LTD, but rather its persistent impairment, that is associated with the transition to addiction.

This persistent impairment in LTD could explain the loss of control on drug intake observed in Addict rats. LTD in the NAC is considered important in rescaling synapses that were enhanced during acquisition of motor responses and cue-reward associations (*31*, *32*), allowing those synapses to encode future associations and restore flexibility to neuronal circuits. The persistent inability to rescale synapses in Addict animals may render drug-seeking behavior consistently resistant to modulation by environmental contingencies, finally resulting in loss of control over drug intake. Thus, the major behavioral difference between Addict and Non-Addict animals, similar to that in humans (*1*), is their capacity to adjust their drug intake as a function of environmental contingencies. Non-Addicts can stop seeking drugs if they know that the drug is not available, if it requires an excessively high workload, or if taking the drug acquires negative consequences. Addicts have lost this ability and continue to seek drugs independently of environmental conditions.

Our results also provide unanticipated insight into the type of homeostatic alterations that characterize Addicts. We expected, as largely assumed in the field, to discover a specific pathological adaptation—a particular phenotype—characterizing synaptic plasticity in Addicts. In contrast, the transition to addiction was associated, at least in the NAC, with a form of anaplasticity, i.e., the incapacity of Addicts to counteract initial drug-induced impairments.

The anaplasticity of Addict rats is relevant to revising conceptualizations of the transition to addiction, currently seen as the progressive development of specific brain adaptations that lead to loss of control over drug intake. Our data suggest that instead, the transition to addiction could be mediated by the incapacity to engage the active processes that allow control of drug intake. After a prolonged exposure to drugs, all the subjects are probably at the point of losing control over drug-intake behavior, as shown by the loss of LTD in all rats. This probably corresponds to the situation when an individual engaged in sustained drug use experiences the sensation that "it is becoming too much" and that "a line is being crossed." Fortunately, for most individuals, the brain adapts to recover a normal plasticity and allows learning to control drug intake. In contrast, the anaplasticity that characterizes addicts makes them enter a downward spiral in which drug-associated stimuli, which can no longer be overridden by other associations, gain more and more power in controlling behavior, finally leading to the compulsive drug intake that characterizes addiction.

Our results suggest that the failure of an individual to counteract the impairment in NMDAR-LTD induced by chronic cocaine intake, which results in a persistent deficit in synaptic plasticity, contributes to the transition to addiction. A clear understanding of the molecular substrates that mediate this lack of adaptation in Addicts could unravel new targets for the development of efficient therapies for drug abuse.

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Incidental Haptic Sensations Influence Social Judgments and Decisions

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Touch is both the first sense to develop and a critical means of information acquisition and environmental manipulation. Physical touch experiences may create an ontological scaffold for the development of intrapersonal and interpersonal conceptual and metaphorical knowledge, as well as a springboard for the application of this knowledge. In six experiments, holding heavy or light clipboards, solving rough or smooth puzzles, and touching hard or soft objects nonconsciously influenced impressions and decisions formed about unrelated people and situations. Among other effects, heavy objects made job candidates appear more important, rough objects made social interactions appear more difficult, and hard objects increased rigidity in negotiations. Basic tactile sensations are thus shown to influence higher social cognitive processing in dimension-specific and metaphor-specific ways.

The hand is one of the most important adaptations in our evolutionary history. From infancy, humans use their hands for two primary functions: to acquire information and to manipulate their environments. These sensory and effector capabilities facilitate learning, communication, the development of social bonds, and a host of other fundamental processes. Yet, despite the fact that tactile sensations are critical to both our intrapersonal and interpersonal lives, touch remains perhaps the most underappreciated sense in behavioral research (*1*).

Hands are purposive devices—they typically are used on objects (active touch) rather than objects being used on them (passive touch) (*2*). Active touch in particular allows for the integration of exploratory and information-processing abilities, as when sensory and motor systems exert influence over each other. That is, tactile sensations can suggest the use of specific muscle movements, whereas physically manipulating objects can enhance sensory sensitivity, improving information acquisition and making subsequent

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perceptual and cognitive judgments more accurate (*3*). For instance, shoppers more readily understand and form confident impressions about products with which they physically interact (*4*). Perhaps less intuitively, this remains true even when tactile cues are nondiagnostic for the actual qualities of the item, as when packaging influences conceptions about products (for example, water seems to taste better from a firm bottle than from a flimsy bottle) (*5*). Findings such as this packaging-to-product transfer suggest that haptically acquired information exerts a rather broad influence over cognition, in ways of which we are probably often unaware. We tested how three dimensions of haptic experience—weight, texture, and hardness—can nonconsciously influence judgments and decisions about unrelated events, situations, and objects.

Why might our sense of touch direct our impressions about untouched or even untouchable things? One possibility is that sensorimotor experiences in early life form a scaffold for the development of conceptual knowledge (*6*, *7*). This conceptual knowledge can subsequently be applied to new experiences. Physical-to-mental scaffolding is, in fact, reflected in the use of shared linguistic descriptors, such as metaphors (*8*–*10*). For example, grasping motions and feelings of warmth elicited by interpersonal touch may form the foundation for beliefs about holding and caring, as expressed in the aphorism, "the world is in our hands." Such metaphors provide insight into the existence of particular scaffolded connections. This "scaffolded mind" perspective (*11*) describes the ontological process by which touch experiences might ground touch-related conceptual knowledge.

How would this work in the moment? Given that established associative links between sensorimotor events and scaffolded concepts do not evaporate over time, touching objects may simultaneously cue the processing of physical sensation and touch-related conceptual processing. Accordingly, feeling the rough bark of an oak tree sensitizes us to rough textures and may also make accessible concepts relevant to metaphorical roughness. Research on embodied cognition is consistent with this position. From this perspective, mental action is grounded in a physical substrate, and thus sensory and motor processing constitute necessary components of cognition (*12*). Our understanding of the world is not an abstract proposition but fundamentally depends on our multisensory experiences with it. Relevant experiences include movements (*13*), emotional events (*14*), and the processing of spatial and temperature dimensions (*15*, *16*). For example, time is understood not by abstract instruction or watching the clock, but by its relation to our experiences with movement through physical space (or spacetime) (*13*). Scaffolding, and the related principle of "neural reuse" (*17*), describe the process by which higher-order cognition emerges from bodily experience: Physical actions and sensations are used to acquire an initial comprehension of more abstract concepts and, as such, become automatically tied to their activation.

In the current paper, we propose that experiences with specific object-related tactile qualities elicit a "haptic mindset," such that touching objects triggers the application of associated concepts (and only associated concepts, not more general feelings or unrelated preferences), even to unrelated people and situations. We report six studies demonstrating how weight, texture, and hardness nonconsciously influence both the acquisition and management of information (social impression formation) and the manipulation of environments (decision-making). We experimentally introduce the connections between these tactile dimensions and conceptual knowledge using common touch-related metaphors.

The experience of weight, exemplified by heaviness and lightness, is metaphorically associated with concepts of seriousness and importance (*18*). This is exemplified in the idioms "thinking about weighty matters" and "gravity of the situation." In our first study, testing influences of weight on impression formation, we had 54 passersby evaluate a job candidate by reviewing resumes on either light (340.2 g) or heavy (2041.2 g) clipboards (*19*). Participants using heavy clipboards rated the candidate as better overall (Table 1) [$F(1, 52) = 4.08$, $P = 0.049$] and specifically as displaying more serious interest in the position [$F(1, 52) = 4.40$, $P = 0.041$] (*19*). However, the candidate was not rated as more likely to "get along" with co-workers ($F < 1$), suggesting that the weight cue affected impressions of the candidate's performance and seriousness, consistent with a "heavy" metaphor, but not the metaphorically irrelevant trait of social likeability. Further, participants using the heavy clipboard rated their own accuracy on the task as more important [mean (M) = 5.35, SD = 1.57] than did participants using the light clipboard (M = 4.36, SD = 1.68), $F(1, 52) = 4.96$, $P = 0.030$, but they did not self-report devoting more effort to the task ($F < 1$), suggesting that impressions were not due to a self-perception effect (people perceiving their own increased effort as indicative of participation in an especially important study).

Our second study investigated how metaphorical associations with weight affect decision-making. Again, 43 passersby were given either light (453.6 g) or heavy (1559.2 g) clipboards, this time featuring a "social action survey" asking whether particular public issues should receive more or less government funding. Issues included several that are considered socially important and serious (such as air pollution standards) and several that are considered idiosyncratic and less widely important (such as public bathroom regulation). Here, a main effect of clipboard condition, $F(1, 38) = 5.46$, $P = 0.025$, was qualified by an interaction with participant gender, $F(1, 38) = 4.59$, $P = 0.039$. Men allocated more money to social issues in the heavy condition (M = 4.00, SD = 0.72) than in the light condition (M = 2.50, SD = 2.12; simple contrast, $P = 0.003$). In contrast, women chose to fund social issues at close to the maximum amount in both heavy (M = 4.00, SD = 0.58) and light (M = 4.02, SD = 0.73) conditions. No effects emerged for the idiosyncratic composite ($F < 1$). These studies suggest that haptic experiences with weight exert conceptually specific influences on both impressions and decisions but do not produce more general positivity or mood influences.

The next two studies examined sensations involving texture, specifically roughness and smoothness, which is metaphorically associated with the concepts of difficulty and harshness. This is exemplified in the idioms "having a rough day" and "coarse language." In study three, 64 passersby read a passage describing an ambiguously valenced social interaction and formed impressions about the nature of this interaction (*20*). Two sets of impressions were collected, one set involving social coordination quality (whether the interaction was adversarial or friendly, competitive or cooperative, a discussion or an argument, and consisted of people on the same side or on opposite sides) and one involving relationship familiarity (closeness of relationship and business or casual interaction style). Before reading, participants completed a five-piece puzzle, either a version with pieces covered in rough sandpaper (rough condition) or a version with the pieces uncovered (smooth condition). Results indicated that participants who completed the rough puzzle rated the interaction as less coordinated (more difficult and harsh) than did

Table 1. Influence of haptic experiences on social impressions. Higher numbers indicate stronger evaluations, with standard deviations in parentheses. For ratings of job candidates on heavy or light clipboards (scale = 1 to 7), $F(1, 52) = 4.08$, $P = 0.049$. For perceived social coordination after rough or smooth puzzles (scale = 1 to 9), $F(1, 62) = 5.15$, $P = 0.027$. For perceptions of employee rigidity (scale = 1 to 7), $F(1, 47) = 4.52$, $P = 0.039$.

Experiment 1: Job candidate suitability		Experiment 3: Perceived social coordination		Experiment 5: Employee rigidness/strictness	
Heavy prime (n = 26)	Light prime (n = 28)	Rough prime (n = 33)	Smooth prime (n = 31)	Hard prime (n = 25)	Soft prime (n = 24)
5.80 (0.76)	5.38 (0.79)	4.74 (1.13)	5.47 (1.41)	5.15 (1.27)	4.44 (1.02)

participants who completed the smooth puzzle (Table 1), $F(1, 62) = 5.15$, $P = 0.027$, but no effect was found for relationship familiarity ($F < 1$). Thus, roughness specifically changed evaluations of social coordination, consistent with a "rough" metaphor, but did not make the interaction seem more generally impersonal.

Would these rough impressions change the decisions people make in social situations? In study four, 42 participants first completed the smooth or rough puzzle and then played an Ultimatum game (*21*). Participants each received 10 tickets for a $50 lottery and chose to give 0 to 10 of the tickets to an anonymous (bogus) participant. If participant 2 accepted the offer, the split became official, but if participant 2 rejected the offer, all tickets were forfeited. Thus, in this bargaining situation, the power was in participant 2's hands. Afterward, participants completed a social value orientation (SVO) scale identifying chronic interaction styles as "prosocial/cooperator," "individualist," "competitor," or "unclassified" (*22*, *23*). Analyses revealed that participants who completed the rough puzzle offered more lottery tickets ($M = 4.22$, $SD = 1.35$) than participants who completed the smooth puzzle ($M = 3.32$, $SD = 1.42$), $F(1, 40) = 4.45$, $P = 0.041$. SVO classifications suggest that this was not because rough-puzzle participants were simply more cooperative. Of participants classified prosocial/cooperative, 70.6% actually completed the smooth puzzle, whereas of those classified individualistic, 75.0% completed the rough puzzle, $B = -1.97$, Wald statistic = 7.09, $P = 0.008$. Following from the results of the previous study in which texture changed impressions about social coordination, here roughness appeared to promote compensatory bargaining behavior (giving more tickets so that the offer is not rejected) in a situation perceived as uncoordinated. The rough priming experience did not merely produce more negative behavior overall.

Our last two studies tested haptic experiences with hardness, which is metaphorically associated with the concepts of stability, rigidity, and strictness. This is exemplified in the idioms "she is my rock" and "hard-hearted." In study five, 49 passersby were asked to watch a magic act and guess the secret. As in many magic acts, participants first examined and verified that there was nothing unusual about the object to be used in the trick—either a soft piece of blanket or a hard block of wood. The act was then postponed (forever) while participants completed an impression formation task as in study three. Here the two target individuals in the ambiguous interaction were described as a boss and an employee. Participants evaluated the employee's personality on trait terms relating to positivity (for example, kind) and rigid/strictness (for example, unyielding). Consistent with metaphorical associations of hardness, participants who felt the hard block judged the employee to be more rigid/strict than participants who felt the soft blanket (Table 1), $F(1, 47) = 4.52$, $P = 0.039$, but they did not judge the employee more positively overall ($F < 1$).

Study six moved beyond active touch manipulations to investigate whether passive touch experiences can similarly drive embodied cognitive processing. Instead of having participants touch objects with their hands, we primed participants by the seat of their pants (*24*). Eighty-six participants sat in either a hard wooden chair or a soft cushioned chair while completing both an impression formation task (similar to study five) and a negotiation task. This latter decision-making task had participants imagine shopping for a new car (sticker price $16,500) and subsequently place two offers on the car (the second assuming that the dealer rejected the first offer). Comparable to study five, participants who sat in hard chairs judged the employee to be both more stable, $F(1, 84) = 4.90$, $P = 0.030$, and less emotional, $F(1, 84) = 5.03$, $P = 0.028$, but not more positive overall ($F < 1$) than did participants who sat in soft chairs. On the negotiation task, no differences in offer prices emerged ($P > 0.14$). We next calculated the change in offer prices from first to second offer, on the presumption that activating the concepts of stability and rigidity should reduce people's decision malleability or willingness to change their offers. Among participants who made a second offer, hard chairs indeed produced less change in offer price ($M = \$896.5$, $SD = \$529.6$) than did soft chairs ($M = \$1243.6$, $SD = \$775.9$), $F(1, 66) = 4.30$, $P = 0.042$. Controlling for whether people reported wanting to buy a car in the next year strengthened this effect, $F(1, 65) = 6.95$, $P = 0.010$. Thus, hardness produces perceptions of strictness, rigidity, and stability, reducing change from one's initial decisions, even when the touch experience is passive in nature. These findings highlight the metaphorical specificity of haptic priming effects: Instead of changing the overall valence of evaluations, hard objects made others seem both more negative (strict and rigid) and more positive (stable), with corresponding effects on decision-making.

These six experiments showed that physical interactions with three fundamental dimensions of touch influence our impressions and decisions, even when the people and events those impressions and decisions concern are entirely unrelated to what is being touched. Each dimension was associated with cognitions reflected in common metaphors: Heaviness produced impressions of importance and seriousness, as well as a preference for funding solutions to important problems; roughness led to impressions of decreased coordination and increased donations as a compensatory response; hardness made others appear more strict and stable but less emotional, and also decreased negotiation flexibility. Across studies, these findings emphasize the power of that unique adaptation, the hand, to manipulate the mind as well as the environment. Our last study also suggested that a haptic mindset can be triggered even when touch occurs in other areas of the body, as might be expected given that many tactile experiences are not limited to the hands.

Theoretically, this research suggests interesting implications for human life history processes. Touch is the first sense to develop ontogenetically (*25*) and thus may be the most relevant for scaffolding later conceptual knowledge. Consider that contemporary interpretations of the classic "Big Five" personality traits posit two higher-order factors with the (tactile metaphor–relevant) labels "stability" and "plasticity" (*26*). Such factors are associated with different hormonal substrates (serotonergic and dopaminergic systems, respectively), and it would be interesting to consider the influence (if any) of varieties of touch experience on these systems' activation. With respect to embodiment more generally, evidence suggests that instances of physical or mental action (such as moving an arm or reading a word) are accompanied by reduced cortical activity in relevant brain regions (*27*), which is indicative of neural pathways being (nonconsciously) cued for further processing of similar actions (*28*). We might expect that neural cueing for particular dimensions of touch experience map onto those that register the associated metaphorical concepts identified here.

Although we have focused on interpersonal perceptions, we expect that self-perceptions are similarly affected by what we touch, which is consistent with the dual nature of priming effects (*28*, *29*). Of course, practical implications abound as well. First impressions are liable to be influenced by one's tactile environment, and control over that environment may be especially important for negotiators, pollsters, job seekers, sensory marketers, and others who are interested in interpersonal evaluation processes. Perhaps the use of such "tactile tactics" will represent the next advance in social influence and communication.

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