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The Sunk Cost and Concorde Effects: Are Humans Less Rational Than Lower Animals?

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The sunk cost effect is a maladaptive economic behavior that is manifested in a greater tendency to continue an endeavor once an investment in money, effort, or time has been made. The Concorde fallacy is another name for the sunk cost effect, except that the former term has been applied strictly to lower animals, whereas the latter has been applied solely to humans. The authors contend that there are no unambiguous instances of the Concorde fallacy in lower animals and also present evidence that young children, when placed in an economic situation akin to a sunk cost one, exhibit more normatively correct behavior than do adults. These findings pose an enigma: Why do adult humans commit an error contrary to the normative cost-benefit rules of choice, whereas children and phylogenetically humble organisms do not? The authors attempt to show that this paradoxical state of affairs is due to humans' overgeneralization of the "Don't waste" rule.

The sunk cost effect is a maladaptive economic behavior that is manifested in a greater tendency to continue an endeavor once an investment in money, effort, or time has been made (Arkes & Blumer, 1985). A prior investment should not influence one's consideration of current options; only the incremental costs and benefits of the current options should influence one's decision. Nevertheless, several researchers have shown that people do attend to prior investments as they consider what course of action to take. For example, Arkes and Blumer (1985, Experiment 2) arranged to have three different types of season tickets sold to persons who approached the Ohio University Theater ticket booth at the beginning of the season. Approximately one third of the patrons purchased season tickets at the full $15 price, one third at $13, and one third at $8. Compared with those who purchased tickets at $15, those who purchased tickets at either of the discounted prices attended fewer plays during the subsequent 6 months. Apparently, those who had "sunk" the most money into the season tickets were most motivated to use the tickets. This is contrary to the maxim that incremental costs and benefits should govern one's decision to attend the plays. Once the tickets had been purchased, all patrons had a license to attend any play. Presumably, the costs and benefits of theater attendance would have been equal for the members of all three groups because participants were assigned randomly to the three price levels. The differential attendance by the discount versus full-price groups was a manifestation of the sunk cost effect: The patrons' sunk cost influenced their attendance decisions.

Much less well known to psychologists is the Concorde fallacy (see, e.g., Dawkins & Carlisle, 1976), aptly named for the supersonic airplane. The plane's dim financial prospects were known long before the plane was completed, but the two governments financing the project decided to continue anyway on the grounds that they had already invested a lot of money. In short, they had "too much invested to quit" (Teger, 1980). Researchers have used the term *Concorde fallacy* to refer to the tendency of lower animals to commit the sunk cost effect. We have found no published paper in the human judgment/decision-making literature that cites any of the extensive literature on the Concorde fallacy, and we have found no published paper in the animal literature that cites the sunk cost effect. One modest goal of this article is to introduce the researchers in each of these two fields to the work being done in the other field. A more ambitious goal of this article is to attempt to reconcile the sharply contrasting assumptions about decision making made by the researchers in these two fields.

How the Concorde Fallacy Came to Be Studied

In a highly influential article, Trivers (1972) proposed that parental investment is a resource whose deployment is the key to understanding many phenomena of social ethology. Trivers (1972) defined parental investment as "any investment by the parent in an individual offspring that increases the offspring's chance of surviving (and hence reproductive success) at the cost of the parent's ability to invest in other offspring" (p. 139). Examples of parental investment include defense of a nest and feeding of the young. Trivers (1972, 1974) used parental investment to explain a large number of phenomena in the animal kingdom, such as differential mortality between the sexes, competition for mates, promiscuity,

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and mate desertion. The latter topic is treated by Trivers (1972) in this way:

> At any point in time the individual whose cumulative investment is exceeded by his partner's is theoretically tempted to desert, especially if the disparity is large. This temptation occurs because the deserter loses less than his partner if no offspring are raised and the partner would therefore be more strongly selected to stay with the young (p. 146).

This means that in most species, male partners are more likely than female partners to desert the partner and the developing young. In general, the male partner has invested very little, so he has less of an investment to lose by deserting. The female partner, on the other hand, has invested a great deal, so she cannot desert without forsaking a large amount of prior effort.

Dawkins and Carlisle (1976) pointed out that Trivers's reasoning is fallacious, an assertion with which Trivers (1976, p. vi) soon agreed. Suppose a parent has two offspring. Both are immature, and both require the nurturance of at least one parent. However, one offspring is a newborn and the other is less immature. If parental resources become depleted, to which of the two offspring should nurturance be given? According to Trivers's analysis, the older of the two offspring has received more parental investment by dint of its greater age, so the parent or parents will favor it. This would be an example of a past investment governing a current choice, which is a manifestation of the Concorde fallacy and the sunk cost effect. Dawkins and Carlisle suggested that the reason the older offspring is preferred is not because of the magnitude of the prior investment, as Trivers had suggested, but because of the older offspring's need for less investment in the future. Consideration of the incremental benefits and costs, not of the sunk costs, compels the conclusion that the older offspring represents a far better investment for the parent to make.

Although it seems that Trivers may have committed the Concorde fallacy, there is another possibility. Perhaps Trivers is correct: Nature commits the Concorde fallacy. That is, there may exist in the animal kingdom examples of organisms' attending to prior investments as they confront current choices. If so, this would represent a continuity between the behavior of humans and lower animals, as there are many examples of humans manifesting the sunk cost effect (see, e.g., Arkes & Blumer, 1985; Dick & Lord, 1998; Garland, 1990; Garland & Newport, 1991; Staw, 1976, 1981; Staw, Barsade, & Koput, 1997; Staw & Fox, 1977). For example, Staw and Hoang (1995) showed that professional basketball coaches gave greater playing time to individuals who were higher draft picks independent of the player's performance. Because higher draft picks cost the team more money, both their greater playing time and their enhanced career longevity are examples of the influence of their high sunk costs. (See also Camerer & Weber, in press.) Using data from over 1,000 firms, McCarthy, Schoorman, and Cooper (1993) showed that entrepreneurs who started their own businesses were more likely to expand them compared with those who purchased the businesses from others. The former group felt greater personal responsibility for all aspects of the design and operation of the business, and research has often shown that personal responsibility exacerbates the sunk cost effect (see, e.g., Staw, 1976). The entrepreneurs' propensity to expand their businesses was particularly evident when the firms' prospects began to deteriorate, a finding congruent with the results of many laboratory sunk cost experiments.

Given that humans fall prey to the sunk cost fallacy, is it the case that animals commit it too, although under the alias of the Concorde fallacy? Trivers's (1972) prominent parental investment theory seemed to imply that animals do commit the fallacy. However, after Dawkins and Carlisle (1976) pointed out the flaw in Trivers's reasoning, the issue was joined. A number of investigators sought evidence for the presence or absence of the Concorde fallacy among lower animals.

Evidence for the Concorde Fallacy

We have performed what we believe to be an exhaustive search of the bibliographic databases for all articles pertaining to the Concorde fallacy. Our conclusion is that there are no unambiguous examples of the Concorde fallacy in lower animals. A number of experimenters who have tested lower animals have confirmed that they simply do not succumb to the fallacy (see, e.g., Armstrong & Robertson, 1988; Burger et al., 1989; Maestripieri & Alleva, 1991; Wiklund, 1990). A prototypical study is that of Maestripieri and Alleva, who tested the litter defense behavior of female albino mice. On the 8th day of a mother's lactation period, a male intruder was introduced to four different groups of mother mice and their litters. Each litter of the first group had been culled at birth to four pups. Each litter of the second group had been culled at birth to eight pups. In the third group, the litters had been culled at birth to eight pups, but four additional pups had been removed 3 to 4 hr before the intruder was introduced. The fourth group was identical to the third except that the removed pups had been returned to the litter after only a 10-min absence.

The logic of the Maestripieri and Alleva (1991) study is straightforward. If each mother attended to past investment, then those litters that had eight pups during the prior 8 days should be defended most vigorously, as opposed to those litters that had only four pups. After all, having cared for eight pups represents a larger past investment than having cared for only four. On the other hand, if each mother attended to future costs and benefits, then those litters that had eight pups at the time of testing should be defended most vigorously, as opposed to those litters that had only four pups. The results were that the mothers with eight pups at the time of testing defended their litters more vigorously than did the mothers with four pups at the time of testing. The two groups of mothers with four pups did not differ in their level of aggression toward the intruder, even though one group of mothers had invested twice the energy in raising the young because they initially had to care for litters of eight pups. Thus, the magnitude of expected benefits, not the amount of prior maternal investment, determined the mothers' defensive behavior. We have presented this study in some detail because it is one of the most conclusive: It pitted the prediction of the past investment viewpoint against the prediction of a future-oriented viewpoint, and the future-oriented prediction was confirmed.

Contrary to the findings of Maestripieri and Alleva (1991), some experimenters have come to the conclusion that lower animals do commit the fallacy (see, e.g., Dawkins & Brockmann, 1980; Lavery, 1995; Weatherhead, 1979). We offer a reinterpretation for each of the three most prominent articles that purport to find evidence for the fallacy in lower animals.

Easily the most famous article purporting to find evidence for the Concorde fallacy in lower animals is by Dawkins and Brockmann (1980), who investigated the behavior of female digger wasps (*Sphex ichneumoneus*). The female digger wasp provisions the nest with dead katydids, which can be consumed by her larva at a later time. Occasionally, 2 wasps provision the same nest, each wasp unaware of the other's existence. When the 2 female wasps happen to arrive at the nest at the same time, they fight over the storehouse of katydids they have both been accumulating. Dawkins and Brockmann found that the combatant that has put the most katydids in the nest more often wins the fight. Perhaps a more important result was that the duration of a fight correlated with the total number of katydids brought by the loser. Because a fight must end when the loser departs, this result leads to the conclusion that the loser's motivation to continue the contest is determined by her prior investment. Dawkins and Brockmann (1980) suggested that this is "stark Concordism" (p. 894).

We respectfully disagree with this characterization. As Dawkins and Brockmann (1980) pointed out, wasps probably do not have the ability to count the total number of katydids inserted into the burrow by both parties. Therefore, each wasp's only index of the burrow's future caloric content is the number of katydids she has brought herself. We suggest that the duration of the fight might very well be determined by future caloric benefits, not by prior exertional investments. Hence, we do not think that Dawkins and Brockmann have provided an unambiguous example of the Concorde fallacy. (This line of reasoning has also been suggested by Fagerström, 1982.) Note that in the Dawkins and Brockmann study, unlike the Maestripieri and Alleva (1991) study, a prediction of the past investment viewpoint was not pitted against the prediction of a future-oriented viewpoint. Dawkins and Brockmann simply attributed the magnitude of the loser's motivation to her past investment. Because the past investment of which the loser is aware is perfectly correlated with the future caloric benefit, we suggest that the explanation offered by Dawkins and Brockmann may not be the correct one.

A second study whose results are said to support Trivers's parental investment theory is that of Lavery (1995), in which half of a sample of convict cichlids (*Cichlasoma nigrofasciatum*) were bred three times before being used in the study and half were bred not at all. All fish were then bred during the experiment, and their parental behavior was observed. Lavery found that experienced cichlids (i.e., those that had been bred a total of four times) were more aggressive toward a fake predator than were nonexperienced cichlids. Lavery concluded that adult fish that had made a larger prior parental investment were more protective of their brood, even if some of the prior investment had occurred during prior breeding episodes. This might be considered an example of the Concorde fallacy because prior parental investment seemingly led to more assiduous protection behaviors. However, as mentioned by Lavery and by Sargent and Gross (1986), the amount of prior investment may be a very good index of the capacity for future investment. In other words, fish that have already raised several prior broods have the potential to raise fewer future broods. Therefore, the cost of a vigorous defense is less for a more sexually experienced fish than for a less experienced one, assuming an approximately equal number of total breeding episodes for each fish. A fish that has raised three prior broods places fewer future progeny in jeopardy by being aggressive than does a fish that has raised no prior broods; the latter has more reproductive opportunities in the future. Hence, the latter's less aggressive defense may be due to the significance of future incremental costs and benefits, not past investment. For the less experienced fish, less aggression now may mean an enhanced opportunity for more reproduction in the future.

The third example purporting to demonstrate Concordian logic in animals is a study by Weatherhead (1979), who examined nest defense behavior of savannah sparrows (*Passerculus sandwichensis*). Because these birds nest in the northern tundra, their breeding season is rather short. Weatherhead reasoned that this situation provided a test of whether these birds attended more to past investment or future benefits. If future benefits were the cause of a bird's nest defense behavior, then such behavior should be maximal as the last possible nesting day approached. Eggs laid after this day would have insufficient warm weather to remain viable. The "early birds" could lay and hatch another brood during the season should their nests be successfully attacked, but the later nesting birds could not. Therefore, the nests of latecomers should be defended more vigorously and somewhat earlier in the nesting sequence. On the other hand, if past investment was the cause of nest defense behavior, then the stage of nest development (i.e., the age of the eggs) should be the key factor. Nests that had been cared for longer should be more vigorously defended, irrespective of the point in the season during which the nest was threatened.

Weatherhead (1979) found that the stage of nest development accounted for far more of the variance than did the number of days remaining in the breeding season. He concluded that past investment, not future benefits, determined the vigor of the nest defense behavior.

Again, we respectfully disagree with the conclusion. As the season progresses, the future benefit of the eggs remains constant, but the incremental cost of tending the nest decreases as the time of hatching draws near. This progressively improving benefit-to-cost ratio may be the reason why the birds show more vigorous defense behavior as the stage of nest development increases. Because these birds have multiple breeding seasons, reckless defensive behavior after the last nesting day has passed jeopardizes all future broods the bird may parent; mortally wounded birds cannot procreate. Thus, the last nesting day is not the critical marker if multiple seasons are considered (Coleman & Gross, 1991; Sargent & Gross, 1985). We therefore suggest that Weatherhead's (1979) data are not convincing evidence of the Concorde fallacy.

We should point out that by positing an alternative explanation for each study purporting to demonstrate the Concorde fallacy in lower animals, we do not prove the point that the Concorde fallacy does not exist in any lower animal. We described the Maestripieri and Alleva (1991) study in some detail because it pitted the Concordian prediction against one that was based on the consideration of future costs and benefits; the cost-benefit prediction was supported. However, the majority of the studies pertaining to the Concorde fallacy present results that may be open to either interpretation. For example, the findings of the Lavery (1995) study can be explained by consideration of future costs and benefits only if one allows the raising of many prior broods to be used as an index of the diminished capacity for future parental investment. More experienced fish—those that have raised prior broods—have fewer future broods and thus place fewer progeny in jeopardy with a vigorous defense of the current brood. However, if an analyst of the Lavery study does not accept prior broods being used as such an index, then a Concordian analysis is the only other explanation yet offered for Lavery's results. We acknowledge that others may prefer this interpretation.

However, we want to be clear concerning the basis on which strategies are selected in lower animals such as fish. One of the reviewers of this article asserted that fish are "stupid." Presumably, these cognitively primitive creatures could not possibly take into account such factors as the number of prior broods in deciding whether to protect a current brood. We do not contend that fish calculate the number of prior broods in contemplating defensive behavior. Instead, natural selection will ruthlessly expunge any strategy that can be bettered by an evolutionarily stable competitor strategy (Maynard Smith, 1974). Any fish with the tendency to fight less aggressively until it has raised several broods might be at an evolutionary advantage over a fish that fights very aggressively beginning with its first brood. Although the mating and fighting strategies of fish can be executed relatively "thoughtlessly," such strategies can still be dictated by their relation to future costs and benefits. We suggest that evolutionary pressures ensure that this relation is a very close one indeed.

Finally, one of our colleagues[1] has suggested that a very different type of research finding may provide evidence for the Concorde fallacy in lower animals. Festinger (1961) noted that more effortful responses exhibit greater resistance to extinction (see, e.g., Aiken, 1957; Eisenberger, Carlson, Guile, & Shapiro, 1979). Festinger interpreted this result as a manifestation of cognitive dissonance in animals. To exert considerable effort on a task in order to gain a modest reward engenders dissonance in animals. To justify this exertion, animals must develop an "extra preference" for this strenuous task. When an extinction schedule is begun, these animals must have not only their habit extinguished but their extra preference as well. Animals performing an easier response do not experience any dissonance and therefore do not have to develop any extra preference to justify their behavior. Thus, their extinction progresses more quickly.

Can the greater resistance to extinction of an effortful response be interpreted as an example of the Concorde fallacy? Animals that have invested a great deal of effort on a task show greater persistence with the task during an extinction schedule, whereas animals that have invested less effort quit sooner. However, there is a parsimonious alternative explanation for this phenomenon that is not based on the Concorde fallacy. According to learned industriousness theory (Eisenberger, 1992), if animals (or humans) are reinforced for emitting a high-effort response, the exertion of a high level of effort acquires secondary reinforcing properties. Of course, if organisms are reinforced for emitting a low-effort response, the exertion of a low level of effort acquires secondary reinforcing properties. When both groups are placed on an extinction schedule, they both exhibit deterioration of response strength, but the high-effort group has further to go before its response strength reaches zero. Hence, its resistance to extinction appears to be greater.

In summary, we can find no convincing cases of animals committing the Concorde fallacy, although there are studies that find that animals as cognitively humble as ducks, blackbirds, or house mice are able to adjust their efforts in relation to prospective costs and benefits and not to past investment. Yet there are plenty of examples of humans demonstrating the sunk cost effect (see, e.g., Arkes & Blumer, 1985; Garland, 1990; Garland & Newport, 1991; Staw, 1976, 1981; Staw & Fox, 1977). In the next section, we attempt to explain why humans may be more susceptible to this type of fallacy than are lower animals.

Table 1
Percentage of Participants Maximizing During the Final 20 Trials (Weir, 1964)

33% condition		66% condition	
Age (years)	%	Age (years)	%
3.6	50	3.6	70
5.5	33	5.5	66
7.0	0	7.3	25
9.2	0	9.1	20
10.8	0	13.3	20
14.8	4	18.0	50
18.0	17		

Note. The participant was scored as a maximizer if the payoff knob was chosen 18 or more times out of the last 20 trials.

Ontological Considerations

It is difficult to test humans and lower animals in the same stimulus situations to compare their susceptibility to the Concorde fallacy/sunk cost effect. It is somewhat easier to test humans of various ages. This may be a suitable substitute strategy, given the assumption that the increase in cognitive sophistication as one ascends a scale of chronological age is analogous to the increase in cognitive sophistication as one ascends the phylogenetic scale. Rather than looking for interspecies differences in which lower animals outperformed adult humans, we searched for cognitive tasks in which children seemed to outperform adult humans.

One such task was described by Weir (1964), who used an apparatus designed by Stevenson and Zigler (1958). The participants ranged in age from 3.6 years to 18 years. Each of them faced a panel containing a horizontal row of three knobs, above which was a signal light and below which was a delivery mechanism for marbles. On each of 80 trials, participants were told to press one of the three knobs. Correct presses would be followed by the delivery of a marble. For all participants, pulling one particular knob was followed by reinforcement, but at a 33% rate for some persons and at a 66% rate for others.

Table 1 contains the results. A participant was deemed to be a "maximizer" if the correct knob was pulled on at least 18 of the last 20 trials. Table 1 shows that the youngest children were more likely to be maximizers than were the participants of any other age.

Weir (1964) attempted to explain these surprising results:

> It is likely that the 3- and 5-year olds are drawn to the payoff button on the basis of a simple reinforcement notion only. . . . Older subjects . . . employ complex strategies. . . . It is interesting to note that . . . the belief that there is a complex solution actually results in fewer choices of the most frequently reinforced alternative. (pp. 477–478)

The older participants were "too smart for their own good." Rather than attending to a very simple reinforcement schedule,

[1] Richard Thaler, personal communication, November 23, 1997.

they used hypotheses or rules that were inappropriate for this straightforward task. (See also Derks & Paclisanu, 1967, for a very similar finding.)

Jacobs and Potenza (1991) came to the same conclusion using children in a social judgment task. Their research was designed to examine the use of the representativeness heuristic (Kahneman & Tversky, 1972). People who use this heuristic make probability judgments based on the similarity or representativeness of one entity to another. Consider the following example, which is similar to one offered by Jacobs and Potenza. If Sarah knows that she is 1 of 12 children trying out for a part in the school play, she might calculate her chance of being selected as 1 in 12. Such thinking would exemplify use of the base rate. On the other hand, if the part in last year's play was awarded to a child who goes to the same church as Sarah, she might decide that because of the fact she is similar to that child in one respect, her chance of being selected is actually much higher. The latter strategy would exemplify representativeness-based thinking because Sarah has used similarity as a basis for judging probability.

Jacobs and Potenza (1991) tested first, third, and sixth graders, as well as college students, using vignettes requiring judgments in the social domain. The proportion of answers based on the representativeness heuristic increased monotonically with age. Their conclusion is consistent with our analysis:

> The use of the representativeness heuristic . . . is based on the development of social schemas that can be used to make judgments in social situations where base rate data are difficult to collect and integrate. If our interpretation is correct, the judgment biases reported in adults could be considered "smart errors." However, they are still errors and they may get in the way of optimal decision making when overused. (Jacobs & Potenza, 1991, p. 175)

The youngest children have not yet developed the social schema into which people can be classified. So, in our example, the individuating information about the church attended by last year's actress will be unlikely to foster representativeness-based thinking in them. Once such schemas are developed, however, they can defeat the more normative base-rate considerations. This would represent a smart error, to use Jacobs and Potenza's term.

The use of rules or hypotheses can be detrimental to performance under certain circumstances, as shown by Weir (1964) and by Jacobs and Potenza (1991). Rosenfarb, Newland, Brannon, and Howey (1992) made the same point in a study that did not investigate age differences but does contain a feature relevant to our analysis. College students responded under a multiple differential-reinforcement-of-low-rate 5-s fixed-ratio 8 schedule, with components alternating every 2 min. For those unfamiliar with this terminology, we should explain that a differential-reinforcement-of-low-rate 5-s schedule requires a participant to respond less than once every 5 s in order to make progress toward a reinforcement. This schedule alternated at 2-min intervals with a fixed-ratio 8 schedule. When this latter schedule was in effect, the participant had to make eight button presses in order to make progress toward receiving a reinforcement. After 52 min on these schedules, participants were shifted without warning to an extinction schedule that lasted 28 min.

Participants were divided into three groups at the beginning of the study. One group was asked during acquisition to develop rules that described the schedule contingencies. Another group was provided with the rules generated by participants in the first group. The final group was neither asked to develop rules nor provided with the rules of others.

The main data of interest pertain to the number of responses emitted during the 28 min of extinction. The group that had neither received nor generated rules emitted fewer responses during extinction than did the other two groups. This result is similar to those of Weir (1964) in that the use of rules or hypotheses led to impaired performance. A difference between the two studies is that in the Weir research, the detrimental influence of rules on performance was manifested during acquisition. In the Rosenfarb et al. (1992) study, the detrimental influence was manifested during extinction. One might have predicted that the adult participants in the Rosenfarb et al. research should have realized, once extinction began, that further responding was a waste of time and effort. In fact, those who used no rules did show much reduced responding. However, use of rules, either one's own or someone else's, seemed to reduce participants' sensitivity to the diminished reinforcement.

Rules and the Sunk Cost Effect

Arkes and Blumer (1985) suggested that a major contributor to the sunk cost effect is people's desire not to appear to be wasteful. Consider the following question, taken from Arkes and Blumer (1985):

> Assume that you have spent $100 on a ticket for a weekend ski trip to Michigan. Several weeks later you buy a $50 ticket for a weekend ski trip to Wisconsin. You think you will enjoy the Wisconsin ski trip more than the Michigan ski trip. As you are putting your just-purchased Wisconsin ski trip ticket in your wallet you notice that the Michigan ski trip and the Wisconsin ski trip are for the same weekend? It's too late to sell either ticket, and you cannot return either one. You must use one ticket and not the other. Which ski trip will you go on? (p. 126)

Over half of the participants asked this question said that they would rather go on the ski trip they would enjoy less—the Michigan trip! This is contrary to the maxim that one should decide on the basis of incremental costs and benefits. Apparently, many participants thought that they should go on the less desirable trip because to go on the less expensive Wisconsin trip would "waste" twice as much money.

A number of experiments have supported the notion that the avoidance of waste is a motivating factor in people's decision to honor sunk costs by not abandoning a failing course of action. For example, Arkes (1996, Experiment 3) presented participants with a vignette describing a person developing a material to be used in camping tents. However, a competitor begins to market a far superior product. Should the person developing the now-inferior tent material abandon the project, thereby forsaking his investment? Significantly more people were willing to recommend abandoning the sunk cost if the material developed so far could be sold to a roofer for $5,000 than if the material were to be sold for scrap, also for $5,000. Scrap implies waste, and people do not want to appear to be wasteful. Therefore, rather than "wasting" the material, they are more willing to honor the sunk cost and continue with product development. In Arkes's example, selling the material to the roofer minimizes the opprobrium of waste, thereby dampening the manifestation of the sunk cost effect. (See Heath, 1995, for another way to minimize the sunk cost effect.)

In the context of a sunk cost situation, abandoning a failing course of action seems to waste the resources already expended. Of course, avoiding waste is generally advisable. In fact, "Waste not, want not" is a rule that most of us have been taught since childhood. Yet to use this principle to resist the abandonment of a futile prior investment represents an inappropriate overgeneralization of this rule (Larrick, Morgan, & Nisbett, 1990, p. 363). One should base one's decisions on the incremental costs and benefits of undertaking any action. The resources already spent should not be a consideration.

Note that the overgeneralization of the "Don't waste" rule is responsible for the sunk cost effect, which is manifested in participants' failure to heed cost-benefit considerations, that is, reinforcement contingencies. This is analogous to what happened in the research reviewed above. Weir (1964) suggested that adult participants who used complex rules were less able to maximize reinforcement compared with the cognitively more primitive toddlers. Rosenfarb et al. (1992) showed that rule usage fostered continued responding even when the reinforcement contingencies were no longer in effect.

Our conclusion is that rules can be highly advantageous, but they can be a detriment if they are overgeneralized to situations in which they are no longer appropriate. The overgeneralization of the "Don't waste" rule is manifested in the sunk cost effect in humans. We suggest that animals do not manifest the Concorde fallacy because animals are much less likely than humans to be able to use abstract rules. As a result, animals are more sensitive to the reinforcement contingencies that confront them in their environment. Any lower animal that maximizes reinforcement less than its competitors is at an evolutionary disadvantage. An animal that behaves in a way that honors prior investments rather than subsequent costs and benefits loses out to an animal that does the opposite. Humans, the species whose members can use abstract rules, occasionally overgeneralize a highly adaptive rule such as "Don't waste." The burden of this overgeneralization is the sunk cost effect, the detrimental impact of which is smaller in magnitude than the benefit of being able to use this highly beneficial rule in other more adaptive contexts.

We should point out that evidence exists that nonhuman animals can use rules (see, e.g., Dehaene, Dehaene-Lambertz, & Cohen, 1998; Thompson, Oden, & Boysen, 1997). Our contention is merely that humans are far more likely to generate and use such rules than are nonhuman animals.

The lack of rule use by nonhuman animals is complemented by an increase in their number of "hardwired" responses. For example, if its chemosensory hairs are stimulated with a sufficiently sweet food, the blowfly (*Phormia regina* meigen) will extend its proboscis (Edgecomb & Murdock, 1992). We predict that the amount of prior effort the insect has invested in seeking the food will not influence proboscis extension. Proboscis extension is mediated by a small number of neurons whose firing cannot be influenced by abstract rules based on waste. Such "nonplastic" hardwired responses are calamitous if environmental changes render their behaviors obsolete because adaptation cannot occur. On the other hand, as Rozin and Schull (1988) pointed out, "environmental quirks can misguide overly plastic organisms" (p. 526), such as humans. We may think nonhuman animals are primitive because they have fewer cognitive resources with which to generalize either their selectively reinforced responses or their hardwired responses to new situations. When generalization of a rule is inappropriate, however, nonhuman animals paradoxically may enjoy an advantage.

Our thesis concerning the misapplication of the "Don't waste" rule is related to research by Simonson (1989) on reason-based choice. Consider Cars A and B depicted in Figure 1. A is superior on Attribute 1, such as gas mileage, but B is superior on Attribute 2, such as safety. A choice between the two cars is difficult because it is not obvious how much of one attribute should be sacrificed in order to obtain an increment of the other. Suppose Car C is introduced into the set of choices. Note that this option is completely dominated by Car A, which is superior to it in both dimensions. Simonson found that introducing C resulted in an increase in the proportion of respondents who chose A compared with the proportion who chose A when only A and B were available! According to the principle of regularity (Luce, 1977), it should not be possible to increase the proportion of people choosing an option by adding items to the set of available choices. This principle makes intuitive sense because the addition of a new option should have only the potential of draining away some choices from the original two options; it should not increase the number of people choosing either of the original ones.

Simonson (1989) explained this surprising result by suggesting that Car C provides a consumer with a good justification for choosing Car A, which is easily discerned as better than C. This justification results in a higher proportion of people choosing A compared with the original situation, in which no obvious justification for A was available. For the same reason, adding Car D to the original two options increases the proportion of people who select B.

Our analysis of the sunk cost situation is analogous. Justifications and reasons cannot interfere with lower animals' efforts at value maximization. On the other hand, humans do base some of their choices on justifications and reasons (e.g., "I can't justify throwing away the expensive Michigan ticket. What a waste that would be! I'm going to Michigan, even though I won't like it as much").

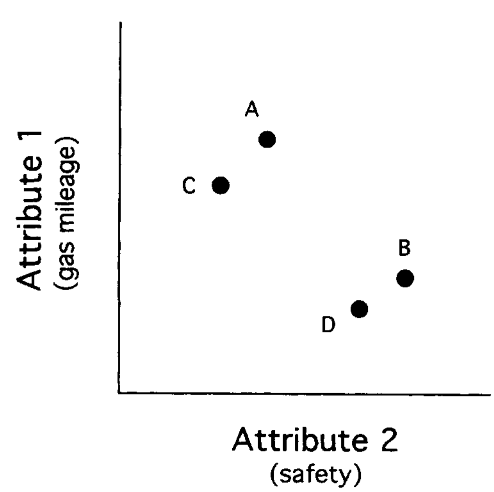

Figure 1. Stimuli A and B comprise the initial choice set. The addition of C to the set increases the proportion of people who choose A. The addition of D to the choice set increases the proportion of people who choose B. (Based on Simonson, 1989.)

Justification plays another role in the analysis of the sunk cost effect. Beginning with a study by Staw (1976), it has been shown a number of times that if the decision maker bears personal responsibility for an initial investment, that person is more likely to "throw good money after bad" compared with the situation in which the decision maker bears no personal responsibility for the initial investment decision (see, e.g., Davis & Bobko, 1986; Staw & Fox, 1977). This finding is usually interpreted in terms of *self-justification* (Brockner, 1992; Staw & Ross, 1978). Those who made the initial decision would be admitting that they had made a mistake if they abandoned their chosen course of action. To justify what they have already done or perhaps to appear to be consistent, they continue to pursue their initial course of action, thereby honoring their sunk cost. Support for this self-justification explanation comes from such studies as Fox and Staw's (1979), in which participants taking the role of administrators who were insecure in their jobs and who knew that their initial policy decision was not popular were particularly prone to continue their failing course of action. Presumably, such a perilous job situation would not be a good time to reveal to others that the initial decision was unwise and should be reversed. Note that these social psychological pressures—justifying one's prior behavior and appearing to be consistent—are irrelevant to lower animals. This is a second reason—independent of the overgeneralization of the "Don't waste" rule—why cognitively more primitive animals may be less susceptible to the sunk cost effect.

An Ontological Test

Our contention is that there are no unambiguous manifestations of the sunk cost effect/Concorde fallacy in lower animals. Further, we suggest that one major reason for this state of affairs is that lower animals cannot overgeneralize an abstract rule like "Don't waste." If we are correct in suggesting that nonhuman animals do not commit the sunk cost effect/Concorde fallacy, then we must also predict that young humans should be less susceptible to the sunk cost effect than are adult humans. Young humans, like nonhuman animals, have more modest cognitive abilities than adults and thus should be less likely to overgeneralize an abstract rule. We now present evidence for our unusual prediction.

We have been able to find three studies that provide evidence relevant to this hypothesis (Baron, Granato, Spranca, & Teubal, 1993, p. 38, Items 6 and 7; Krouse, 1986; Webley & Plaisier, 1997). The Krouse and Webley and Plaisier studies used the same methodology, so they provide corroborative evidence for each other. Furthermore, they used many more participants than did the exploratory studies of Baron et al. We acknowledge that both the Krouse and the Webley and Plaisier experiments are not sunk cost studies, but they are close. They pertain to "mental accounting" (Tversky & Kahneman, 1981).

According to traditional economic analysis, sunk costs should not influence present economic decisions. The sunk cost fallacy is due to the inability to segregate prior losses from the current decision as to whether the incremental benefits outweigh the incremental costs. Consider Tversky and Kahneman's (1981, p. 457) "lost ticket scenario." The numbers in parentheses are the percentage of participants who chose each option. All participants were adults.

> Imagine that you have decided to see a play where admission is $10 per ticket. As you enter the theater you discover that you have lost a $10 bill.
>
> Would you still pay $10 for a ticket for the play?
> Yes (88%) No (12%)
>
> Imagine that you have decided to see a play and paid the admission price of $10 per ticket. As you enter the theater you discover that you have lost the ticket. The seat was not marked and the ticket cannot be recovered.
>
> Would you pay $10 for another ticket?
> Yes (46%) No (54%)

The results of this experiment were that if one lost the money, one was likely to buy another ticket. However, if the money had already been assigned to the ticket, one could not segregate this prior loss from the current decision as to whether the benefit of having the ticket outweighed the incremental cost of $10. As a result, the ticket seemed too costly ($20), and it was less likely to be purchased. Note that this is very similar to a sunk cost situation in that one has already invested in an endeavor. In the lost ticket scenario, one should attend only to the incremental costs and benefits of paying $10 and seeing the play. Instead, the participants who read the second scenario were less able to segregate their prior loss of the ticket, just as people in traditional sunk cost situations are unable to ignore the assets already sunk in the endeavor. The second-scenario participants therefore deemed the total $20 price to be too high and were not likely to go to the play.

Those in the first scenario lost a $10 bill, which had not yet been assigned to the play. The $10 price was deemed to be attractive enough for 88% of the participants to decide to attend.

The key difference between the groups is that, compared with those who lost the money, those who lost the ticket were less able ignore the loss as they considered the incremental costs and benefits of paying $10 for a new ticket. Being less able to ignore prior losses is the hallmark of the sunk cost effect or Concorde fallacy. Would children show the same differences found among adults by Tversky and Kahneman (1981) in the two scenarios?

Webley and Plaisier (1997) tested children at three different age groups (5–6, 8–9, and 11–12) with the following modification of the Tversky and Kahneman (1981) experiment:

> Imagine you are at a fairground with your parents. Your mother gives you a 50 pence coin, and your father gives you a one pound coin. After walking around for a while you decide to use the 50 pence coin to buy a ticket for the merry-go-round. [But then you discover that you have lost your ticket./But then you discover that you've lost the 50 pence coin so you can't use it to buy a ticket for the merry-go-round.] Would you use the one pound coin to buy a new ticket? (p. 9)

Half the children in each of the three age groups received one of the two sentences inside the brackets. Table 2 contains the results.

Note that the older children provided data analogous to those found by Tversky and Kahneman (1981): When the money was lost, the majority of the respondents decided to buy a ticket. On the other hand, when the ticket was lost, the majority decided not to buy another ticket. This difference was absent in the youngest children. Note that it is not the case that the youngest children were responding randomly. They showed a definite preference for purchasing a new ticket whether the money or the ticket had been lost. Like the animals that appear to be immune to the Concorde fallacy,

Table 2
Percentage of Participants Willing to Buy Another Ticket in the Tversky and Kahneman (1981) Study Using Adults and in the Webley and Plaisier (1997) Study Using Children of Various Ages

	Condition			
	Lost ticket		Lost money	
Study	% buy	% do not buy	% buy	% do not buy
Kahneman & Tversky	46	54	88	12
Webley & Plaisier				
Age group (years)				
11–12	20	80	90	10
8–9	50	50	90	10
5–6	80	20	70	30

young children seemed to be less susceptible than older children to this variant of the sunk cost effect. The results of the study by Krouse (1986) corroborate this finding: Compared with adult humans, young children, like animals, seem to be less susceptible to the Concorde fallacy/sunk cost effect.

An alternative reason has been offered for why the modal response of the young children in both the Krouse (1986) and the Webley and Plaisier (1997) studies was to buy a ticket. Perhaps the impulsiveness of young children (Mischel, Shoda, & Rodriguez, 1989) fostered their desire to buy a ticket for the merry-go-round right away, regardless of whether a ticket or money had been lost. However, this alternative interpretation does not explain why the younger children said that they would buy the ticket less often than the older children in the lost-money condition. Nor does this explanation explain the greater adherence to normative rules of decision making by younger children compared with adults in cases where impulsiveness is not an issue (see, e.g., Jacobs & Potenza, 1991; Reyna & Ellis, 1994).

Costs and Benefits of Rules

The ability to abstract rules and apply them to new situations is obviously an enormous cognitive asset. However, rules can be overgeneralized. This is a cost. The sunk cost effect is a prime example of a cost of the overgeneralization of rules (Arkes, 1991; Ayton & Arkes, 1998). We suggest that overgeneralization of the eminently sensible rule "Don't waste" contributes to the manifestation of the sunk cost effect. Nonhuman animals and young humans do not know this rule, so its overgeneralization is not an issue for them. This is not to say that lower animals and young humans are wasteful. In fact, lower animals seem to be more sensitive to reinforcement consequences than are adult humans, thereby maximizing—not wasting—their reward opportunities (Kollins, Newland, & Critchfield, 1997). Adult humans, rather than attending strictly to the incremental costs and benefits of each possible option, are prone to apply the "Don't waste" maxim where it is not appropriate.

As an example, consider the following scenario taken from Arkes (1996). The numbers in parentheses before each possible answer indicate how many participants chose that answer.

> Mr. Munn and Mr. Fry each live in an apartment near the local movie theater. Mr. Munn can go to the movies only on Monday night. Mr. Fry can go to the movies only on Friday night. Each movie costs $5, no matter which night it is shown. Each movie generally is shown for a whole week.
>
> Since Monday night is generally a pretty "slow" night at the movies, the manager of the theater offers a package to those who go to the movies on Mondays. Although tickets are $5, the manager will sell a three-pack for $12. The three-pack can be used on any three Mondays during the next month. Mr. Munn looks over the schedule for the next month and sees only two movies he is interested in seeing. So he decided not to buy the three-pack. Instead he pays $5 on each of the first two Mondays of the month to see a movie. Mr. Fry also pays $5 on each of the first two Fridays of the month to see a movie.
>
> Then there is a change in the schedule. One of the movies that was supposed to come that month cannot be obtained. Instead the manager substitutes a new movie that both Mr. Munn and Mr. Fry are somewhat interested in seeing. Had Mr. Munn bought the three-pack, he could have seen this new movie without paying any more money than the extra $2 he would have needed to buy the $12 three-pack. Since he didn't buy the three-pack, both Mr. Munn and Mr. Fry will have to pay $5 to see the new movie.
>
> The question is: will one of the two men be more likely to pay to see the new movie, or will they be equally likely to pay to see it? Check the option that corresponds to your prediction.
>
> (12) They will be equally likely to pay to see the new movie.
>
> (2) Mr. Munn will be more likely than Mr. Fry to pay to see the new movie.
>
> (34) Mr. Fry will be more likely than Mr. Munn to pay to see the new movie. (pp. 215–216)

The majority of the participants thought that Mr. Munn would be reluctant to go to the movie. When asked to explain this reasoning, approximately half of these participants explicitly mentioned the avoidance of waste as the basis for Mr. Munn's reticence. Mr. Munn could have gone for only $2 had he purchased the three-pack. He did not, so the $5 expenditure would appear to be wasteful. Thus, participants believed Mr. Munn would be less likely than Mr. Fry to purchase the ticket, even though the incremental costs and benefits were the same for the two gentlemen. Adults in the movie scenario overgeneralized the "Don't waste" rule. Note that the youngest children in the Webley and Plaisier (1997) study did not commit the analogous error, whereas the older children did. Younger children, like phylogenetically humble organisms, appear to know what is best for themselves.

Inappropriate generalization of previously learned rules has been reported elsewhere in the literature (e.g., Goodie & Fantino, 1996, p. 248; Kollins et al., 1997). For example, Kollins et al. attempted to explain why nonhuman animals appear to be much more sensitive to operant consequences than are humans. A prime example is the button-press response, which in humans is "highly variable and generally appear[s] to be less sensitive to consequences than other types of responses" (Kollins et al., 1997, p. 213). The reason for this finding, according to the authors, is that button presses are part of the everyday routine of humans, and their performance in any experiment would therefore be contaminated by overgeneralization of prior reinforcement history. Lower animals in an experimental situation involving button presses cannot overgeneralize what they have learned from the number pad of their telephones, for example, because animals have no such reinforcement history. Their behavior is therefore controlled more precisely by the operant consequences present in the experiment. Experimenters note their conformity to reinforcement contingencies and puzzle over humans' less exact adherence to the cost-benefit rules of choice.

The Superiority of the Normative Rule

The normative rule contradicted by both the Concorde fallacy and the sunk cost effect is that only the incremental costs and benefits of the current options should influence one's decision. How costly are violations of the normative rule? Larrick, Nisbett, and Morgan (1993) presented evidence that better students and higher paid academics adhered to this rule more than did weaker students and lower paid academics. We certainly do not dispute the fact that adhering to the rule makes for better decisions than not adhering to it. Nonetheless, the concept of an optimum decision strategy is incomplete without reference to the costs and other constraints relevant to its use. According to the notion of bounded rationality (Simon, 1956, 1992), the computational limits of cognition and the structure of the environment may foster the use of "satisficing" rather than optimal strategies (see also Chase, Hertwig, & Gigerenzer, 1998). Thus, for many everyday decisions, perhaps a fast and frugal heuristic like "Past investment predicts future benefits" is a serviceable substitute for the normative rule (Gigerenzer, Czerlinski, & Martignon, 1999; Gigerenzer & Goldstein, 1996). However, this simple rule fails in precisely those circumstances in which additional resources do not result in a concomitant increase in future benefits. The inability of humans to identify such situations a priori is the reason the sunk cost fallacy occurs. However, given that past investment is typically correlated with prospective value, perhaps the cost of vulnerability to the sunk cost fallacy is not so great as the benefits gained from use of such a computationally cheap rule. It is humbling to consider what lower animals would think of humans if their experiments demonstrated our vulnerability to the sunk cost effect and our apparently rather casual observance of the normative rules of choice. At least some comfort can be taken from the fact that they would be able neither to articulate nor to overgeneralize their findings.

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