008; Fairclough & Houston, 2004; Gailliot, 2008; Gailliot & Baumeister, 2007; Gailliot et al., 2007; Gailliot, Peruche, Plant, & Baumeister, 2009; Masicampo & Baumeister, 2008). This indicates that the suppression of death-related thought after mortality salience is improved by glucose and impaired by low glucose or metabolic problems. Consistent with this rationale, mortality salience impaired self-control (i.e.,

it reduced persistence at solving word fragments) in one study among participants who had consumed a placebo but not a glucose drink (Gailliot et al., 2007). The glucose drink presumably provided metabolic energy for self-control that had been depleted by suppressing thoughts of death. A few studies suggest that mortality salience might increase attempts to increase one's metabolic energy, such as increasing the desire to buy food and to increase eating (Friese & Hofmann, 2008; Mandel & Smeesters, 2008; cf. Goldenberg, Arndt, Hart, & Brown, 2005). Perhaps mortality salience increases rating because people seek energy that can be used to avoid thinking about death.

Effortful thought suppression reduces the implicit and explicit accessibility of suppressed thoughts (Anderson & Green, 2001; Arndt et al., 1997; MacLeod, 1989; McBride & Doshier, 1997; Pyszczynski et al., 1999). Individuals with optimal glucose levels therefore should be more successful in suppressing death thoughts. When mortality is salient, people respond defensively by increasing support for their worldviews, such as by reacting more positively toward people who support their cultural norms and values and more negatively toward those who disagree with their cultural norms and values (e.g., Florian & Mikulincer, 1997; Greenberg et al., 1990; Heine, Harihara, & Niiya, 2002; Landau et al., 2004; Ochsman & Mathey, 1994). Because glucose might enable more effective suppression of death thoughts and reduce their accessibility, then it should reduce defensive reactions to mortality salience. Consistent with this hypothesis, consuming food (v. eating nothing) reduced worldview defense caused by mortality salience, in the form of less negative judgments of worldview transgressions (Hirschberger & Ein-Dor, 2005). The food provided glucose that may have enabled more effective suppression of death-related thought and consequently less worldview defense.

A second reason that glucose should influence worldview defense following mortality salience is derived from research on personal threat. Perceptions of threat tend to occur when the demands of the threat exceed resources available to cope (Blascovich & Tomaka, 1996; Blascovich & Mendes, 2000). Glucose is one resource used to cope with (i.e., suppress or avoid) thoughts of death. When it is low, death reminders should be more threatening. Defensive reactions therefore should be stronger. It is possible that mortality salience might increase eating (Friese & Hofmann, 2008; Mandel & Smeesters, 2008) partly because individuals seek metabolic resources (e.g., glucose) to cope with the threat of death.

The third reason that glucose should reduce defensive reactions to death reminders is that glucose is one substrate that determines both the physical and psychological threat of death. When glucose is low, physical death is more likely (e.g., from starvation, a weakened immune system, or a reduced capacity for energy demanding thought and behavior that aids in survival) and death is more threatening psychologically, as the individual should be less able to cope. Death reminders therefore should be more threatening both physically and psychologically when glucose is low, thereby leading to stronger defensive reactions.

Thus, defensive reactions to mortality salience should be reduced with additional glucose. Glucose might enable more effective suppression of death-thoughts and/or reduce the extent to which death is perceived as physically or psychologically threatening. To test this hypothesis, participants wrote about either death or a control topic, consumed a glucose drink or placebo, and then completed a measure of worldview defense.

The prediction was that mortality salience would increase worldview defense but that this effect would be attenuated among participants who consumed a glucose drink.

## Method

### Participants

The final sample included 93 college undergraduates (73 women, 20 men) who participated in exchange for extra credit toward a course grade. Excluded from this sample were 8 participants who failed to complete the required experimental materials and 13 participants who failed to drink the assigned beverage. The dependent measure of worldview defense pertained to American values and attitudes toward foreigners, and so 19 participants of non-US (foreign) ethnicities were excluded from the final sample.

### Materials and Procedure

Participants first consumed 14 ounces of lemonade sweetened with either sugar (glucose condition) or a sugar substitute (placebo condition). The glucose drink contained approximately 140 calories, whereas the placebo contained 0 calories. Participants and the experimenter were blind to condition.

Next, participants wrote about either death or a control topic (dental pain). Participants in the mortality salience condition were asked to describe the emotions, the thought of their own death aroused in them and to write about what would happen to their bodies as they physically die (Rosenblatt, Greenberg, Solomon, Pyszczynski, & Lyon, 1989). Participants in the dental pain condition answered the same questions except they were about dental pain rather than death.

The effects of the mortality salience manipulation used typically emerge only after a short delay or distraction (Pyszczynski et al., 1999). To provide this delay and distraction, and to allow sufficient time for the glucose (if any) in the drinks to be metabolized, participants completed measures of liking and taste for the drinks and a measure of mood and arousal. Specifically, they indicated the extent to which the drink tasted good, sweet, bitter, and salty, had good texture and appearance, was difficult to drink, was pleasant to drink, and how much they liked the drink. They then completed the Brief Mood Introspection Scale (BMIS; Mayer & Gaschke, 1988). The BMIS contains 20 items indicative of mood (e.g., happy, sad) and arousal (e.g., peppy, drowsy). Participants rated each item to indicate how they were feeling at the present moment, using a scale from 1 (*definitely do not feel*) to 7 (*definitely feel*).

Last, participants completed a measure of worldview defense. Specifically, participants read two handwritten essays about the United States that were ostensibly written by two foreigners (borrowed from Greenberg, Simon, Pyszczynski, Solomon, & Chatel, 1992). The order of the two essays was counterbalanced across participants. One essay was pro-US and praised Americans, whereas the other essay was anti-US and criticized Americans. Participants evaluated the truth and validity of the essay and the likeability, intelligence, and knowledge ability of each essay's author on 9-point scales. The summed evaluations of each essay served as the measures of favorability toward worldview-consistent and worldview-inconsistent opinions, respectively. In accord with past research (e.g., Greenberg et al., 1994), worldview defense was defined as the difference between these two measures. Larger differences indicate more

pronounced worldview defense.

## Results

A 2 (Drink condition: Glucose drink vs. placebo)  $\times$  2 (Essay condition: Mortality salience vs. dental pain) analysis of variance (ANOVA) on worldview defense scores indicated a significant interaction,  $F(1,89) = 4.04, p < .05$ . See **Figure 1** for means. Tests of simple effects indicated that mortality salience, compared to dental pain salience, increased worldview defense in the placebo condition,  $F(1,42) = 4.23, p < .05$ , but not in the glucose-drink condition,  $F < 1, ns$ . Thus, mortality salience did not increase worldview defense among participants who consumed a glucose drink.

Analyses indicated that these results were not attributable to differences in taste, appearance, or likeability between the two drinks or to mood or arousal. Specifically, separate 2 (Drink condition: Glucose drink vs. placebo)  $\times$  2 (Essay condition: Mortality salience vs. dental pain) ANOVAs on taste, sweetness, bitterness, saltiness, texture, appearance, pleasantness, and likeability of the drink, as well as on how difficult the drink was to consume and on mood indicated no significant interactions,  $F_s < 2.03, p_s > .15$ . A 2  $\times$  2 ANOVA on arousal indicated a marginally significant interaction,  $F = 3.26, p = .07$ , suggesting the highest arousal among participants in the placebo condition who wrote about death. The 2-way interaction between drink and essay conditions on worldview defense remained marginally significant when controlling for arousal,  $F = 3.20, p = .08$ , however, indicating that the effects were not driven by arousal.

## Discussion

Consistent with past work, the current study found that mortality salience increased worldview defense. This effect occurred only among participants who consumed a placebo, however, and not among participants who consumed a glucose drink. The rationale was that glucose would reduce worldview defense because it allows for more effective suppression of death-related thought via self-control, is a resource used to cope with death (thus the threatening nature of mortality salience

should be reduced), and/or is a signal that death is more threatening physically and thus psychologically. Glucose reduces defensive reactions to mortality salience, whereas low glucose predisposes individuals to increased defensiveness after mortality salience.

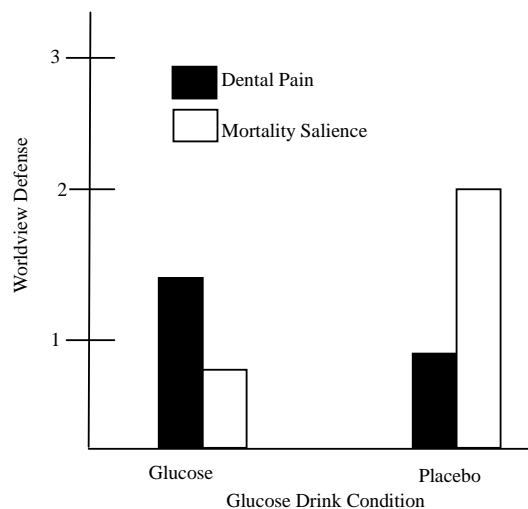
Past work has shown that mortality salience has a cognitive cost. It activated controlled suppression mechanisms that impair self-control afterwards (Gailliot et al., 2006; Gailliot et al., 2007). The current work suggests that mortality salience might also have metabolic costs. Suppressing thoughts of death could plausibly reduce glucose faster than it is replenished.

Another implication is that glucose can be used as an aid to help people cope with death or suppress or avoid death-related thought. Rather than respond defensively, which can often entail derogating others, a glucose drink might quell at least some of the potential terror elicited by thoughts of death. Metabolic problems aside from low glucose (e.g., hunger, malnourishment) might also moderate defensive reactions to death.

Diabetes and glucose-6-phosphate dehydrogenase deficiency, two metabolic disorders, have been linked with reduced aggressive restraint (DeWall, Gailliot, Deckman, & Bushman, 2009), one form of self-control, suggesting that these disorders might relate to reactions to mortality salience as well.

The amount of metabolic energy that can be used during a given amount of time is limited (Klieber, 1961). A large body of evidence demonstrates that energy used by one process therefore can be diverted away from others (Gailliot, Hildebrandt, Eckel, & Baumeister, 2009). Hence, processes that influence glucose (e.g., immune defense, biological reproductive activity, stress) could also influence defensive responding to mortality salience. Cancer cells, for instance, use a disproportionately large amount of glucose (Schoen et al., 1999; Weber et al., 2003; Younes, Lechago, Somoano, Mosharaf, & Lechago, 1996). Some evidence suggests that their metabolic-energy use might divert energy away from and thereby impair frontal lobe functioning (Cleeland et al., 2003; Meyers, Albitar, & Estey, 2005; Meyers, Byrne, & Komaki, 1995). Individuals with cancer therefore might especially struggle to avoid thinking about death or engaging in defensive responses not only because of their potentially terminal condition but also because the cancer cells might divert metabolic energy away from the suppression of death-related thought or contribute to low glucose levels that predispose toward heightened defensiveness. Metabolic activity increases in the ovaries during premenstrual syndrome, and these increases appear to divert energy from and impair self-control (Gailliot et al., 2009). Women therefore might be especially likely to engage in defensive responding to mortality salience while experiencing premenstrual syndrome symptoms.

Evidence indicates that the psychological capacity for some processes operates through the existence of earlier, biological systems (e.g., morality and disgust, Wheatley & Haidt, 2005; emotional and physical pain, DeWall & Baumeister, 2006; Eisenberger & Lieberman, 2004; Eisenberger, Lieberman, & Williams, 2003; MacDonald & Leary, 2005). Processes enacting self-control rely heavily on glucose levels (e.g., Gailliot & Baumeister, 2007; Gailliot et al., 2007). If metabolite levels are indicative of survival capacity, with low glucose indicating a greater threat of death (e.g., increased weakness and hunger), then it is possible that the capacity for self-control operates on a preexisting metabolic system that alerts one to the threat of death. Thus, it is the same system that alerts one to the possibility of physical death and that manages psychological thoughts



**Figure 1.** Worldview defense as a function of essay and drink conditions.

of death.

Work from evolutionary psychology suggests that people think and behave in ways functional to goal attainment, such as perceiving increased threat from others when afraid or increased sexual interest when sexually aroused (Maner, Gailliot, & DeWall, 2007; Maner et al., 2005). The current findings suggest a functional response concerning low glucose and mortality. When glucose is low, the individual is in a weaker, more vulnerable state, and thoughts of death might come to mind more readily. The thoughts of death function to increase the individual's connection to culture, which facilitates survival. It is functional that, in a weakened state, thoughts of death might increase so as to mesh the individual in a stronger system that facilitates survival.

Evolution is viewed mostly in terms of natural selection based on survival and reproduction. One underemphasized view is that natural selection operates in terms of energy (Gilliland, 1978; Lotka, 1922; Odum, 1995). Organisms that acquire, use, and control larger amounts of energy tend to survive and reproduce, as will those that are more efficient. Organisms that do not maximize energy are selected against. Over time, species increase their capacity to process or control larger amounts of energy. People have evolved so as to be capable of sustaining and being part of a larger cultural system (Baumeister, 2005). Culture clearly is a high energy system, providing people with energy (e.g., oil, food) or energy-saving devices (e.g., machines for transportation, vaccines that aid in immune defense). It is fitting that people strengthen their ties to culture after mortality salience when their biological energy (glucose) is low. When personal energy is low, people seek a system that provides energy, consistent with the idea that thoughts and behaviors have been naturally selected to promote the control of higher amounts of energy.

Future work on the topic of glucose and mortality salience should examine what mediates the current effects. Theoretical and empirical arguments suggest that glucose reduces world-view defense after mortality salience because people are more effective at the self-controlled suppression of death-related thought, less threatened by death, or more distant from actual physical death. Any of these could potentially mediate the current effects.

Humans are metabolic organisms. Life is a process of acquiring and using metabolic energy. To stop the metabolic flow is to end life, to reduce the metabolic flow is to tend closer to death. Likewise, when glucose is low, death might be more threatening in that people respond more defensively to mortality reminders. This new perspective on the management of mortality concerns and metabolism raises numerous exciting avenues for future research.

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