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The Gargle Effect: Rinsing the Mouth With Glucose Enhances Self-Control

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It has become increasingly clear that engaging in self-control on one task can impair self-control on a subsequent task (Baumeister, Bratslavsky, Muraven, & Tice, 1998; Hagger, Wood, Stiff, & Chatzisarantis, 2010). What is less clear is why this impairment occurs. One explanation holds that people have a limited amount of energy at their disposal for behavior control and that acts of self-control consume this energy (e.g., Muraven & Baumeister, 2000). Thus, performing one act of self-control can reduce the energy people have available for subsequent acts of self-control.

Gailliot et al. (2007) extended this model by suggesting that the source of self-control energy is glucose. In their study, participants exercised self-control, drank lemonade sweetened with either glucose or a nonglucose sweetener, waited 15 min (for the glucose to reach the brain), and then engaged in a self-control task. The researchers found the usual self-control impairment among participants who drank the nonglucose sweetener, but not among participants who drank glucose. They concluded that drinking glucose increases the energy available to control the self.

This conclusion has since been challenged in two ways. First, Kurzban (2010) explored the data of Gailliot et al. (2007) and found that only some participants demonstrated the expected drop in glucose level following self-control; in fact, some actually showed an increase. Overall, there was no relation between changes in glucose level and level of self-control in the data.

Second, Molden et al. (2012) found that glucose can enhance self-control even when it is not ingested. They had participants engage in a self-control task, rinse their mouths with glucose or a nonglucose sweetener (without swallowing), and then engage in a second self-control task. Rinsing with glucose eliminated the self-control impairment even though it did not increase the amount of glucose in the participants' blood. This pattern is consistent with research showing that rinsing with glucose activates receptors in the mouth that, in turn, activate motivational areas in the brain (J. M. Carter, Jeukendrup, & Jones, 2004; Gant, Stinear, & Byblow, 2010). Orally rinsing with glucose, for instance, can improve the performance of bicyclists and may do so by signaling reward areas in the brain (Chambers, Bridge, & Jones, 2009).

Given that cases have been made for both metabolic and motivational roles for glucose in self-control, we conducted an experiment to help clarify the issue—a conceptual replication of Molden et al. (2012). Such replications are vital to establishing the reliability of research findings (Simmons, Nelson, & Simonsohn, 2011).

Method

Participants engaged in self-control and then rinsed with either glucose or a nonglucose sweetener while performing a second self-control task. Unlike Molden et al. (2012), we placed no restrictions on who could participate or when. Molden et al. required participants to weigh at least 110 lb, to abstain from food for at least 4 hr prior to the experiment, and to participate between 9:00 a.m. and noon or between 4:00 p.m. and 7:00 p.m. We omitted these requirements because we did not assess blood glucose levels. Also, Molden et al. had participants perform the glucose/nonglucose rinse before performing the second self-control task; we had participants rinse concurrently with performing that task, to reduce further the possibility that participants could metabolize the glucose and thus increase their energy levels. If glucose rinsing mitigated the usual self-control impairment even under these conditions, then we would have strong evidence that glucose moderates self-control in a nonmetabolic way.

Fifty-one students participated to fulfill a course requirement. They began by following a complex rule to cross out *E*s on a page from a statistics book. This task has been shown to impair subsequent self-control (Baumeister et al., 1998).

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Next, participants performed the Stroop task while rinsing their mouths with lemonade. The lemonade was sweetened with either glucose (glucose condition) or Splenda (Splenda condition), and it was not swallowed. The Stroop task involved identifying the font color of various words presented on a computer screen. On congruent trials, the color of the word matched the meaning of the word (e.g., the word "GREEN" written in the color green). On incongruent trials, the color of the word did not match the meaning of the word (e.g., the word "GREEN" written in the color red). This task demanded self-control on incongruent trials. Participants responded by pressing labeled keys on the keyboard. Finally, participants rated the sweetness and pleasantness of the lemonade and their enjoyment of the lemonade. We combined these measures to form a composite rating of the drinks.

Results

Following standard practice, we log-transformed the reaction times on the Stroop task to normalize the distributions. (We analyzed these normalized distributions, but we report the non-transformed values for ease of interpretation.) Compared with participants who rinsed with Splenda-based lemonade (M = 924.61 ms), those who rinsed with glucose-based lemonade (M = 839.87 ms) were faster on trials in incongruent trials, $t(49) = -2.129$, $p < .05$ (see Fig. 1). There were no differences between conditions for reactions times on the congruent trials, overall reaction times on both trial types combined, or the number of errors participants made (ps > .05). Although participants in the glucose condition rated the lemonade more favorably than participants in the Splenda condition did (M = 5.42 and M = 4.89, respectively), $t(49) = 2.129$, $p = .038$, these ratings were not correlated with performance ($r = -.22$, $p = .12$).

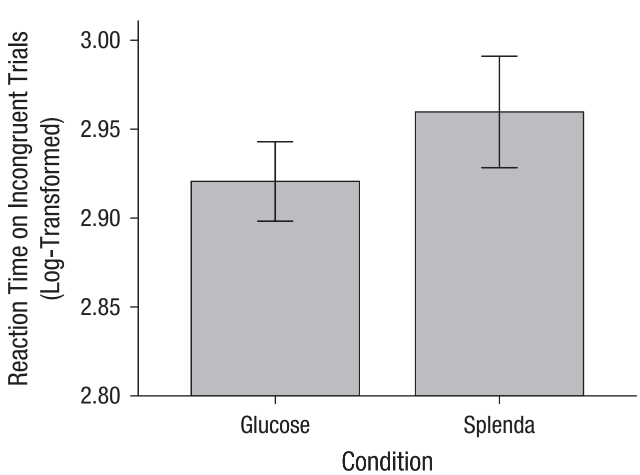

Fig. 1. Mean log-transformed reaction time on incongruent trials of the Stroop task as a function of condition. Error bars represent 95% confidence intervals.

Discussion

The results conceptually replicate those of Molden et al. (2012) and provide further support for the hypothesis that glucose moderates self-control nonmetabolically. Because participants did not ingest the glucose, they could not have absorbed a significant amount of it into their bloodstream. Moreover, it takes glucose 10 to 15 min to enter the brain after ingestion (Zourek, Jankovec, & Hykova, 2011). Our participants rinsed with glucose as they performed the Stroop task, so any glucose they might have ingested would not have had time to affect their energy level. The fact that we obtained results similar to those obtained by Molden et al. despite using a somewhat different methodology strengthens support for the hypothesis that glucose can influence self-control without increasing metabolic energy level.

Molden et al. (2012) suggested that glucose eliminates self-control impairment by activating brain areas associated with reward, which, in turn, increases participants' motivation. We believe it is possible to be more specific. Chambers et al. (2009) found that rinsing with glucose increased activation in the anterior cingulate cortex and the striatum. These areas are associated with the selection and inhibition of action (Balleine, Delgado, & Hikosaka, 2007; Eagle & Baunez, 2010) as well as with the detection of errors and response competition (C. S. Carter & Van Veen, 2007; Pardo, Pardo, Janer, & Raichle, 1990). It is possible, therefore, that glucose improves self-control directly by activating operations that underlie successful self-control.

Declaration of Conflicting Interests

The authors declared that they had no conflicts of interest with respect to their authorship or the publication of this article.

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