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**Bovine Prospection, the Mesocorticolimbic Pathways, and Neuroethics: Is a Cow’s Future Like Ours?**

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**Abstract**

What can neuroscience tell us, if anything, about the capacities of cows to think about the future? The question is important if having the right to a future requires the ability to think about one’s future. To think about one’s future involves the mental state of prospection, in which we direct our attention to things yet to come. I distinguish several kinds of prospection, identify the behavioral markers of future thinking, and survey what is known about the neuroanatomy of future-directed bovine beliefs and desires. I suggest, in conclusion, that instead of asking whether a cow’s prospection is *conscious,* ask whether it is *like ours*—with “ours” understood to include all human beings.

**Keywords**

Cattle cognition; Mesocorticolimbic pathways; Nonhuman animal consciousness; Bovine prospection; Thinking about the future; Neuroethics

**Introduction**

A Holstein is locked in a stanchion at a feed trough, her eyes wide with anticipation, her neck outstretched. At the start of this YouTube video sequence (1), the cow is clearly looking forward to something. Or is she? Can cows think about their future? In this chapter I briefly explain the moral significance of the possibility that cows look forward, and offer some stipulative definitions of different modes of prospection. By prospection I mean thinking about what is yet to come. I survey what is known about human behavior and neuroanatomy when we have prospective beliefs and desires, and proceed to make some testable empirical predictions about what we should expect to find in cows if they prospect. I propose an analogy between bovine prospective beliefs and desires and the prospective beliefs and desires of non-reporting congenitally severely cognitively limited humans, such as humans with neotenic complex syndrome. In conclusion, I suggest that we stop asking whether a cow’s prospection is real or conscious and ask instead whether it is like ours—with “ours” understood to include all humans.

**Why Bovine Prospection Matters**

In North America, steers, heifers and bullocks (for the sake of economy of expression, I will refer to all bovines, male or female, young or old, as *cows*) are typically killed at a young age for meat. Good milk producers are milked for several years and then slaughtered. Common justifications for treating cows in this way include claims that cows: are not contractors (2,3); lack rights (4); do not possess language, rationality, or self-consciousness (5); and so on. The idea here is a familiar one, that animals cannot have a right to life because they cannot take an interest in their future (6,7). There is little justification for causing animals unnecessary pain. However, many believe it is permissible to kill animals humanely—swiftly and painlessly—because animals act only “on instinct,” live entirely “in the moment,” or have only “nonconscious experiences” [for discussion, see (8)]. Without conscious anticipatory plans looking forward in time, cows, one may reason, only have value because they are sentient. The cow’s value as an individual able to acquire pleasure is lost when the animal is killed, but the value is replaced the moment the next sentient cow comes into being (9,10). On the other hand, however, if an individual looks forward to her future, killing her deprives her of her ability to satisfy her desires. If killing a prospective individual is *prima facie* wrong because it robs them of all future experiences, then killing cows may be *prima facie* wrong because it robs them of their future.

These considerations show that bovine prospection matters. If a cow cannot take an interest in her future, it may be that she has no right to it. If, on the other hand, she can take an interest in her future, she may have a right to it.

**Rights and Interests**

Should cows be able to think about their future, and if we can show that they can, then we will have taken a first step -- a big step -- toward undermining the common justification of humane slaughter. For, according to one widely accepted view, rights require interests (11). An individual cannot have a right to something unless they have an interest in it. And, their interests must be sufficiently weighty that the interests can support saddling others with the obligation to refrain from depriving the rights-holder of that to which the rights-holder has the right. For example, lead-free water is essential for the healthy development of children, so the children of Flint, Michigan have a sufficiently weighty, legitimate interest in having access to lead-free water to establish a right to have access to lead-free water. A creature that did not require lead-free water to be healthy would have no similar interest, and thus no right to it. This is the presumed connection between rights and interests. Having an interest in something does not by itself establish a right to it, but having a right to something requires having a legitimate interest in it (12–14).

If having a right to *x* requires that one have an interest in *x*, then having a right to one’s future requires that one have an interest in one’s future. If cows have no interest in their future, they cannot have a right to it. But if they do have an interest in their future, they may have a right to it. So, much hangs on the next question.

Do cows think about their future? Let’s return to the cow at the feed trough. Call her Betsy. If we run the video, the next thing we see is a youth, call him Jake, approaching Betsy with a feed tub. He dumps some grain in front of Betsy’s neighbors, and then some in front of Betsy. He throws the tub, presumably still with grain in it, in front of the cow two stalls to Betsy’s right. Betsy stretches for it but, unable to reach it, proceeds to unlock her stanchion using her horn. After backing out, she reaches over her neighbor’s neck and uses her tongue to unlock her neighbor’s stall. The neighbor withdraws. Betsy repeats the procedure a second time on her second neighbor. After both neighbors have vacated, Betsy enters the second neighbor’s stall, grabs the tub, and pulls it toward her.

**What Is This Cow Planning?**

Rewind to the first frame. What is Betsy thinking about her future, if anything, as she first observes Jake’s approach? Here are three possibilities.

[a] Here comes Jake with our grain. When he gets here if he dumps it all in front of Babe like he did yesterday then I’m going to headbutt her out of the way. She’s his favorite but that’s not fair. They’re both about to learn that I’m not taking it any more.

[b] BELIEF [if tub arrives, feed]

BELIEF [if tub does not arrive, no feed]

DESIRE [feed]

[c] [*blank*]

Call the first response *autobiographical* prospection. If [a] is correct, then Betsy is thinking about what the future holds and she is able to tell herself a story about it. Few objective observers of cows would attribute such human-like foresight to Betsy but, were she to possess it, she would likely have fitness advantages over conspecifics (15).

Call the second response *intuitive* prospection. In [b], Betsy has beliefs about and a desire for the future. Nonetheless, lacking the ability to form sentences and narratives, she cannot use these mental states to tell a story about her future. We storytellers can arrange her cognitive, conative, and emotional states into a narrative about her future but, according to [b], we would not be justified in thinking Betsy understands our story. Defenders of this second option find support in ethologist Wolfgang Kohler’s idea that no animals have future-oriented thoughts extending beyond their present circumstances. According to the influential Bischof-Kohler hypothesis, after any animal has eaten her fill, she is unable explicitly to think about—much less plan for—the next hunger bout because she lacks the ability to represent herself and her future self, much less the temporal psychological connections between them (16,17). Nonetheless, at the moment, Betsy implicitly has the sense that grain is coming, that an obstacle stands in her way, and that she must find a way around it. This, at least, is one plausible story we could tell to explain her behavior.

According to [c], Betsy has no beliefs or desires at all, no thoughts about the future. Call this answer *stimulus-response*. Defenders of [c] might argue that because cows lack language they cannot form beliefs about the present, much less the future (5,12,18). I will have more to say about cows and language shortly.

I’ll argue for [b]. Cows have intuitive prospection.

**Prospection: Some Definitions**

Here I offer some stipulative definitions of key terms I will employ.

***Prospection*** is any mental state directed toward the future (19). I am engaged in prospection when I wonder whether raspberries will be genetically engineered for cold tolerance by the end of the decade.

***Nonconscious prospection*** is an unfelt bodily movement toward a future goal. I am engaged in nonconscious prospection whenever my subcortical autonomic system is making predictions about where my fingers will wind up a few milliseconds from now as I reach for a raspberry. Carruther’s distracted driver steering around a double-parked lorry is engaged in nonconscious prospection as he successfully guides his vehicle to his goal without knowing or feeling what he is doing—and without the capacity to remember afterwards the details of what he has done (6). When a blindsight patient successfully walks around an object he cannot see in order to reach the end of a hallway, he is engaged in nonconscious prospection (20). Suhler and Churchland explore the neurobiological parameters that support such nonconscious monitoring and control (21). Animals, like humans, have sophisticated neural and chemical processes that keep them moving toward their goals even though they are unaware of the processes.

***Intuitive prospection*** is the fast, automatic, implicit process of anticipating or bringing about a future event without analyzing or deliberating about it (22). Unlike nonconscious prospection, in which one feels nothing at all, intuitive prospection is a subjective experience. Tulving described our ability to look backward in time and draw on implicit memories to ride a bike, for example. The bike rider automatically follows rules to keep the contraption upright but does not need to pay attention to the rules. Similarly, looking forward in time, intuitive prospection is an ability to initiate behavior in light of one’s goal without consciously turning one’s attention to the steps necessary to attain it. I am engaged in intuitive prospection whenever I want a raspberry and, knowing they are in the refrigerator, walk unthinkingly to the kitchen and open the fridge. Panksepp, building on Tulving, calls this kind of experience a part of unknowing, or *anoetic* consciousness, and the work of the “core-Self” (23–25); Damasio calls it a state of the *protoself* (26) .

***Deliberative prospection*** is a slower, rational, explicit process of consciously directing one’s attention to the future and planning the steps necessary to bring it about (22). I am engaged in deliberative, or episodic (Tulving), prospection whenever my first-order desires and beliefs about the future are disposed to be under my conscious control. By “disposed to be under my conscious control” I mean capable of being influenced by signals coming from my frontoparietal cortical region (27). Tulving described our ability to look backward in time and remember the who-what-where-when details of a personal event. I can perform similar simulations of future events whether those events are indexed personally to me or not. I engage in impersonal deliberative prospection when I reflect on the fact that global temperatures are rising and a child born in 22nd century North Carolina may have a shorter life-expectancy than a child born there in this century. Panksepp calls this a part of *noetic* consciousness; Damasio, *core* consciousness (23,26).

***Autobiographical prospection***is a variety of deliberative prospection. Here, future thoughts are indexed to the person doing the thinking: a mindreading individual with a biographical sense of self travels mentally through time. One pictures oneself as a character playing a role in a more-or-less richly detailed story. And one then reasons backward from this future simulation to plan the steps necessary to bring the simulation into being. Autobiographical prospection requires a subjective sense of time, a theory of mind, second-order beliefs—beliefs about one’s beliefs—and narrative understanding. Narrative understanding allows one to see oneself as a character in a plot (28–31). I am engaged in autobiographical prospection when I am thinking about what to serve Mom for breakfast tomorrow and, recalling that she thinks large dark raspberries are sweetest and wanting to impress her, I write myself a note to go shopping for the biggest berries I can find. Panksepp, again following Tulving (24), calls this kind of experience a part of *autonoetic* consciousness; Damasio, *extended* consciousness (23,25,26); and Szpunar, Spreng, and Schachter call it “planning” (32).

What sort of prospection, if any, is Betsy capable of? Does she have second-order beliefs about her future mental states in the way required for autobiographical prospection? Or is she capable only of the lower-order intuitive prospection, non-self-consciously interpreting events-to-come in terms of narratives only observers can construct for her? And perhaps there is even less to it. Is Betsy always acting nonconsciously, unaware of anything she does, her mind an empty blank?

To answer such questions we must examine two linked sources of evidence: behavioral and neuroanatomical. To figure out which neuroanatomical structures, if any, are being recruited in cows for which prospective purposes, we must begin by describing the target behavior. If we don’t clearly identify the prospective behavior’s beginning and ending points, we won’t know when to look for activated neural networks when we go looking for prospection’s neural correlates.

**Cow Behaviors**

What do cows do? One is tempted to say: not much. Most of the time they graze, ruminate, and rest, standing around, staring at nothing in particular. They enjoy chewing their cud and switching their tails, lying down, sleeping, hanging around familiar conspecifics, and avoiding antagonistic confrontations (33). They like to groom and be groomed, rub their necks on the ground, scratch, and lick (34). Most of the time they’re doing things we interpret as displays of bovine contentment. “They appear to understand patience and composure,” writes Jon Katz (35), and this might lead us to think that cows aren’t actually thinking at all. They’re merely acting “instinctually,” responding with unlearned behaviors to stimuli.

However, as Katz adds, “cows…haven’t been allowed to be smart” (35). Indeed, the hundreds of years of domestication have produced tame animals who are docile compared to their wild relatives. And some cows are even raised as pets, in pampered conditions that do not allow the animals to develop their native capacities. Consequently, it is easy to underestimate the intelligence of cows [for a review, see (36)]. Cows can learn to do most of the things dogs can learn to do: to follow (37), to stay, kneel, or spin (38), to fetch balls (39) and to gain entry to buildings by pressing buttons (1). They can learn to negotiate mazes to find food (39). They can learn, without training, to work a pump handle to bring up water from a well and figure out by observation how to press a lever to get extra feed (40) [but, so far, apparently cannot be trained to defecate in prescribed areas (41)]. But can they foresee their futures?

Let’s rewind Betsy’s video yet again. In the moment she’s watching Jake’s approach, is she travelling mentally through time, seeing herself a half minute from now having released her neighbor and about to take her neighbor’s place? Is she saying to herself, “Silly farm boy, you think you can keep this old girl out of the corn? Just you watch me”?

We have no behavioral grounds to attribute autobiographical prospection to Betsy. She gives no indication that she has conscious representations of her own mind, much less Babe’s or Jake’s. There’s no behavioral evidence to suggest she represents herself to herself as herself, thinks about her future self, or conceptualizes herself as a psychological continuity that persists between now and the future. We have no reason to believe she has a sense of what motivates Jake to do what he does, nor that she has ideas about what Jake might think about her. There is no evidence that she has a sense of what justice requires in the barnyard.

To have an autobiographical capacity one must be a self-conscious agent with the mental facility to construct narratives with plots replete with characters facing obstacles. The story needs a beginning, a middle, and a denouement, that is, some explanation of how the affair ends. I take seriously Morgan’s canon, always to prefer the lowest possible level explanation of an animal’s psychological state (42). The simplicity of bovine behaviors make it very difficult to believe that cows can take an autobiographical interest in their future. I am unaware of empirical attempts to test cows for their ability to understand plots, character-constructions, or narratives, or for a cow’s ability to understand the requirements of morality. Experiments for such traits may eventually be devised, but I am skeptical cows will pass them for reasons I give elsewhere (43–45).

If we are to guard against anthropomorphizing cows and illegitimately ascribing human mental qualities to them, we should be cautious about ascribing to them moral states such as envy, humiliation, jealousy, pride, embarrassment, and shame. To have a virtue or vice one must be, well, a character in a narrative plot. One must understand oneself as a self and be conscious of how one’s actions are affecting other selves. This kind of self-conception is what cows probably lack.

However, to avoid anthropomorphism one need not resort to a reductionistic stimulus-response view. We need not assume that animal experience is nonconscious, lacking all phenomenal qualities all of the time (6). Nor need we become mysterians either, agreeing with neuroscientist Joseph Ledoux that “we can never know whether another animal has conscious emotional feelings” (46). For a more plausible view is readily available, and that is this. Some animal experiences are nonconscious, some are unconscious, and some are conscious. Eventually a mature physical science may supply causal explanations of consciousness. In the meantime, many philosophers are convinced, as am I, that we must borrow the belief and desire framework of folk psychology. It’s the best of the current options on offer to characterize conscious animal experiences (47,48).

A non-anthropomorphic folk psychological description of what it is like to be a cow looking forward involves two key steps. First, determine which neuroanatomical structures humans recruit when they prospect. The prospective target behaviors include combinations of things such as squinting or widening eyes, tilting the head, favoring an ear, sniffing the air, stretching the neck. Second, determine whether relevantly similar neuroanatomical structures are found in cows and, if they are, whether they are recruited when the cow’s behavior indicates prospecting (squinting, tilting, etc.). If bovine structures are present and active during the bovine behaviors we suspect are prospective in nature, then the burden of proof will have shifted to those denying cows have an intuitive sense of their future. I am not suggesting that having such structures is necessary for prospection (and they may not be, to take just two examples, for birds or octopuses). I am suggesting that having them, and having them functioning in neurotypical ways, may be sufficient for intuitive prospection.

**Hypothesis: Cows Have Intuitive Prospection**

Let me say a bit more about what needs to be shown if we are to believe in bovine intuitive prospection. First, notice that intuitive prospection is like autobiographical prospection in that it has a narrative structure. To have a narrative structure is to have temporally encapsulated contiguous episodes integrated into a larger whole, a plot (28,30,49). When my thoughts about my future have a plot, I foresee the end state as connected to my beginning point by a story that explains the entire sequence. The story explains my decisions as I look and move ahead, showing how the series of events in my past lead to the choices I am making now. I see my story, in other words, as a unified whole, unified from past to future by the agency of a character, me. *I* tie together and explain the entire sequence (50). What is the connection between narrative and explanation? An explanation is required to show how the many features of my perspective—my memories, values, emotions and aspirations—form a coherent account of the individual in question. A story is needed to explain *me.* Without a story, I dissolve into a series of disconnected states of affairs. Others’ actions also require narrative explanations. When a mindreader is explaining someone else’s actions, the mindreader employs third-person biography for the explanation. Both biography and autobiography have narrative form; both employ the four elements of what the Aristotelian poetic tradition calls tragedy: plot, character, mood and setting (29).

If this analysis of time, narrative, and personal identity is correct, then the difference between intuitive and autobiographical prospection is not in their relative structures, for each has a narrative form. The difference is in their perspective. Autobiographies are narratives told from the first-person perspective to explain one’s own actions. They require that the actor be able to say “I.” Biographies are narratives told from the third-person perspective to explain someone else’s actions. They do not require that the actor be self-conscious or capable of telling the explanatory story, only that some narrator or other be able to tell a veridical story about the actor. This is what it meant by the claim that intuitive prospection is biographical, not autobiographical.

Do cows have intuitive prospection? To show that they do we would need to show that a story is available to explain cows behaviors. The next section attempts to do just that by drawing on work of Peter Carruthers concerning animal metacognition (51–53).

**Bovine Prospection: Belief and Desire**

At t*1* Betsy possesses three mental states:

[1] BELIEF [feed is in tub]

[2] BELIEF [if tub is reached, eat]

[3] DESIRE [eat]

[1], [2] and [3] automatically produce movement at t*1* as Betsy stretches her neck toward the tub. Betsy engages in this behavior regularly, unreflectively perceiving food, positioning her body to ingest it and swallow it. If this were all there were to Betsy’s behavior, then we should do away with the reference to BELIEF because we could explain her behavior more simply in stimulus-response terms.

Like most of our movements while eating, a cow’s movements while eating are caused by subcortical neural networks operating below her level of attention. The external world stimulates a perception, the relevant subcortical pathways process it, and Betsy eats. In these cases, the “Betsy’s mind is blank” interpretation is validated by the evidence. The sight of feed is the rewarding stimulus and Betsy’s unreflective reaching for it is the response. We can always expand our explanation and interpret her behavior in terms of beliefs but, in the ordinary case, there is no need and Morgan’s canon tells against the expanded explanation. Sub-threshold neural interactions suffice to explain uninterrupted eating behaviors. End of story.

However, as it happens during this particular meal, Betsy cannot reach the tub. Caught up short in satisfying her desire, she must now turn attention to what she is doing. Here, at t*2*, she finds herself with a genuine belief, that is, one that cannot be explained by the stripped-down stimulus-response apparatus:

[4] BELIEF [feed is unreachable]

[4] introduces a matter that Betsy’s automatic systems cannot handle. *Additional effort required to reach the goal! How to proceed?* She pauses. Perhaps she feels some anxiety. Perhaps she wonders if she is still committed to [3]. I am not suggesting that Betsy is carrying on an internal monologue with herself conducted in the English sentences found here. But I am suggesting that she has some kind of cow-ese, some kind of representational format in which to do her thinking. The format need not be language-like; it might be more like a map, or like music, or like gestures. It might even have more to do with odors. Whatever the internal bovine representational format, Betsy must be able to use it to represent, interpret, and interact with the external world (54). If she finds that she still wants to eat, then she must use her thinking tools to inhibit her current urge to press again, only harder, against the stanchion. She needs a novel strategy. She calculates.

At t3, Betsy has a new set of attitudes:

[5] BELIEF [if tub is not reached, do not eat].

[6] BELIEF [tub cannot be reached unless neighbor moves]

[7] DESIRE [neighbor moves]

[8] BELIEF [neighbor does not move unless *this* lock opens]

[9] BELIEF [this lock does not open unless head is used]

[10] BELIEF [if head is used, this lock opens]

[11] BELIEF [if head is not used, this lock does not open]

[12] DESIRE [this lock opens]

The frustration of her initial strategy combined with the causal reasoning found in [10], [11], and [12] result in her deliberately extinguishing the instinct to push harder and harder against her stanchion. Instead, she pauses, looks around, and then backs away from the stanchion. She carefully repositions her head and slides open the lock. Backing out, she again briefly surveys the scene and turns to the next challenge, moving her neighbor.

At t*4*, Betsy has taken on another set of beliefs and desires:

[13] BELIEF [*that* lock does not open unless tongue is used]

[14] BELIEF [if tongue is used, that lock opens]

[15] DESIRE [that lock opens]

The combination [13] - [15] produce the use of her tongue to open the neighbor’s lock. This updating of mental states continues in an iterative process until she is finally able to reach the tub. At that point, at least twenty seconds after t*1*, her story is complete. The obstacles that arose as she strived to bring a future state into existence have been overcome. She does not know the story that unifies her beginning intention with her final achievement, but we do.

Notice that the analysis is not autobiographical because nowhere in it do we find the subjective words I or me. Beginning with [4], a plot begins to form as an unexpected challenge comes into play and presents an obstacle the actor must confront. Unlike the combination of [1] – [3], the beliefs and desires constituting [1] – [15] represent a temporal series of desires and beliefs united by an individual’s psychology grappling with a problem. To this extent, a narrative is required to explain the coherence of the set. The story, told from the third person stance, not autobiographical. It does not require that the actor have a theory of mind. Nor does it invoke metacognitive states such as *imagining* one’s future bodily location, *regrouping* oneself after an initial defeat, *envisaging* others’ emotions, or *judging* the fairness of their actions. While Betsy’s story is not a first-person narrative, nor even a narrative involving a person, it is nonetheless a narrative.

Betsy’s prospection, then, is biographical. If this analysis of bovine prospection is correct, we can proceed to look for neu/roanatomical evidence to see whether cows have structures to support the mental states just ascribed to them. To do this we must determine whether cows have neural pathways that support belief and desire and their selective inhibition. Since little is known about the neuroanatomic pathways in bovine limbic systems, let us begin with our own case. Localizing belief and desire in the human brain can provide starting points as we try to peer into the cow brain.

**Neural Correlates of Human Desire**

By desire I mean the positive attitudes of wanting, yearning, craving, and liking. By the satisfaction of a desire I mean the pleasurable state that accompanies desire’s fulfilment For example, hunger and thirst are desires and it’s a pleasure to have them satisfied. Desires can be conscious or unconscious (although probably not nonconscious). According to MacLean’s triune interpretation (55) of the human brain—a convenient approximation if no longer a sound scientific theory—unconscious desires are localized in the evolutionarily most ancient, so-called reptilian, brain: the lower, subcortical, third of the organ. Conscious desires necessarily involve the youngest, most recently evolved, third of the human brain, the so-called neomammalian complex, or neocortex (55). To have self-aware, conscious desires, then, seems to require in humans a neocortex [although, for important qualifications see Ledoux (56), Merker (57) and Philippi et al. (58)].

The affective neuroscientist Jaak Panksepp interprets desires as part of the reward system of the brain, the approach and avoidance systems (23,59), or what Panksepp dubs the SEEKING system. The SEEKING system animates us, moves us forward, promotes “an energized appetitive disposition, which unconditionally promotes exploration and foraging for resources…”(59). It can function consciously or unconsciously, operating above or below the level of phenomenal consciousness and executive control. When the system involves the cortex, we consciously assess whether to move toward the pleasurable opportunity, be it an offer of companionship, protection, knowledge, affection, or sustenance. When the system does not involve the cortex (23,60), we gravitate unthinkingly toward the reward, especially if it appears to be easily obtained. A partner of the SEEKING system is the FEAR system, which can launch us without thinking into rapid avoidance behavior. The SEEKING system can launch us without thinking into rapid acquisitive behavior. For this reason, it is the top prospect as the neural network recruited by the brain during intuitive prospection.

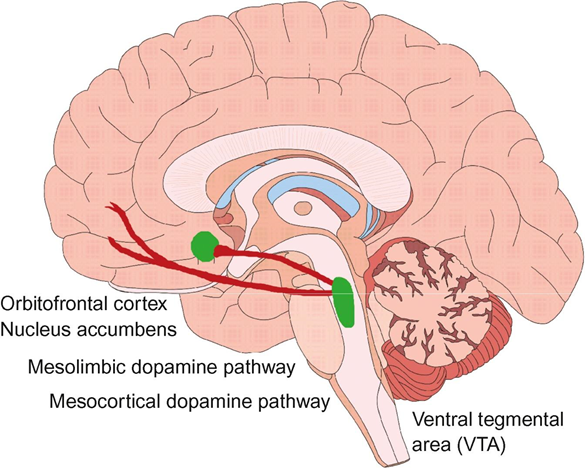


Fig x.1. The Reward System: Liking, Wanting, Learning. Reprinted with permission from Elsevier (61).

As suggested in Fig. x.1, the human SEEKING system is set in motion by the ventral tegmental area (VTA), the green area in the midbrain, inside the pons, to the right, posterior, end, of the figure. When the VTA receives a representation of a rewarding stimulus from the eyes or nose, it immediately sends dopamine to the nucleus accumbens (also called the ventral striatum, of which it forms the largest part). It is the green area to the left, or anterior, end of the figure (62). The VTA and nucleus accumbens are connected by the *mesolimbic dopamine pathway*, the topmost pathway in red. This pathway is contained within the subcortical basal ganglia of the medial forebrain (61) and is recruited for fast, “quick and dirty” processing. It accounts for desires without awareness. Electrical stimulation of this pathway causes feelings of pleasure, desire, and novelty-seeking (63) whether or not one consciously seeks such feelings. Call it the subcortical road.[[1]](#footnote-1)

When a reward can be easily achieved, the subcortical road ‘coaxes’ dopamine out of the nucleus accumbens and an immediate choice is made to pursue the pleasurable stimulus (65). When a baby glimpses the smiling face of his mother, the subcortical road is activated and he moves toward his mom without thinking about it. When a rat is faced with a simple learning task, such as pressing a button to obtain a low reward (say, two food pellets), the subcortical road is activated (66). The role of the mesolimbic dopamine pathway in desire is well-established. Amphetamines and cocaine cause five-fold increases in the level of dopamine along the subcortical road (67). Heroin, nicotine, marijuana, and alcohol all stimulate dopamine production in the area. Since drug addiction is a behavior difficult to overcome, and since the subcortical road is a set of processes not under one’s executive control, the mesolimbic path has become a key target for scientists researching new therapies for drug abuse (68–71).

The SEEKING system is also recruited during deliberative prospection which uses a second pathway, the *mesocortical dopamine pathway*. Running parallel to the mesolimbic pathway, it too originates at the VTA but, sidestepping the nucleus accumbens, heads directly for the orbitofrontal cortex (61). It is activated when the pursuit of an unconscious desire is frustrated and we need more time and planning to achieve the goal. If one must assess one’s options, negotiate obstacles, or find alternative means of reaching a goal, this cortical road leaps into action. By connecting the executive systems in the cortex with the subcortical limbic circuits, it is also capable of initiating top-down “stop” signals to extinguish initiatives in the limbic system.

In sum, the mesolimbic and mesocortical pathways handle different tasks and in different ways. When a simple cognitive task has an obvious low-cost solution, the subcortical road suffices and acts quickly. If you lesion the mesolimbic pathway of a rat, the animal gets slower at responding to rewarding stimuli (66). If the task is more complex and demands cognitive effort and judgment, the mesocortical pathway takes over. If you lesion the mesocortical pathway of a rat, the animal becomes less likely to expend extra effort if it is required to achieve a high reward (say, four food pellets) (66). These findings are consistent with the idea that when an animal no longer has access to its limbic system, it loses much of its ability to react quickly and grab rewards. And the findings are consistent with the idea that when an animal no longer has access to its cortex, it loses much of its ability to inhibit its impulses, accurately assess longer term costs and benefits, and make prudent utility calculations.

The two pathways are dissociable (72). While the subcortical road handles easy learning tasks, the cortical road handles more complex tasks. Put speculatively, if the mesolimbic pathway is recruited for unconscious seeking behavior it is probably recruited for intuitive prospection. And if the mesocortical pathway is recruited for conscious seeking behavior, it is likely at play during deliberative prospection.

Having reviewed what is known about the neuroanatomy of human desire, what do we know about the cow?

**Neural Correlates of Bovine Desire?**

Does the cow recruit brain structures similar to ours when the cow exhibits desires about its future? We know little about the correlates of bovine desire; I am unaware of any fMRI studies of cow brains. The problem, as George M. Strain, Professor of Neuroscience at Louisiana State University, puts it, is that

Not many people are interested in bovine neuroanatomy or neurophysiology….You won’t have any luck finding neural correlates of ‘desire’ in cattle … because we don’t recognize such as being present in animals, or at least have no way to identify it and measure it (personal correspondence, 19 June 2018).

Given the state of research, we cannot say definitively that cows have a SEEKING system similar to humans. However, given what we know about the mesolimbic pathways in humans, rats (54), rhesus monkeys (55), and other mammalian species (56), we can make some informed predictions about the cow brain. While we know that there are differences between the human and bovine brain—including their respective size, the structure of the frontal cortex, encephalization quotients, and number of A10 cells in the VTA (57)—whether such differences make a difference to whether a cow can look forward is still to be determined. However, given our shared evolutionary history, and extensive similarities between all mammalian brains, it is not unreasonable to hypothesize that we may eventually find in cows the bovine equivalents of the human neural SEEKING system. Fig x.2 illustrates this prediction.

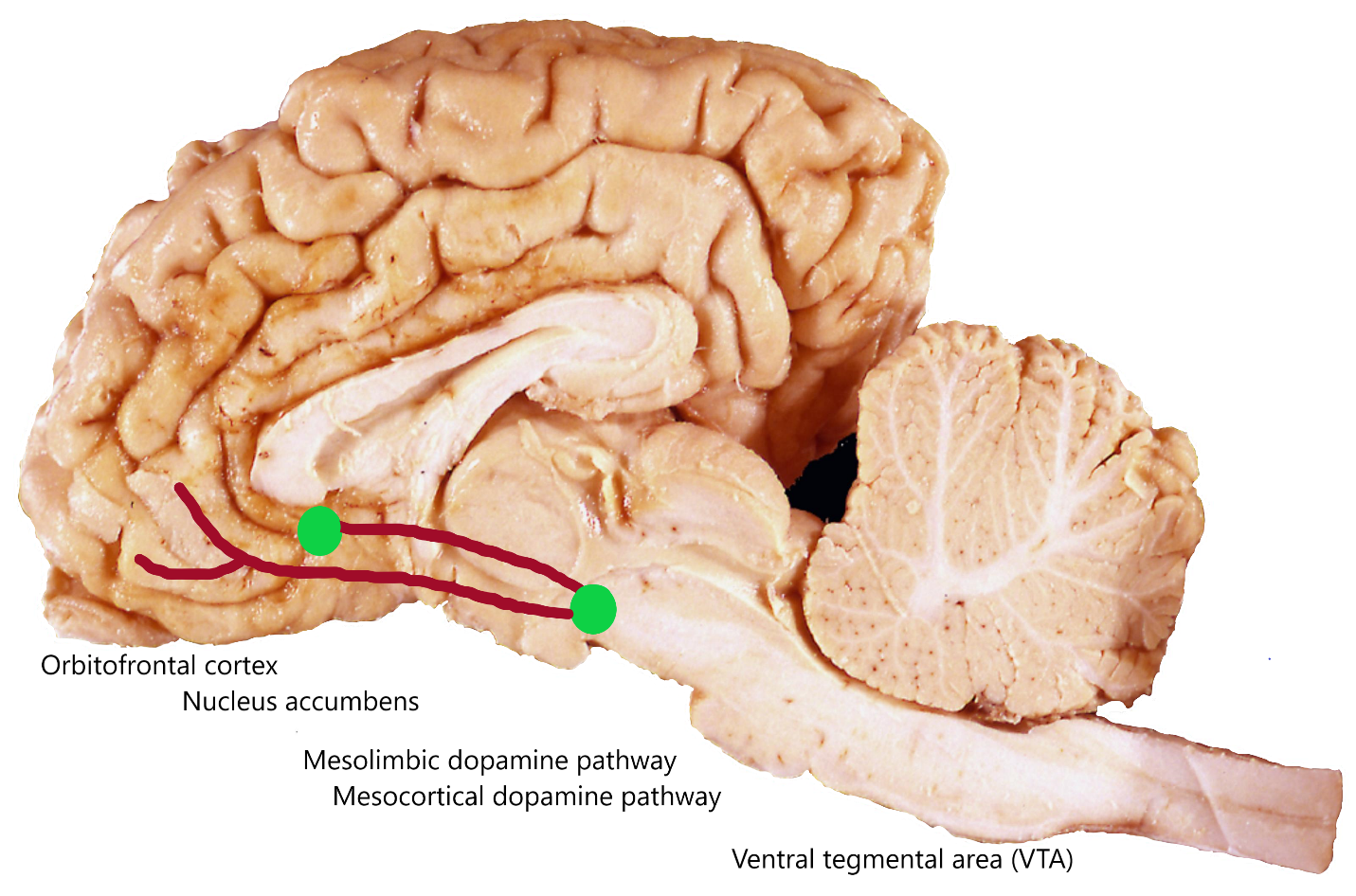


Fig x.2: Prediction: Bovine SEEKING system. Figure based on midsagittal view, “The brain of *Bos taurus*, version 3.0” (73), reprinted with permission of Floris Wouterlood, with hypothetical markings and labels superimposed and brain circumference outline removed.

Is a cow’s VTA connected to its nucleus accumbens by a subcortical mesolimbic dopamine pathway? If so, we should predict that cows recruit it during unconscious seeking behaviors. Should this hypothesis prove to be correct, we would have empirical support for the claim that cows have intuitive prospection. For, as the Russian biologist Dobzhansky observed, “nothing in biology makes sense except in the light of evolution” (74). And it would make little evolutionary sense for an animal to expend energy developing and maintaining a complicated set of neural pathways and structures if they did not serve a key function. This is some reason to believe that the physical structures seen in Fig. x.2 support prospective feelings in cows, if the structures exist in cows, just as similar structures support prospective feelings in us.

Perhaps, however, we are moving too quickly. Critics may point out that not all of an organism’s traits are adaptive. For example, vestigial organs are useless historical accidents that continue to get passed from generation to generation (think human tailbones, male nipples, or wisdom teeth). It is possible that a cow’s VTA, nucleus accumbens, or dopamine pathways are not adaptations and do not serve the functions in cows that they serve in humans. The evolutionary path leading to humans may have involved exapting the neural structures in question[[2]](#footnote-2). If our VTA, nucleus accumbens, and dopamine pathways were originally selected for purposes other than the purposes they serve in humans today, then the fact that cows also have them will not suffice to show that they support the same functions or feelings in cows as they do in humans. A critic might object to my argument by pointing out that individual humans may have been selected over time because they possessed novel adaptive traits that co-opted the VTA and nucleus accumbens and put them to new uses. In that case, and according to this line of objection, then the argument from analogy between cow and human neural architectures fails to show that individuals of both species have similar feelings as well as structures because shared structures may support different functions.

In response to this objection, it is important to note that neural pathways and brain connectomes are not organs like wings, tailbones or appendices. Unlike a vestigial trait that comes to be used for a function for which it was not originally selected (e.g., feathers originally selected for capacity to regulate temperature, not to fly), a complex network of neural connections must be strengthened through repeated use in order to support the original function for which it is selected. While such connections may be exapted over time and so enlisted for new uses, complex neural structures such as those under consideration are unlikely to be constructed in the first place unless they are being used repeatedly for some complex psychological purpose. Since neural architectures are far more complicated than limbs or organs, it is hard to see why these architectures would have been chosen had they not originally served in our last common ancestor with cows something like the functions the traits now serve in us.

It also seems that the structures in question are old and dedicated. That is, their presence in animals of different species is evolutionarily ancient and their functioning does not appear to require other, widely scattered, brain areas in the way that human language, for example, does (75). If the VTA and nucleus accumbens are connected in cows, then the bovine pathway may sponsor in cows the tacit anticipatory feelings that the human pathway sponsors in humans. I do not take these claims to refute the objection. However, if my assumptions are correct, the objection is weaker than it initially appears. It is not implausible to conclude that the presence in cows of the human-like neural structures identified above would provide a reason, a powerful albeit defeasible reason, to believe that cows have something very like the mental states supported by these structures in humans.

In addition, we may ask whether cows have a cortical road connecting the VTA to the frontal cortex. If they do, this fact would provide reason to believe that cows can exercise executive control, inhibit urges, and consciously plan strategic interventions to achieve their goals. I admit, however, that this conclusion is far from established. Further research is needed, in any case, to determine whether cows have a mesocortical dopamine pathway.

Having completed a survey of how human and bovine brains may handle desire, what do we know about how they each handle belief? Unlike the SEEKING system, our beliefs appear to be impossible without the cortex. Begin again with the human case.

**Neural Correlates of Human Belief**

Which regions of the cortex are recruited to support which beliefs probably depends on the complexity of the belief. We know that more complex beliefs expressed in propositions and narratives take a longer time and a greater area to process than do simpler beliefs expressed in words.

At Uri Hasson’s lab at Princeton, undergraduate experimental subjects listened to short stories while researchers mapped their cortical activations using fMRI (76). As the task went from simple to complex, the time it took the brain to process the ideas took longer and longer and involved more and more regions. When the subjects first heard a short story, they heard gibberish because it was played in reverse. In trying to make sense of incoherent noises, the subjects recruited only a small part of their temporal lobes. Fig x.3 shows these sections in red, the sections posterior (P) to the lateral sulcus (LS). When the sound played was an intelligible word, however, the yellow areas were also recruited, the posterior (P) regions of the superior temporal sulcus. If an entire sentence was played, the larger green areas were added, areas stretching toward the temporal-parietal junction (TPJ) plus regions anterior to (A) the central sulcus (CS). When subjects heard an entire paragraph, distant expansive blue regions of the brain were activated, including medial prefrontal cortex (mPFC) and intraparietal sulcus (IPS).

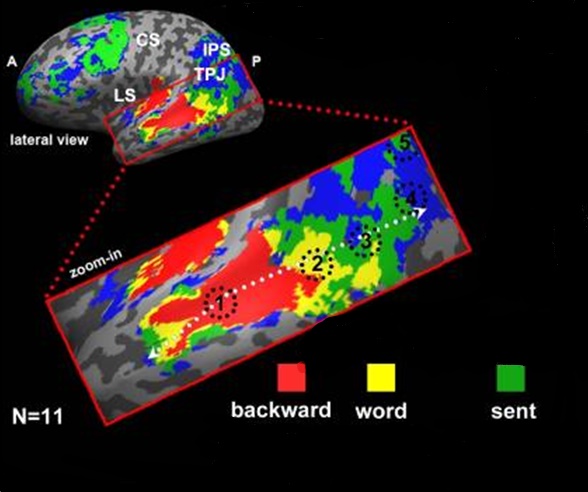


Fig x.3. Hierarchical topography of temporal receptive windows in fMRI image. Reprinted with permission of *The Journal of Neuroscience* from (76). Figure cropped and modified with permission of Uri Hasson.

Lerner et al. call the length of time it takes for the brain to make meaning out of sounds a temporal receptive window. Generally speaking, we require at least a half second to process a word, 3 seconds for a sentence, and 17 seconds for a paragraph. As we move from comprehending a word to a sentence to a story, our temporal receptive window expands as does the area of the brain in play.

It is not implausible to think that the red, yellow, and green areas activate during deliberative prospection as we form narratives about the who, what, and where of the future. Nor is it a stretch to think that the blue “paragraph” areas must also be recruited when, during autobiographical prospection, we form stories about our future. Going forward, at least, I shall help myself to these assumptions.

**Neural Correlates of Bovine Belief: What Do We Know?**

We know almost nothing about how cows process beliefs. However, basing our hypotheses on what we know about humans and other mammalian species, we may again hazard a prediction. We may predict that differences in the complexity of bovine beliefs will be reflected in patterned differences in bovine brain activation. For example, should a cow hear an incoherent noise and try to make sense of it, part of her cortex may be activated, perhaps the red area near the lateral sulcus (LS) indicated in Fig x.4.

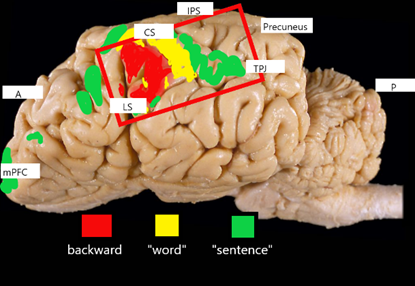


Fig x.4. Prediction: Bovine BELIEF system. Figure based on lateral view figure of “The brain of *Bos taurus*, version 3.0” (73), reprinted with permission of Floris Wouterlood, with hypothetical markings and labels superimposed.

On the other hand, should the noise turn into a recognizable vocalization of one of the animal’s familiars—such as a cow’s low frequency call for her calf (77)—larger regions, I now hypothesize, become involved. Call the yellow areas plus the red area, somewhat tendentiously, the cow’s WORD system, here proposed to involve areas posterior (P) to the central sulcus (CS). If cows can process even longer and even more complex vocalizations—such as higher frequency extended bellows intended to coordinate social interactions (61)—it may be that the larger green areas are needed. These may include regions, as in humans, anterior to the temporal-parietal junction (TPJ) and the medial prefrontal cortex (mPFC). Call this the cow’s SENTENCE system. I understand beliefs and desires in terms of propositional attitudes. There are many propositions that can be represented in any one of the thousands of human languages spoken through time. Cows do not speak any of these languages, but they may nonetheless think using analogous representational formats. Imagine that cows use, say, images, maps, rhythms and melodies, or gestures to represent objects and ideas to themselves and others (54,78). In that case, cows have words, the cognitive tool needed to represent objects even if cows lack narrative, the cognitive tool needed to represent selves.

Few would predict that cows understand, or will come to understand, human assertions, much less narratives. However, I leave open the possibility that cows may have a capacity to process beliefs and desires expressed in bovine terms more complicated than the bovine WORD system can handle. Thus, Fig x.4 proposes green areas. However, since we have no reason to think cows have autobiographical capacity, Fig x.4 has no blue areas.

Let us sum up before moving ahead. We have behavioral evidence that cows form intermediate-length intuitive prospections, that is, prospections that look dozen of seconds into the future. We have neuroanatomical hints that their brains may have the structures necessary to support such intuitive, narratively-structured, prospections. And we have testable hypotheses to determine whether these structures are recruited when cows ostensibly prospect. But now, again, comes the hard question. Is a cow’s prospection *conscious*?

This is an impossible question to answer because it is not well formed. We mean too many different things by “conscious.” In fact, the language used in this area quickly becomes confusing, as Panksepp’s identification of “anoetic consciousness,” and Carruther’s category of “nonconscious experience” exemplify. The usual strategy of trying to address the issue is to define the characteristics of what we take consciousness to be in humans and then ask whether this or that animal has those characteristics. This strategy has not proven fruitful. I agree with Carruthers that we should stop asking whether animals are conscious “not because they aren’t,” but, rather “because [there’s] no fact of the matter (79).” Instead, we can ask a more tractable question.

**Is a Cow’s Prospection *Like Ours*?**

To try to answer this question, we must first ask who we are. I assume “we” includes aphasic nonreporting humans who cannot tell us whether they are conscious prospectors. And I will assume that they are, in fact, conscious prospectors. By an aphasic nonreporting human, I mean an individual who congenitally lacks the autobiographical capacity to understand their life as a story.

**Belief and Desire in Neotenic Complex Syndrome**

An adult with neotenic complex syndrome may provide an example. Brooke Greenberg could not construct, follow, or understand her life as having a narrative arc because of profound delays in her mental development. When she died at age 20 she had never spoken, read, written, walked without support, fed herself, controlled her bladder, passed false-belief tests, or lived independently. She was capable of recognizing family members and enjoyed playing with her sisters and rocking in swings. She could “vocalize for attention and occasionally smile/laugh socially” (80). She had, as one of her doctors put it, the “cognitive development” of “a child less than 1 year old” (80). An MSNBC production, “A Child Frozen in Time,” shows Ms. Greenberg at age 16 in her walker, looking ahead toward the home room of her special education school building (81). She slowly scoots ahead, propelling herself down the hall. When she reaches the spot, she turns right, to the delight of everyone, including her mother, her teacher, and herself.

Let’s go back to the first frame. At the beginning of the sequence, she is peering down the hallway preparing to launch herself toward her homeroom. As she begins to push herself forward, she intends to move ahead, her behavior is goal-directed, and she has a representation of where she wants to wind up. But is it correct to say that she travels mentally through time to envision the future moment at which she will have reached her goal? I think this is unlikely given the limits of her cognitive capacities. However, along her way down the hall she inhibits the urge to give up and collapse in her walker. We see an aide pulling her along at one point, but Brooke does not want assistance and she perseveres on her own. We can easily imagine her encountering a janitor’s cart that blocks her path and her responding to the challenge by devising a way around it.

Three descriptions of Ms. Greenberg’s mental state at the beginning of the hallway sequence are available.

[a] There’s my Mom, my teacher, and Grandma in front of my homeroom. When I maneuver my way into the classroom, I hope they don’t jump up and down in front of the students like they did yesterday. I know they want to cheer me on, but they embarrass me when they make a show.

[b] BELIEF [if target room is entered, smiles all around]

BELIEF [if target room is not entered, no smiles all around]

DESIRE [smiles all around]

[c] [*blank*]

Notice that in [c] Brooke has no beliefs or desires, no conscious states; she’s not feeling anything. Defenders of this option might point out that Brooke lacks language and cannot form beliefs about the future. The first response is autobiographical prospection, the second response is intuitive prospection, and the third answer is stimulus-response. Which is correct? I’ll argue for the second.

We have no grounds to adopt the first, autobiographical, interpretation. To attribute such thoughts to Brooke we would have to assume that she is conscious of her own thoughts and body, has a theory about the intentions and thoughts of others, beliefs about what motivates them, ideas about how they perceive her, and a sense of what justice requires. We have no evidence to attribute such thoughts to her, no evidence that she has the capacity for moral agency or the mental facility either to construct narrative plots or attribute moods to characters. Absence of evidence is not evidence of absence, but neither is the promise of forthcoming evidence the bringing forth of evidence [for further discussion, see (82)].

Nor is there any reason to think her mind is blank. She has a unified perspective on the world which she vocalizes to express pain or happiness, frustration or accomplishment, discouragement or satisfaction. She can recognize friends and foes. She has basic emotions, beliefs and desires and executive control over them. She can aim at goals, devise hypotheses for achieving them, and choose rationally among them. She has a welfare, can be harmed or benefitted, and she can decide on strategies to overcome obstacles in her way.

**Nonreporting Human Intuitive Prospection**

A first order biographical analysis of Brooke’s mind would begin at t1 by attributing three mental states to her:

[16] BELIEF [if target room is entered, smiles]

[17] BELIEF [if target room is not entered, no smiles]

[18] DESIRE [smiles]

[16], [17] and [18] are unconscious states presumably processed by the mesolimbic pathway. They automatically produce leg-moving behavior at t*1* as Brooke propels herself forward without thinking. If [16] – [18] sufficed to move Brooke into her room, then she would not need to recruit the mesocortical pathway and we could do away with the reference to BELIEF because we could explain her behavior in subcortical, stimulus-response terms. In most instances, Brooke’s movements in her walker are unreflected upon and unavailable for her to reflect upon. If this were a complete description of the episode, then the “Brooke’s mind is blank” interpretation would be validated by the evidence. In that case, and contrary to the facts, her perception of the room would be the rewarding stimulus and her automatic movement into the room would be an unfelt response. We could always go on to interpret her behavior in terms of beliefs but there would be no need and doing so would violate Morgan’s Canon. In the imagined case, sub-threshold neural interactions suffice to explain behavior. End of story.

However, as it happens, Brooke cannot reach the room directly. Interrupted in her attempt to satisfy her desire, she must now turn her attention to what she is doing. Here, at t*2*, she finds herself with a genuine belief, one that surprises her and one that cannot be explained by the stripped-down stimulus-response apparatus:

[19] BELIEF [path is blocked]

[19] introduces a matter that Brooke’s automatic systems cannot handle. *Additional effort required to reach the goal! How to proceed?* She pauses. Perhaps she feels some anxiety and wonders whether she is still committed to [18]. I am not suggesting that Brooke is carrying on an internal monologue with herself conducted in the English sentences found here. But I am suggesting that she has some kind of tacit language of thought she uses to represent and interpret the world. If she finds that she still wants smiles, then she must inhibit her current urge to press again, only harder, against the janitor’s cart. She needs a novel strategy. She calculates. Is the reward she seeks worth the effort? Yes, she decides. Now, at t*3*, still desiring to make others happy, she thinks:

[20] BELIEF [if path is blocked, room is not entered]

[21] BELIEF [if alternate path is found, room is entered]

[22] DESIRE [enter room]

[23] BELIEF [alternate path requires left turn]

[24] DESIRE [turn left].

[25] BELIEF [alternate path requires right turn].

[26] DESIRE [turn right].

Calculation begins. Combining [20] - [22] with [23] - [26] and making the relevant utility assessments, the cortex, as it were, determines that the goal is worth the effort. It promptly sends a signal down the mesocortical pathway that is strong enough to stop the mesolimbic system from continuing to urge renewed pushing against the janitor’s cart. The prefrontal cortex commands a novel twisting motion and the motor cortex responds, engineering new leg thrusts to the left and then to the right.

At t*3*, a few dozen seconds after t*1* and after clearing the janitor’s cart, Brooke has two new beliefs.

[27] BELIEF [push straight ahead, enter room].

[28] BELIEF [do not push straight ahead, do not enter room].

The iterative updating process of narratively connected mental state sets continues until Brooke combines [27] and [28] with [22] and completes her plan. At t*4*, she enters the room. To smiles all around.

We have good reason to deny that aphasic nonreporting humans like Brooke Greenberg have moral responsibility. If one does not have representations of oneself over time or a narrative understanding of how one’s personal identity in the past is related to one’s future, one cannot understand how one’s actions are connected to their consequences (83). Likewise, for individuals with depersonalization disorder or dissociative amnesia, moral accountability may be compromised or nonexistent. In conditions in which one cannot locate one’s identity, one cannot be regarded as a morally autonomous agent. Nonetheless, such beings can be moral patients, and moral patients can be harmed. They are not by virtue of their psychological limitations open subjects for exploitation.

We have no reason to deny that aphasic nonreporting humans like Brooke Greenberg intuitively look forward to things in their future. It feels like something to be them looking forward. With a little imagination, the rest of us can come to understand much of how that feels, too.

**Conclusion**

Is all cow prospection nonconscious? The behavioral evidence suggests otherwise. Cows aim at goals, suppress urges to act instinctually, turn their attention to what they are doing, and negotiate obstacles in the way of their goals. They can look several dozens seconds, at least, into the future. We can tell stories about how they are dealing with twists and turns in the plots they, unbeknownst to them, are living out. If neuroanatomical research shows what is unlikely—that cows lack a mesocortical pathway—then we may have reason to doubt that cows can take an interest in their future. In the meantime, given the evidence of mesocortical pathways in other mammalian species, we have little justification to think cows lack a cortical road. While I have not definitively shown that cows have intuitive prospection, I have accomplished two preliminary tasks. First, I have described a research program to test for bovine intuitive prospection. And, I have noted that the weight of evidence lies on the side of the assumption that cows seek, anticipate, and look forward.

How to get inside a cow’s head? First, think about who *we* are: a varied lot, with a diverse range of cognitive capacities. Second, follow Temple Grandin’s gesture, that “[a]utism is a kind of way station on the road from animals to humans” (84). Third, assume, as we must, that *we* includes aphasic nonreporting humans with severe cognitive limitations who look forward to their futures. Assume, further, that some autistic people think in alternative representational formats, such as pictures, and that cows think in these formats, too. If all of these claims are true, as I believe they are, cognition may not require propositional thought at all. Finally, ask: Are there any morally relevant differences between the intuitive prospection of some of us and the intuitive prospection of some cows? I don’t see any.

How then should we treat cows? This is a question for another day. Note, however, that if cow neuroanatomy turns out to be as predicted, cows probably can take a morally-relevant interest in what is to come. This much does not establish that feeder calves have a right to life that we violate when we slaughter them for beef. However, it makes a non-starter out of the idea that those calves must lack a right to their future because they lack the capacity to take an interest in it.[[3]](#footnote-3)

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**Figure captions**

Fig x.1. The Reward System: Liking, Wanting, Learning. Reprinted with permission from Elsevier (61).

Fig x.2: Prediction: Bovine SEEKING system. Figure based on midsagittal view, “The brain of *Bos taurus*, version 3.0” (73), reprinted with permission of Floris Wouterlood, with hypothetical markings and labels superimposed and brain circumference outline removed.

Fig x.3. Hierarchical topography of temporal receptive windows in fMRI image. Reprinted with permission of *The Journal of Neuroscience* from (76). Figure cropped and modified with permission of Uri Hasson.

Fig x.4. Prediction: Bovine BELIEF system. Figure based on lateral view figure of “The brain of *Bos taurus*, version 3.0” (73), reprinted with permission of Floris Wouterlood, with hypothetical markings and labels superimposed.

1. Analogously, Joseph LeDoux identifies two pathways involved in fear processing (64) originating at the sensory thalamus. An unconscious pathway connected to the amygdala is recruited for fast and approximate processing. Ledoux

   says it sponsors fear without awareness. A conscious pathway connected to the cortex is recruited for slower, more precise processing. Ledoux says it sponsors conscious fear. [↑](#footnote-ref-1)
2. Thanks to Andrew Fenton for pointing this out. [↑](#footnote-ref-2)
3. I am grateful for comments from Bill Bauer, Veljko Dubljevic, Robert C. Jones, and Eze Paez. I owe special debts of gratitude to the editors, L. Syd M Johnson and Andrew Fenton, for assistance in clarifying the argument; to Floris Wouterlood for providing the cow brain figures; and to Stevan Harnad for an invitation to discuss the ideas at the 2018 University of Québec at Montréal Summer School in Animal Cognition. [↑](#footnote-ref-3)