

# Winter Olympics Special: The Slippery Science of Ice Skating

By Michael Q. Bullerick



Learning how to ice skate is a tricky bit of business that requires athleticism, a healthy sense of balance, and a high pain threshold. Of course, you also need a decent pair of skates and a pond-sized patch of slippery ice. Those last two items are easier to summon than the rest and they have been for a period going on 3,000 years now. But it might be surprising to note—especially during the Winter Olympics—that until just a few years ago, physicists didn't fully understand how skating worked. More precisely, they lacked a fundamental knowledge of what *exactly* makes ice slippery.

Sure, they knew that running a thin blade along smooth ice reduces friction in a way that accounts for a good deal of the gliding that makes skating fun. But that's not all of it. People slip and slide on ice without the benefit of ice skates and even while trying to stand still. Why?

Almost everyone will say that ice is slippery because it's—well—wet. Except that it isn't. Not in a purely scientific sense. Ice only feels wet due to the melting effect caused by your much warmer touch. At the freezing point, which any grade school child can tell you is 32 degrees, water crystalizes, meaning it goes completely solid. Yet despite

that transformation, and the absence of a liquid lubrication, you can still slip and skate just as well. That fact becomes obvious at rinks where ice temperatures are kept at about 26 degrees, and in the context of subzero conditions, which any ice skater will tell you makes no difference beyond an upgrade in outerwear.

But if water isn't the thing that puts the "slip" in slippery, what is? In pondering that very question over a century ago, Michael Faraday—one of Albert Einstein's science heroes—wondered if it was possible for water (liquid) and ice (solid) to exist in a state halfway between each other beyond the freezing point. After pressing two ice cubes together and watching them fuse to form a single block, Faraday hypothesized that ice might perhaps contain an intrinsic "solid but liquid-like" invisible molecular layer, and that such a quasi-layer might even hold steady in subzero temperatures.

Following Faraday's lead, scientists began turning their attention to pressure and friction. The resulting theory, called the "pressure-melting effect," asserted that a skater's weight would exert intense pressure on the point where the blade contacted the ice. In turn, this pressure would generate just enough heat to melt a thin layer of ice for use as a lubricant. This process, the theory continued, would remain undetectable to the naked eye because the thin film of water would instantly refreeze with each glide step.

Not surprisingly given its plausibility, the pressure-melting effect is still routinely referenced as fact. But the theory simply doesn't hold water—literally or figuratively. For one thing, it fails to completely explain the important point about why people who wear wide-soled shoes still slide on ice even while attempting to stand still, although reduced friction plays a part. For another, there's the work of Robert M. Rosenburg. In his 2006 article in *Physics Today*, the emeritus professor of chemistry at Lawrence University proved

that the average skater exerts a pressure of only 50 pounds per square inch, which results in a melting temperature of only .03 degrees at contact point. That's nowhere near a steep enough drop to melt ice.

As it turns out, the critical mystery lubricant is not water but—as Faraday had surmised—the ice itself. More specifically, it's the tiny ice molecules that comprise the top layer of any frozen block. Although these molecules are bound to the ones below them within the larger mass, they are not as solidly compressed. As a result, they can readily fuse with new ice layers, as Faraday demonstrated with his ice cubes, and they are loose enough to get pushed free and roll around, making them as efficient a lubricant as water molecules.

As difficult as it is to believe, that critical point wasn't proven until 1996, when Gabor A. Somorjai, a surface chemist at the Lawrence Berkeley National Laboratory, bombarded three thin ice layers with low energy electron diffraction, a technique used to determine crystalline structures. The procedure should have yielded similar scattering signatures for all three layers of ice molecules but Somorjai's tests revealed only two. That's because the molecules in the upper third layer, although solid, were behaving much like a liquid, vibrating at amplitudes three or four times faster than those in the lower layers. In short, Somorjai had confirmed the existence of Faraday's intrinsic, "liquid-like" layer of ice. What's more, he also confirmed, as Faraday had surmised, that such a layer was present even in subzero temperatures. Somorjai's tests went as low as minus 235 degrees.

That's far too drastic a temperature for ice-skaters to risk their lives testing but sporting goods manufacturers are currently using the lab findings to experiment with materials, finishing techniques, blade curvatures and edge cuts of their skates. And research development departments across various industries are doing the same, referencing the findings to improve stability, grip and the stopping power of tires and

footwear that are set to hit the market in the coming years. Until that happens—or unless you’re an ice skater—it’s probably best to keep off the ice.

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## Can Death Row Last Meals Reveal Guilt or Innocence?



**By Michael Q. Bullerdick**

Although it’s true death row guards once routinely wagered on what a condemned man might select for his last meal, the morbid game was abandoned long ago, less out of empathy than boredom. That’s because, for the better part of a half-century or so, the penultimate menu has been fairly predictable: fried chicken, a cheeseburger or steak cooked medium rare and served with some kind of potato (almost always French fries), followed by pie à la mode (apple or pecan) or a bowl of ice cream. The real gamble, it seems, is not *what* an execution-bound inmate will eat—but *if* they’ll eat. And that decision, Cornell University researcher Kevin Kniffin recently revealed, can be a reliable “tell” of whether an inmate knows or has convinced himself that he’s innocent.

The idea that our conscious or subconscious mind could impact

such matter-of-fact decisions is not as peculiar as it seems at first glance. Researchers long ago discovered a link between emotional states and the act of consumption, including which personality types drink and eat more when depressed versus those who do the opposite while in the same emotional state. What's more, researchers have also shown how foods can be imbued with significance depending on social context and deeply ingrained belief systems. Holiday meals exemplify the point perfectly. A turkey dinner is just that—but serve it to family and friends on Thanksgiving and it becomes something special. Similarly, a pint of chocolate ice cream can seem deeply romantic if you have someone to share it with on Valentine's Day, but it can become a pitiful means to drown your sorrows if you're depressed about being alone. Pairing a cracker with a sip of wine could hardly be described as anything more than a meager snack, but consuming the same during Sunday church service represents the ritualistic means for entering into communion with God to billions of devout Christians worldwide.

To those on death row, a last meal represents far more than a last chance to eat. Viewed from a psychological perspective, it's both a powerful final sensory experience and a rare opportunity to assert one's will after being experiencing a severely restrictive form of incarceration. Given all that, a last meal should be extremely appealing to both the innocent and the guilty. But that's not always the case. In fact, a significant number of inmates choose to assert their will by rejecting their last best perk. Why—and what's to be gained? Could such refusals be rooted in the level of remorse we like to think guilty people experience, especially during their final hours? Or is it rooted in the despair and abject fear that the innocent must suffer while execution looms?

For his part, Kniffen hypothesized that those who knew themselves to be innocent—or had truly convinced themselves they were—would request lighter meals or reject them outright

due to emotional turmoil arising from a profound sense of injustice. In such cases, he suspected they might have trouble bringing themselves to eat due to feelings of frustration, anger and terror coalescing in “a desire to withhold consent for the proceedings,” Kniffen wrote in describing his findings in the journal *Laws*. Contrastingly, Kniffen theorized that inmates who had accepted or confessed their guilt would likely feel some measure of relief and be able to indulge in the same way that Marion Pruettt managed it. Preutt, a spree killer executed in Arkansas in 1999, confessed his murderous misdeeds and then ordered a high-calorie last meal, explaining that he could enjoy it because he had “made his peace.”

To test his hypothesis, Kniffen reviewed the records of 247 executions that occurred in the United States between 2002 and 2006 and correlated last meals (acceptance or rejection) with the last words of inmates who either “(1) denied guilt; (2) admitted guilt or apologized; or (3) made a minimalist statement in which they neither denied nor admitted guilt or declined to speak.” In line with his theory, Kniffin’s analysis revealed that those who had denied guilt were 2.7 times more likely to decline a last meal than those who admitted guilt. A secondary finding revealed that those who admitted guilt were more likely to request brand name foods and last meals that were 34% higher in calories—proving, at least, that confession may be as good for the appetite as it is for the soul.

An additional implication of Kniffen’s findings may further complicate the much-debated subject of legal competency—an individual’s ability to understand the consequences of his actions and accept his penalty. In fact, an anecdote involving executed killer Ricky Ray Rector’s last meal has already factored into the issue of how competency should be assessed and managed when it comes to capital punishment. On execution day in Arkansas, Rector had reportedly asked guards that were taking him to the lethal injection chamber to save his slice

of pecan pie for when he returned. Rector had been sentenced to execution over the shooting death of a police officer. His attorneys argued, however, that his subsequent botched suicide attempt, which had resulted in an accidental lobotomy, made the death penalty highly unwarranted since Rector's mental faculties were insufficient to grasp his circumstances or testify and because the bullet to his brain had rendered him docile and incapable of future violence. His team lost the argument and the case, followed by several appeals, before Rector was put to death on January 24, 1992. Given his unnerving request, however, they may have had a valid point.

Of course it would be folly to require that judges and state governors consider granting last-minute stays of execution on the basis of an inmate's decision to decline a last meal. Kniffin himself rejects such a notion as "an over merited implication of his findings that could routinely "encourage the denial of a last meal" by inmates seeking to game or mock the justice system. Texas death row inmate Lawrence Russell Brewer did just that, ordering an extravagant meal and then refusing to touch a bite of it before his 2011 execution for the racially motivated dragging death of James Byrd, Jr.

To the extent that Kniffin's research can be used to determine *absolute* guilt or innocence, he's quick to caution it "can only provide a dimension of *ad hoc* analysis." He doubles down on the point in his conclusion, writing, "It is possible these findings could influence future considerations involving executions.... [But the data] should be most useful for understanding and assessing the innocence and perceived innocence of people who have been executed in the past."

That may be so but there's no doubt the findings will add to the complications and contentiousness of future death row appeals, especially cases such as Ricky Ray Rector's, that seem to challenge the legitimacy of an execution.