and efficiently. To him a car was totally a tool, confirmed by the fact that he rarely drove except to travel out of town. But he, nevertheless, bought his wife, Dorle (a stylish and artistic matron from European wealth), a Mercedes convertible. As she zipped around Hyde Park with the top down and her blond hair blowing in the wind, Hess realized that for his wife a car was far more than a means of transportation, and he felt obliged to humor her "drug" habit. Fast sporty cars are fun, even exhilarating, to drive, and a Mercedes in the 1960s was still an uncommon status symbol as well. Obviously, there were constraints on what one could do with such a vehicle. It was not very useful for transporting more than two persons, had limited trunk space, and insurance and repairs were costly. So, I guess the way to understand automobiles is to invoke both the tool and drug metaphors. But wait, any use of food that does not just provide nutrition and calories should be looked at in this way also – as a drug. Food was also one of the first mediums of exchange and the spice trade a most important early part of international trade.

The point of these examples is to argue that, as formulated, I find this proposed drug metaphor an "emperor" theory of money that has no clothes. Oops, clothing also is both instrumental and a drug of choice for shopaholics, and has been an important means of exchange (cloth, silk, cotton, wool, not to say boutique "rerun" shops).

Does money act as a drug on dopamine receptors in the basal ganglia and related structures or is the drug idea merely a metaphor? The authors opt for the latter, but much of the article seems to argue the former. To them money "intrudes on the normal functioning of the nervous system" (sect. 2.2.1) by mimicking substances involved in basic instincts that are, in fact, centered in these same brain areas. Although still somewhat controversial, these areas seem to contain often overlapping systems involved in basic motivations, cravings, feelings, compulsions, conditioning, and both behavioral and drug-based addictions, including excessive running, gambling, and so forth (references in Burghardt 2001; 2005). I think that the drug word may have shock value, but essentially adds nothing since any behavior not based on rational or instrumentally adaptive behavior is, for L&W, acting as a drug. This dichotomy is just another learning– instinct contrast that neglects the biological processes connecting instrumental and instinctive behavior.

L&W also assert that money is unique in having no intrinsic drive-reducing or instinctive properties based on current or past environments, and thus is an entirely new phenomenon that needs formal incorporation into an evolutionary account of behavior. In doing this they have to deal with the origins of money in our evolutionary past. This they view as a challenge since they claim that money is unique to our species (an interesting assertion itself since tool use, tool making, language, counting, altruism, even moral behavior have fallen by the wayside as qualitative distinctions between humans and other species). So what to do? After going through the first four sections of the target article, I awaited the new ideas that were going to emerge from their evolutionary analysis. Surprisingly, the critical heart of the paper on the origins of money is in but a fraction of the text (sects. 5.2 and 5.3) where we find that reciprocal altruism and play are the roots of the origins of money as drug.

Insofar as altruism as a source of money is concerned, I will focus just on the claim that, while altruism is old, the trading instinct is unique to our species; an assertion that cannot be sustained. We have known for decades of gift-bearing flies and gift exchanges among birds (see Judson 2002). Indeed, these gifts may become divorced from their original reinforcer (food) and become symbolic. Although ethology (Tinbergen 1951) is cited, the seminal concept of ritualization is not. While such "gifts" in other species may not always be explicit payoffs or serve as generalized reinforcers, they certainly are trades. Furthermore, exchanges are the essence of many social insect societies, even interspecifically (aphids pay for protection with secretions). Mutualism, symbiosis, and similar "trading" phenomena are endemic in organic life. The roots of trading may run deep in our phylogenetic heritage, and the evolution of money may have been a small evolutionary step, albeit with major consequences.

The second instinct that is invoked to explain the origins of money is play. Having just written a treatise on this topic (Burghardt 2005), I was anxious to see how L&W deployed the concept. I was surprised that play is invoked without any consideration of what it is or the nature of its instinctive origins. In fact, the only topic discussed is toy exchange, based on the authors' own studies published in economic venues. To end their paper on such a thin two-paragraph thread of support is disappointing. First, whether play, even object play, is a separate instinct (or behavior system) or is derived from other systems (such as predatory or fighting), is still an open issue in many species. Second, whether exchanging toys is a means of learning how to manage resources rather than a behavioral relic or a precocial performance of adult behavior with no important "practice" component, is largely unknown. A just-so story does not constitute data, especially when the adaptive function of play in juvenile animals has rarely been demonstrated experimentally (Burghardt 2005). If play exchange is training for money management, as L&W assert, the problems so many people have with money management makes such play quite ineffective.

Finally, the loose use of the term "instinct" is disturbing and shows that the new style of evolutionary psychology, by largely eschewing engagement with data on other species, is in danger of losing any claim to be a naturalistic evolutionary science. The classical ethologists, along with their critics, made remarkable progress in conceptualizing instinctive behavior and motivational systems. I fear that articles such as this one will make the current incarnation of evolutionary psychology problematic to both evolutionary biologists and social scientists.

Money as epistemic structure

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Abstract: A testable model of the origin of money is outlined. Based on the notion of epistemic structures, the account integrates the tool and drug views using a common underlying model, and addresses the two puzzles presented by Lea & Webley (L&W) – money's biological roots and the adaptive significance of our tendency to acquire money.

Epistemic structures (ESs) are structures that organisms add to their environment to lower the cognitive complexity associated with tasks (Chandrasekharan 2005). For instance, wood mice (*Apodemus sylvaticus*) distribute small objects, such as leaves or twigs, as points of reference while foraging. Such "waymarking" has been shown to diminish the likelihood of losing interesting locations, and is exhibited even under laboratory conditions, using plastic discs (Stopka & MacDonald 2003). The male bower bird builds colorful bowers (nest-like structures), which are used by females to make mating decisions (Zahavi & Zahavi 1997). Bacterial colonies use a strategy called "quorum sensing" to know that they have critical mass to attack a host. Individual bacteria secrete molecules known as auto-inducers into the environment; when the chemical breaches a threshold, the colony attacks (Silberman 2003).

We have developed and implemented an evolutionarily plausible model of the origin of such external structures, using artificial agents that possess only reactive behaviour (the agents just sense and act, they do no internal processing). The model uses cognitive load reduction in a recursive fashion: it is an effect of

ES generation, but it is also *the cause that drives generation*. We make two assumptions: (1) organisms sometimes generate random structures in the environment (pheromones, leaf piles, etc.) as part of their everyday activity; and (2) organisms can track their physical or cognitive effort (i.e., they get tired), and they have a bias to reduce tiredness. The term "tiredness" indicates the "felt" quality of the feedback, which allows tracking of cost using affect – that is, without using a separate computational module.

Some of the randomly generated structures in the world are now encountered by the agents, and in some random cases, these structures make tasks easier for the organisms (following pheromones reduces travel time, avoiding leaf-piles reduce foraging effort). In other words, these structures *shorten paths in the task environment* (see Kirsh 1996). Given the postulated bias to avoid tiredness, these paths get preference, and they are reinforced. Since more structure generation leads to more of these paths, structure generation behaviour is also reinforced. We have implemented this model using both genetic algorithms (evolutionary learning) and the Q-Learning algorithm. The latter implementation shows that reactive agents can learn, *within their lifetime*, to add ESs systematically to their world to lower cognitive load (Chandrasekharan & Stewart 2004). Such within-lifetime learning to reduce cognitive load has recently been shown in homing pigeons. They follow railways and highways to reach their target, even taking exits (Guilford et al. 2004).

The tiredness model explains the process underlying the generation of two of the three ES types possible (structures for oneself, structures for oneself and others, structures exclusively for others). It only partially explains the third. The second type is explained by appealing to the similarity of systems: if a structure provides congeniality for me, it will provide congeniality for other systems like me. The similarity of agents led to them forming structures that were useful for everyone, even though they were just concerned about reducing their own tiredness.

A similar learning system could explain the first of Lea & Webley's (L&W's) puzzles: the origin of money. The tiredness approach is suited to modeling money because, given a barter system, money lowers both physical and cognitive effort, as it helps lower the number of physical transactions, and reduces the computational complexity of tracking branching transactions (agent X has Good B and she wants Good A, but agent Y, who has Good A, doesn't want Good B. Agent X now needs to find an efficient and guaranteed path from her Good B to Good A.). With multiple goods, the branching transaction problem becomes extremely complex, particularly with added constraints like perishability, security, and so forth. Money can be seen as an epistemic structure that emerged to shorten such complex paths in the barter environment, by providing a common structure that can connect any path, reducing both cognitive and physical load.

Applying our model of ES generation to such a view of money, given any barter environment with sufficient cognitive load and transaction costs, and agents that seek to lower their tiredness, a commodity that is in demand by most agents (salt, sugar, spice, gold, etc.) would be used to connect branching paths efficiently. The commodity would acquire this money role the same way pheromones acquired an epistemic role in our simulation. In this view, money emerges not because of evolutionary or genetic advantages, but because of a central survival advantage – the lowering of energy utilization. To test this hypothesis, we are currently designing a network-based barter experiment and a parallel simulation model.

What about L&W's second puzzle: the tendency to acquire money? In the model above, this could be explained by including dopamine as a second reinforcement factor, acting in tandem with tiredness. So, once the use of money is learned by agents in a barter environment, a dopamine-based system takes over. This system "extends" the use of money as a path-connecter – to a tendency to acquire money. Schultz (1992; reported by Braver & Cohen 2000) has shown that dopamine responds initially to a rewarding event, but with training this response "migrates" to predictive cues. This behaviour, where learning chains backwards in time to identify (and reinforce) successively earlier predicators of reward, has been modeled by Montague et al. (1996) using a temporal difference learning algorithm (similar to Q Learning). Such a dopamine-based model would explain the tendency to acquire money (and the pleasure it provides) as an adaptive extension of money's role in lowering tiredness.

Besides cognitive load, two other factors could drive this migration. One, epistemic structures like money significantly expand the space of actions possible (see Kirsh 1996). Being the connector of all possible paths in a trading system, money expands the action space of agents exponentially. Two, epistemic structures make a system more robust, by raising task-success in noisy and high processing load environments (see Chandrasekharan 2005). These two advantages, combined with lowered energy use, make the tendency to acquire money a highly adaptive response.

Money and the autonomy instinct

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Abstract: Applying the reciprocity instinct to monetary transactions implies that the reaction to monetary debt and monetary credit are similar. However, evidence suggests an asymmetry. I suggest that the "autonomy instinct" fits better with human behavior towards money. I show that people value autonomy, and I show how money can serve this instinct.

I concur with Lea & Webley's (L&W's) analysis that human behavior towards money is consistent with Drug Theory rather than with Tool Theory. I also concur with their claim that this implies that money should hinge on a pre-existing instinct. I do not concur with L&W's claim that money mainly parasitizes on humans' reciprocity instinct.

Applying the reciprocity instinct to monetary transactions requires two cognitive tools: a sensitivity to what others owe you (cf. cheater detection module; Tooby & Cosmides 1992) and a sensitivity to what you owe others (cf. the reputation concern; Axelrod 1984). The function of both is to bridge the time lag between the two transaction phases (i.e., giving and receiving) that define an exchange situation. L&W claim that money fills the gap between giving and receiving. Money removes the temporary imbalance between giver and receiver and the negative affect related to that imbalance.

It is critical to L&W's claim that people are willing to fill the time lag between the two transactions with money in *both* directions. They should be motivated not only to get the money they deserve but also to pay the money they owe. Credit cards should be equally as aversive as prepay cards. However, common intuition and recent findings suggest that people do not want to pay their debts as quickly as possible to get rid of the feelings of obligation. People are willing to live on credit and use simple heuristics to decide how much they can borrow (Soman & Cheema 2002). Credit cards are very popular (turnover in Europe in 2004: €617.3 billion), whereas prepaid cards remain marginal and often remain tied to one retailer (e.g., B+S Card Service GmbH 2005), although there is no practical reason why people would not be willing to prepay their expenses. There just seems to be no demand for such a product, although prepay cards would be an efficient way to self-regulate expenses (Trope & Fishbach 2000). Further, there is evidence that living on credit does not hurt when durables are involved (Prelec &