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Our inclination to trust a stranger stems in large part from exposure to a small molecule known for an entirely different task: inducing labor

The Neurobiology of Trust

By Paul J. Zak

KEY CONCEPTS

- The development of trust is essential for appropriate social interactions, so how do people decide whether to trust a new acquaintance or potential business partner?
- Using an experimental task called the trust game, researchers have found that oxytocin, a hormone and neurochemical, enhances an individual's propensity to trust a stranger when that person exhibits non-threatening signals.
- Greater understanding of oxytocin's functions and interactions with other key brain chemicals could lead to insights into many disorders marked by impaired social interactions, such as autism.

—The Editors

If you were asked to fall backward into the arms of a stranger, would you trust the other person to catch you? Such a situation, a common exercise in group therapy, is a bit extreme. But every day most people place some degree of trust in individuals they do not know. Unlike other mammals, we humans tend to spend a great deal of time around others who are unfamiliar. Those who live in cities, for instance, regularly navigate through a sea of strangers, deciding to avoid certain individuals but feeling secure that others will, say, give accurate directions to some destination or will, at the very least, refrain from attacking them.

In the past several years, researchers have begun to uncover how the human brain determines when to trust someone. And my colleagues and I have demonstrated that an ancient and simple molecule made in the brain—oxytocin (ox-ee-TOE-sin)—plays a major role in that process. The findings are suggesting new avenues for discovering the causes and treatments of disorders marked by dysfunctions in social interactions.

Searching for Trust

I came to the study of oxytocin's relation to trust via a somewhat circuitous route. In 1998 Stephen Knack, an economist in the World Bank's Development Research Group, and I began trying to find out why trust among people varies dramatically across different countries. As part of this effort, we constructed a mathematical model that described the kinds of social, legal and economic environments that might be expected to produce high and low levels of trust. In the course of the study, we discovered that trust is among the strongest known predictors of a country's wealth; nations with low levels tend to be poor. Our model showed that societies with low levels are poor because the inhabitants undertake too few of the long-term investments that create jobs and raise incomes. Such investments depend on mutual trust that both sides will fulfill their contractual obligations.

As I thought about the importance of trust in alleviating poverty, I began to wonder how two people decide whether to place faith in each other. Having that information could help policymakers design economic systems that facilitate this process. Laboratory studies had demonstrated that those in the same situation can vary widely in their propensity to trust another individual, but no one had described a coherent mechanism for what goes on in the human brain

TRUSTING STRANGERS can be hard, such as in a group therapy exercise that has a person fall backward into another's arms. Luckily for the smooth running of society, a neurochemical called oxytocin primes people to trust others.

to instill trust. I therefore set about trying to uncover the neural underpinnings of such feelings.

A large body of animal research pointed to oxytocin as a likely contributing factor. This short protein, or peptide, which is composed of just nine amino acids, was known to be produced in the brain, where it serves as a signaling molecule—a neurotransmitter. It also slips into the bloodstream to influence distant tissues, making it a hormone as well. At the time, this peptide was best known in humans for its role in stimulating milk flow in nursing women and in inducing labor; even today about half of women who give birth in the U.S. receive synthetic oxytocin (called pitocin) to hasten uterine contractions. But documenting the peptide's more subtle effects was difficult because its concentrations in the blood are extremely low and it degrades rapidly. The animal work, though, indicated that oxytocin in some way facilitates cooperation—which requires trust—in certain mammals and that a close relative, vasotocin, apparently promotes friendly interactions in other creatures as well.

According to evolutionary biologists, vasotocin appeared first in fish about 100 million years ago. In those animals, it facilitates sexual reproduction by reducing a female's natural fear of being approached by a male when she is ovulating. Biologists conjecture that a mechanism for reducing fear during ovulation evolved because the benefits of sex—offspring and greater genetic diversity—outweigh the danger of becoming the other fish's lunch.

In mammals, vasotocin evolved into two closely related peptides, oxytocin and arginine vasopressin. Research on rodents that began in the late 1970s showed that these molecules, too, promoted affiliation with others. Cort A. Pedersen and his co-workers at the University of North Carolina at Chapel Hill, for instance, demonstrated that oxytocin prompted nurturing behavior in rodent mothers.

Shortly afterward zoologists C. Sue Carter and Lowell L. Getz, both then at the University of Illinois at Urbana-Champaign, examined oxytocin in two genetically and geographically related species of voles: prairie voles and montane voles [see "Monogamy and the Prairie Vole," by C. Sue Carter and Lowell L. Getz; SCIENTIFIC AMERICAN, June 1993]. Male prairie voles are upstanding citizens: they typically cohabitate with their mates for life, live in social groups and are attentive fathers. Male montane voles, in con-

[THE AUTHOR]

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COURTESY OF CENTER FOR NEUROECONOMICS, CLAREMONT GRADUATE UNIVERSITY (*Zak*); MARK ANDERSEN *Getty Images* (*woman*); RYAN McVAY *Getty Images* (*man*)

trast, are cads: they are promiscuous, solitary and indifferent to their offspring. Carter and Getz, as well as several subsequent researchers, showed that the difference between the social behaviors in these vole species could be ascribed to the locations in their brain of receptors for oxytocin and arginine vasopressin. To have an effect on brain cells, molecules first have to bind to specific receptors on the neurons' surface. In prairie voles those receptors are concentrated in brain regions that make monogamy rewarding—in midbrain areas that modulate release of the neurotransmitter dopamine, which reinforces the value to the male of cohabitation and care of offspring.

The Trust Game

Although the animal research did not address the issue of trust formation specifically, the importance of oxytocin in drawing animals together implied to me that it might also underlie trust, presumably a necessary condition for closeness. Around the same time, scientists had found ways to reliably and readily measure small changes in oxytocin levels in blood samples.

My reading of the rodent literature suggested that nonthreatening social signals induced oxytocin production in the brain of signal recipients, and I wondered if, in humans, the approach of strangers who gave positive signals might stimulate release of the peptide in others. My colleagues—Robert Kurzban, a psychologist now at the University of Pennsylvania, and William Matzner, then my graduate student at Claremont Graduate University—and I therefore set out to test that idea and to see if oxytocin production would be affected by, and affect, social behaviors in humans.

We still, however, had to figure out how we might measure the degree of trust between unacquainted people. The rodent researchers could simply drop a strange individual into another's cage to test whether nonthreatening behavior could promote the release of oxytocin, but humans' ability to evaluate potential social situations is far too sophisticated for a similar experimental design. People's reactions can be swayed by many other factors, including physical looks, clothing, and so forth. Luckily, experimental economists Joyce Berg of the University of Iowa and John Dickhaut and Kevin McCabe, both then at the University of Minnesota, had already devised a task in the mid-1990s that would do the trick. In this task, test subjects can signal that they trust a stranger by sacrificing their own money and transferring it to the stranger. They send money to a stranger because they believe the stranger will reciprocate and return more money back to them. The researchers called it the "trust game."

In my lab, the trust game runs as follows: my staff recruits subjects who earn $10 if they agree to spend an hour and a half with us [*see box above*]. We assign the participants randomly into pairs in which the two do not see or communicate directly with each other. Then we have them make decisions about sharing their money with the partner. In each pair, one person is designated subject 1 and the other subject 2. At the start we describe to both individuals how the game works. First subject 1 is prompted by a computer to decide whether to send some of the $10 participation payment to the other person. The amount given is tripled in an account for subject 2. If subject 1 decides to part with $6, for instance, subject 2 will end up with $28 (three times $6 plus $10), and subject 1 will be left with $4.

In the next step, the computer informs subject 2 of the money transfer and allows that person to return some amount of money to subject 1, with the proviso that none need be sent back and the assurance that the participants' identities

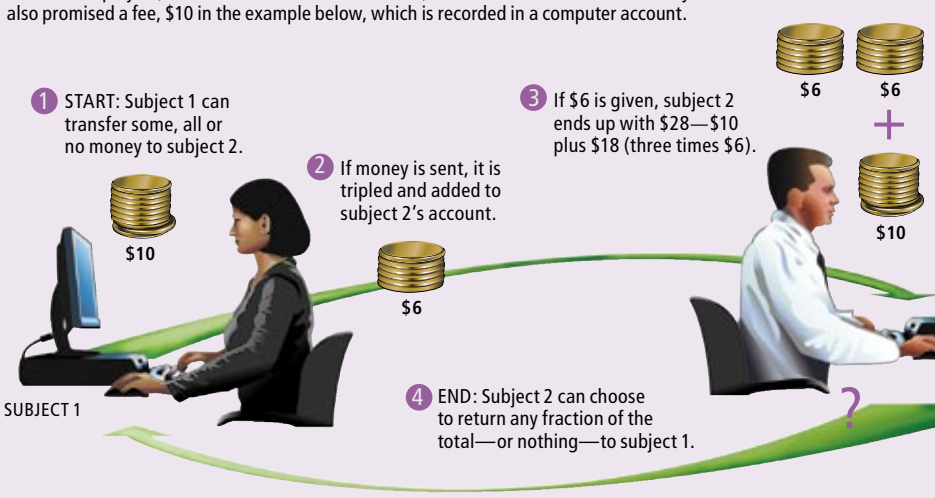
[OXYTOCIN EXPERIMENTS]

PLAYING THE TRUST GAME

To study the role of oxytocin in trust, the author and his colleagues had subjects play what is called the trust game. The team found that receiving a signal of trust led to a rise in oxytocin in the blood (an

THE BASIC GAME

SETUP: Two players, who have no face-to-face contact, are told the rules in advance. They are also promised a fee, $10 in the example below, which is recorded in a computer account.



ANALYSIS: If subject 1 sends money and subject 2 returns enough of the proceeds, both profit. If subject 2 betrays subject 1 and is stingy, subject 1 can lose money. Subject 1's trust is assessed by the amount transferred to subject 2. Trustworthy behavior by subject 2 is measured by the amount returned.

FAST FACTS

- Levels of oxytocin have been shown to spike in men and women during sexual climax. Its presumed role in postcoital affection has earned it the nickname the "cuddle hormone."
- Oxytocin was first isolated and synthesized in 1953 by Vincent du Vigneaud of Weill Cornell Medical College in New York City. He was awarded the Nobel Prize in Chemistry two years later in recognition of this achievement.
- Until recently, oxytocin levels in the blood were difficult to study because the substance is present in extraordinarily low concentrations and degrades to half its original quantity in only three minutes.

PHOTOGRAPH BY PAUL J. ZAK; ILLUSTRATION BY LOGAN PARSONS

indication of greater production by the brain). Further, oxytocin caused an increase both in trust and in trustworthy behavior.

FINDINGS

An oxytocin rise boosts trust:

- After inhaling an oxytocin nasal spray, subject 1s sent 17 percent more money than control subjects who took a placebo did.
- Twice as many subject 1s (almost half the total) who received oxytocin gave all their cash to their partners.

Oxytocin increases trustworthiness:

- Subject 2s showing the highest oxytocin blood levels returned the most money to their partners.

Flaws in the brain's ability to respond to oxytocin might contribute to social disorders:

- A few subject 2s with unusually high oxytocin levels returned nothing. This observation could be explained by a disturbance in the brain's oxytocin system that could suggest pathology.

and decisions will remain confidential. Whatever money subject 2 returns is debited from subject 2's account on a one-to-one basis (that is, the sum is not tripled). No deception is permitted—payments are actually made based on these choices. Immediately after the participants make their decisions, we ask them to provide blood samples so we can measure oxytocin levels.

Interpreting the Game

The consensus view among experimental economists is that the initial transfer measures trust, whereas the return transfer gauges trustworthiness. Researchers have run this trust game numerous times in many countries and for large stakes.

In our experiments, about 85 percent of those in the subject 1 role sent some money to their partners. Of the partners who received the money, 98 percent then went on to return some money to subject 1s. Interestingly, people typically could not articulate why they were trusting or trustworthy. But based on the rodent work, I suspected that being trusted by subject 1s would induce an oxytocin rise and that those who received greater sums from subject 1s would experience the greatest increases.

Indeed, we found that subject 2s' brains produced the peptide when they received money from their partners and thus felt trusted by those strangers. In addition, when people were shown greater trust in the form of more money, their brains released more oxytocin. To be sure that sense of being trusted accounted for the oxytocin rises, we observed a control group of participants who received monetary transfers that clearly occurred at random, not because someone decided to place faith in their reciprocity. Such a control was important to rule out whether money itself caused the oxytocin release—it did not.

We also found that subject 2s with high levels of oxytocin were more trustworthy—that is, they sent more money back to subject 1s who had trusted them. Receiving a signal of trust appears to make people feel positive about strangers who have trusted them.

A possible evolutionary explanation for the strong release of oxytocin in the experimental setting is that humans have a long adolescence and that natural selection favored people who could bond strongly with others over a long time—until youngsters grew up and were able to manage on their own. Our closest genetic relatives, chimpanzees, become sexually mature in seven or eight years, whereas humans may take roughly twice as long and, to thrive, must continue to be looked after by (and remain attached to) their parents throughout that period. An ancillary effect of extended care for the young could be that humans have a powerful propensity for attachment and thus also strongly attach to nonkin who become friends, neighbors or spouses. If that surmise is correct, it is no surprise that humans also bond to pets, places and even their cars.

Boosting Trust Artificially

Our research with the trust game showed that oxytocin release occurred only in subject 2s—those who had received a trust signal. Also, people in the subject 1 role who started the experiment with higher oxytocin levels were not more likely to trust others (to give subject 2s more money). This observation might seem contradictory at first blush, but it is consistent with the animal studies, which showed that oxytocin release happens only when individuals have had social contact with others. It is the rise in oxytocin levels, not the absolute level, that seems to make the difference. One can therefore think of positive social signals and interactions as the flipping of a switch to an "on" state: when the switch goes on, the human brain says, "This person has shown that

OXYTOCIN AND GENEROSITY

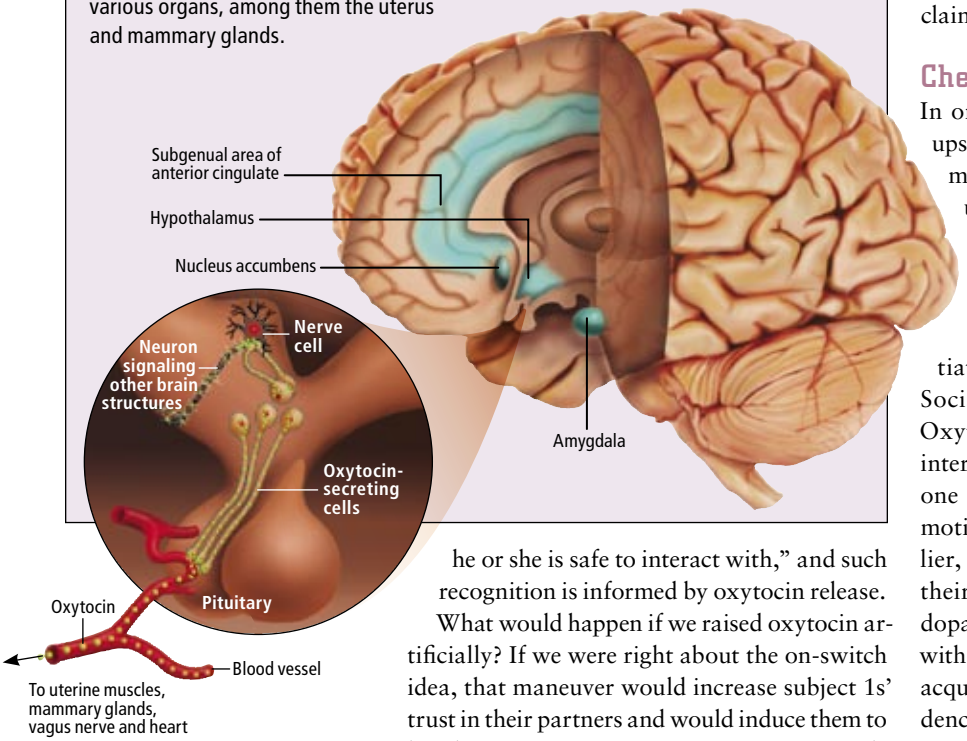
Imagine being asked to split a $10 stake with a stranger. If the stranger accepts your offer, you are both paid, but if your offer is rejected, you both get nothing. What would you offer? And if you received an offer, what is the smallest amount that you would accept?

This game can be used to measure generosity—defined as offering someone more than he or she needs. A study conducted at the author's laboratory recently showed that those who inhaled a dose of oxytocin made offers that were 80 percent higher than those given a placebo. Moreover, subjects who received oxytocin did not demand more money than was offered. These results suggest that oxytocin amplifies our empathy for others and motivates a desire to help them.

[BASIC NEUROBIOLOGY]

OXYTOCIN AND THE BRAIN

Several brain structures (*highlighted in green*) are involved in the release and response to oxytocin. These structures share three features: they have dense fields of oxytocin receptors, which convey oxytocin's "messages" to nerve cells; they control emotions and social behavior; and they modulate midbrain dopamine release, which makes people feel good and so rewards and reinforces specific behaviors. Although the trust-related effects of oxytocin stem from its activity in the brain, the chemical acts elsewhere as well. Some brain cells secrete it into the bloodstream (*detail at bottom left*) to influence various organs, among them the uterus and mammary glands.



he or she is safe to interact with," and such recognition is informed by oxytocin release.

What would happen if we raised oxytocin artificially? If we were right about the on-switch idea, that maneuver would increase subject 1s' trust in their partners and would induce them to hand over more money to strangers. To study this issue, a research team from the University of Zurich headed by economist Ernst Fehr and me had about 200 male investors breathe in a dose of oxytocin formulated as a nasal spray (enabling the drug to reach the brain) and compared their behavior with that of control subjects who inhaled a placebo. We found that those who received oxytocin gave 17 percent more money to their partner. More tellingly, twice as many dosed subject 1s (nearly one half of them) as controls exhibited maximal trust: they transferred all their money. This experiment shows that a rise in oxytocin in the brain reduces our natural (and wholly appropriate) anxiety over interacting with a stranger. It should be noted, though, that some participants who were given oxytocin did not exhibit a high degree of trust. Apparently, for some, a rise in oxytocin is not enough by itself to overcome worry over strangers.

Let me be clear that our experiment had nothing to do with manipulating people's minds to empty their wallets, because it certainly did not turn subjects into will-less automatons. Nor did it offer the possibility that salespeople or politicians could spritz oxytocin into the air or spike people's food or drink to force others to trust them. Oxytocin breaks down in the gut, so oral administration has no effect on the brain. Further, intravenous or nasal delivery is easy to notice, and sniffing it from the air would not raise brain levels appreciably. (Do not be fooled by claims of companies selling "trust in a bottle.")

Chemistry of Distrust

In one experiment, a female subject became upset when she received only a small amount of money from her partner. Her reaction started us thinking about what happens when people are distrusted. Many important systems in the brain are controlled by opposing forces. Eating, for example, is largely driven by hormones that signal when to initiate, and then when to terminate, feeding. Social behaviors may have similar controls. Oxytocin constitutes a positive side of personal interactions; it literally feels good when someone seems to trust you, and this recognition motivates you to reciprocate. As discussed earlier, to induce mammal mothers to attend to their offspring oxytocin causes the release of dopamine in deep midbrain regions associated with rewarding behaviors such as sex and food acquisition. In follow-up research, we found evidence of an opposing, or negative, side to the trust-forming mechanism, at least in males.

When male subject 2s are distrusted (sent little money by a subject 1), they experience a rise in a derivative of testosterone called dihydrotestosterone (DHT). The more distrust men were shown in the game, the higher was their DHT level. This molecule can be thought of as high-octane testosterone; it is primarily DHT that causes the dramatic changes such as body-hair growth, increased muscularity and vocal-cord thickening that hit males during puberty. Elevated levels also boost the desire for physical confrontation in trying social circumstances. Our finding indicates that men have an aggressive response to being distrusted.

Females and males reported equally that they disliked being distrusted, but women did not display the "hot" physiological response of the men. Most male subject 2s who were distrusted returned nothing to their partners, whereas most women were proportional reciprocators across the board; they tended to return about an equal fraction of what they were sent no matter

LOGAN PARSONS

how much money was involved. We think of women as "cooler" responders, although we do not yet fully know the physiological underpinnings for this difference. The possibility of an aggressive response to a signal of distrust may make us more trusting of others. If we know that showing distrust provokes aggression, we may display more trust than we might otherwise to avoid this response.

Measuring brain activity during the trust game using functional magnetic resonance imaging techniques has indicated that trusting a stranger produces strong activity in deep midbrain regions where dopamine binds and contributes to our sense of reward. This result helps to explain why subject 2s who received money usually felt inclined to return some of it to subject 1s even though doing so was economically disadvantageous. The positive feelings subject 2s experienced when reciprocating trust appear to have psychically rewarded them and reinforced a desire to be trustworthy in the future.

Although most people can be deemed trustworthy, 2 percent of subject 2s in our studies were particularly untrustworthy—they kept all or nearly all the money they were sent—and, significantly, they exhibited unusually high levels of oxytocin. This result suggests that these individuals have oxytocin receptors in the wrong brain regions (for instance, those that do not modulate dopamine release) or have dysregulated receptors. In the latter case, the neurons would essentially be deaf to oxytocin release, regardless of how much was made. Tellingly, the highly untrustworthy possess personality traits that resemble those of sociopaths, who are indifferent to or even stimulated by another's suffering.

Future Insights

Today my laboratory focuses on examining whether deficits in oxytocin activity in the brain contribute to disorders marked by disturbed social interactions. People suffering from autism, for instance, have low oxytocin levels. Studies by others have found that replacing the peptide in these subjects did not produce any increase in their social engagement. As was likely true of the untrustworthy people in the trust game, this result suggests that those with autism may have an oxytocin receptor dysfunction.

Similarly, patients with brain lesions in areas normally rich in oxytocin receptors have difficulty determining which people appear trustworthy and which appear untrustworthy. Many neurological and psychiatric disorders involve abnormal social interactions, including schizophrenia, depression, Alzheimer's disease, social anxiety disorder and Huntington's disease. A faulty oxytocin system, as we have seen in those who are untrustworthy, may play a part in these maladies. Greater understanding of its workings may lead to new treatment methods.

Oxytocin's operations within the body appear to be quite dynamic; the peptide interacts with other hormones and neurotransmitters whose levels vary minute by minute and over one's life span. Estrogen, for example, increases the uptake of oxytocin by the body's tissues, whereas progesterone does the opposite. Such effects suggest that both physiological and environmental cues drive our desire to interact socially. They also indicate that our life experiences may "retune" the oxytocin mechanism to a different "set point" and thus to different levels of trust throughout the course of life. Residing in a safe, nurturing environment may stimulate us to release more oxytocin when someone trusts us—and to reciprocate that trust. Stress, uncertainty and isolation all work against the development of a trusting disposition. As our studies continue, we will better understand how this simple peptide allows people to have empathy for and sustain trust in those around them, even complete strangers. ■

LOGAN PARSONS

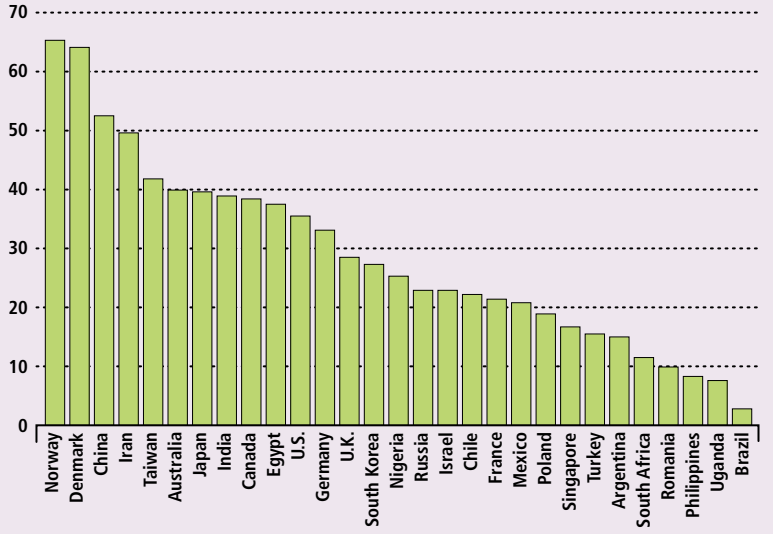
[INTERNATIONAL RESEARCH]

National Trust

The author's research into trust levels in different countries led him to investigate the role of oxytocin in forming trust. This research attempted to identify the social, political and economic conditions that explain the differences among respondents from various countries who answered the question: "Do you think most people can be trusted?"

TRUST LEVEL BY COUNTRY

Percent of respondents who think that most people can be trusted



MORE TO EXPLORE

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