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Limits on social influence on food choices of Norway rats

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ABSTRACT

We examined social influences on food choices of Norway rats choosing between pairs of diets that differed in their relative palatabilities. We found in two experiments that prior interaction with a demonstrator rat fed either a cayenne-flavoured diet (experiment 1) or a cinnamon-flavoured diet (experiment 2) significantly affected the observer rats' intake of their respective demonstrators' diets. However, as the amount of cayenne pepper in the cayenne-flavoured diet was increased, so that it became increasingly unpalatable relative to a cinnamon-flavoured alternative diet (experiment 1), the effects of demonstrator rats on their observers' intake of the cayenne-flavoured diet diminished. Similarly, as we added sugar to a cinnamon-flavoured diet, so that it became increasingly palatable relative to an alternative cocoa-flavoured diet (experiment 2), the effects of demonstrator rats on their observers' choices between the cinnamon- and cocoa-flavoured diets diminished. Taken together with findings in the literature, the present results suggest that the greater the difference in a subject's affective responses to two stimuli, the less the effect that social influences have on its responses to those stimuli.

A naive 'observer' rat, *Rattus norvegicus*, choosing between two roughly equipalatable foods after interacting with a 'demonstrator' rat fed one of them, shows an enhanced preference for whichever food its demonstrator ate. For example, observer rats that interact with a demonstrator rat fed a cinnamon-flavoured diet, and are then offered a choice between a cinnamon- and cocoa-flavoured diet, eat more of the cinnamon-flavoured diet than do observer rats that interact with a demonstrator rat fed the cocoa-flavoured diet before being offered the same choice (Galef & Wigmore 1983).

Such social effects on food choice are surprisingly powerful. A single brief interaction between observer rats that had learned an aversion to a palatable food, and a pair of demonstrator rats that had eaten that food, resulted in half the observers abandoning their aversions and eating the food that they had learned to avoid (Galef 1985, 1986; Galef et al. 1990).

More relevant to the present study, social learning can also induce ingestion of unpalatable foods. Each of 12 rats, offered a choice between powdered rat chow and chow adulterated with cayenne pepper, ate more of the unadulterated rat chow than the pepper-flavoured chow. On the other hand, 5 of 12 rats that interacted on several occasions with demonstrator rats fed cayenne-pepper flavoured chow, ate more of the pepper-flavoured chow than the unadulterated chow (Galef 1989).

As the preceding examples illustrate, situations can be created in which social influence enhances preference for potentially dangerous and unpalatable foods. However, the existence of such situations reveals little about the range of circumstances in which interaction with conspecifics that have eaten a dangerous or unpalatable food will increase preference for that food. Observer rats might be influenced less by interaction with a demonstrator rat that had eaten a very unpalatable or particularly toxic food than by interaction with a demonstrator that had eaten a slightly unpalatable food or mildly toxic one.

Galef (1985) varied the strength of the toxin used to induce a learned aversion to a very palatable diet (Diet NPT: normal-protein test diet) in observer rats, and then examined the effects of interaction with a demonstrator rat fed Diet NPT on its ingestion by observer rats. He found that the greater the pharmacological insult used to induce an aversion to Diet NPT in observers and, consequently, the stronger their aversion to Diet NPT, the smaller the effect of interaction with demonstrator rats fed Diet NPT on the amount of Diet NPT that observers ate.

Dugatkin (1996) recently published a study conceptually similar to that of Galef (1985), but examining social influences on female guppies', *Poecilia reticulata*, choices between pairs of males differing in relative physical

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attractiveness. Dugatkin (1996) set in opposition the tendencies of female guppies from the Paria River in Trinidad to affiliate with: (1) the more orange-coloured of two males (Briggs et al. 1996; Houde 1988); and (2) whichever of two males they saw courting another female (Dugatkin 1992; Dugatkin & Godin 1992). Dugatkin found that females that had watched the less orange-coloured of two males court, affiliated with the courting male only if his orange area was slightly smaller (4–24%) than that of the alternative male. If two males differed markedly (40% or more) in amount of orange coloration, then females preferred the more orange of the two males, even after they saw the less orange-coloured male court another female. Thus, in guppies, social influence reversed a weak but not a strong female preference based on the coloration of males.

Dugatkin (1996) discussed his data in terms of the relative strength of genetic and cultural factors in determining mate choice. We prefer to consider Dugatkin's results as demonstrating a boundary condition on the social modification of behaviour. Regardless of how one interprets Dugatkin's (1996) data, they are important because they define circumstances in which social influence can or cannot modify performance of a biologically important act.

We undertook the experiment reported here to determine whether effectiveness of demonstrator rats in inducing ingestion of a palatable or unpalatable food varied systematically with the relative palatability of the food that demonstrators ate. Finding a similar relationship between: (1) the relative attractiveness of male guppies to conspecific females and the social influence on mate choice; (2) the relative attractiveness of foods to rats and the social influence on food choice; and (3) the relative strength of learned aversions to foods and the social influence on intake of those foods would suggest a general rule concerning the conditions under which social influence will modify preferences (Cabanac 1979).

EXPERIMENT 1

In experiment 1, we examined the effects of interaction with a demonstrator rat fed either a cinnamon- or cayenne-flavoured food on the food choices of rats offered a choice between cinnamon- and cayenne-flavoured foods of varying relative palatabilities.

Methods

Subjects

A total of 157 experimentally naive, 42-day-old, female Long-Evans rats served as subjects, 54 in study 1, 49 in study 2, and 54 in study 3. All subjects were born and reared in the Central Animal Facility at the McMaster University Medical Centre to breeding stock acquired from Charles River Canada (St Constant, Quebec).

An additional 103, female Long-Evans rats 49–56 days old that had served as subjects in other experiments served as demonstrators in studies 2 (49 subjects) and 3 (54 subjects).

Diets

We prepared five cayenne-flavoured diets (Diets 1.0 Cay, 3.0 Cay, 5.0 Cay, 7.0 Cay and 9.0 Cay) by mixing, respectively, either 1.0, 3.0, 5.0, 7.0 or 9.0 g of cayenne pepper purchased in bulk (Horn of Plenty, Dundas, Ontario) with 1000 g of powdered Purina Rodent Laboratory Chow No. 5001 (Ralston Purina, Woodstock, Ontario). We also prepared a cinnamon-flavoured diet (Diet Cin) by mixing 10.0 g of McCormick's Fancy Ground Cinnamon (McCormick Canada Ltd, London, Ontario) with 1000 g of powdered Purina chow.

Apparatus

Throughout the experiment, we housed and tested each subject individually in a wire-mesh hanging cage measuring 18 × 34 × 19 cm. We presented food to subjects in semicircular cups (4 cm deep × 10 cm diameter) that we hung on one wall of each subject's cage. We collected spillage, which was minimal, on paper trays placed under each subject's cage.

Procedure

Study 1. We undertook study 1 to establish the palatabilities, relative to Diet Cin, of the five cayenne-flavoured diets used in the experiment. We offered each member of five independent groups, each composed of either eight or nine subjects, a choice for 24 h between weighed samples of Diet Cin and one of the five cayenne-flavoured diets. At the end of the 24-h preference test, we weighed the food cups and determined the percentage of each subject's total intake that was cayenne-flavoured diet.

Study 2. Study 2 was undertaken to examine the effect of interaction with a demonstrator rat fed either Diet Cin or Diet 3.0 Cay on the food choices of members of independent groups of either eight or nine rats choosing for 23.5 h between Diet Cin and either Diet 1.0 Cay, 3.0 Cay or 5.0 Cay. To begin the experiment, we fed 49 demonstrator rats powdered Purina chow for 1 h/day for each of 2 consecutive days. Following a third 23-h period of food deprivation, we fed each demonstrator rat either Diet Cin or Diet 3.0 Cay for 1 h, then placed the demonstrator in the home cage of one of the 49 observer rats for 30 min. At the end of the period of interaction between demonstrators and observers, we removed all demonstrators from the experiment and offered each observer, for 23.5 h, a choice between weighed samples of Diet Cin and either Diet 1.0 Cay, Diet 3.0 Cay or Diet 5.0 Cay. At the end of the choice test, the experimenter weighed the food cups in each observer's cage and determined the percentage of each subject's total intake that was cayenne-flavoured diet.

Study 3. The procedure that we used in study 3 was identical to that of study 2 except that: (1) we fed all 54 demonstrators used in study 3 either Diet Cin or Diet 7.0 Cay; and (2) we offered independent groups of 9–11

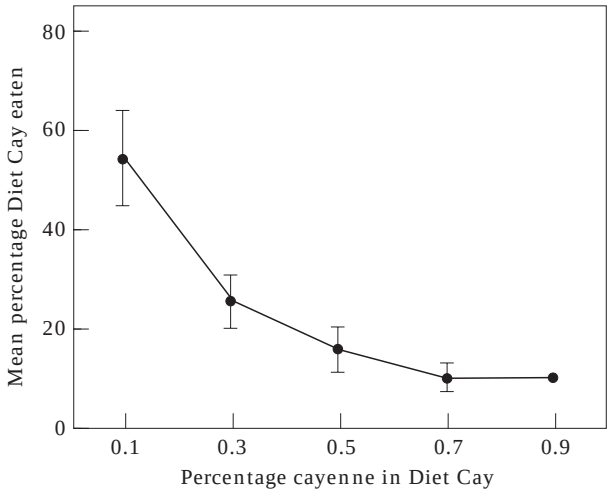

Figure 1. Mean (±SE) percentage of cayenne-flavoured diet (Diet Cay) eaten by subjects in study 1 of experiment 1 offered a choice between a cayenne-flavoured diet and a cinnamon-flavoured diet as a function of the percentage of cayenne pepper in the cayenne-flavoured diet.

observers a choice between Diet Cin and either Diet 5.0 Cay, Diet 7.0 Cay or Diet 9.0 Cay.

Results and Discussion

Study 1

The relative amount of cayenne-flavoured diet eaten by subjects offered a choice between cayenne- and cinnamon-flavoured diets was profoundly affected by the amount of cayenne pepper in the cayenne-flavoured diet ($F_{3,34}$=12.39, P<0.0001; Fig. 1). The more cayenne pepper in the cayenne-flavoured diet, the less of that diet subjects ate.

Study 2

Both the diet fed to demonstrators ($F_{1,43}$=25.56, P<0.001) and the amount of cayenne pepper in cayenne-flavoured diets offered to subjects during the choice test ($F_{1,43}$=25.85, P<0.0001) affected the magnitude of social influence on the amount of cayenne-flavoured diet that subjects chose to eat (Fig. 2a). Most relevant to the issue of the effects of relative diet palatability on the social influences on diet choice, we found a significant interaction between the effects of demonstrators on observers' diet choices and the amount of cayenne pepper in cayenne-flavoured diets offered to observers ($F_{2,43}$=4.04, P<0.03). The greater the disparity in the palatability of the diets, the less the impact of demonstrators on the food choices of their observers.

Study 3

With increasing concentrations of cayenne pepper in the cayenne-flavoured diets offered to observers during the choice test, the influence of demonstrators on the food choices of their observers disappeared (Fig. 2b). In study 3, there was no significant main effect of the demonstrators' diet on the food choices of their observers ($F_{1,27}$=1.63, NS), no significant main effect of concentration of cayenne pepper in the cayenne-flavoured diet on observers' food choices ($F_{1,47}$=2.08, NS), and no significant interaction between the variables ($F_{2,47}$=1.00, NS).

Effect of demonstrators diet on observers' food choices in studies 2 and 3

We offered observers in both study 2 and study 3 a choice between Diet 5.0 Cay and Diet Cin, and treatment

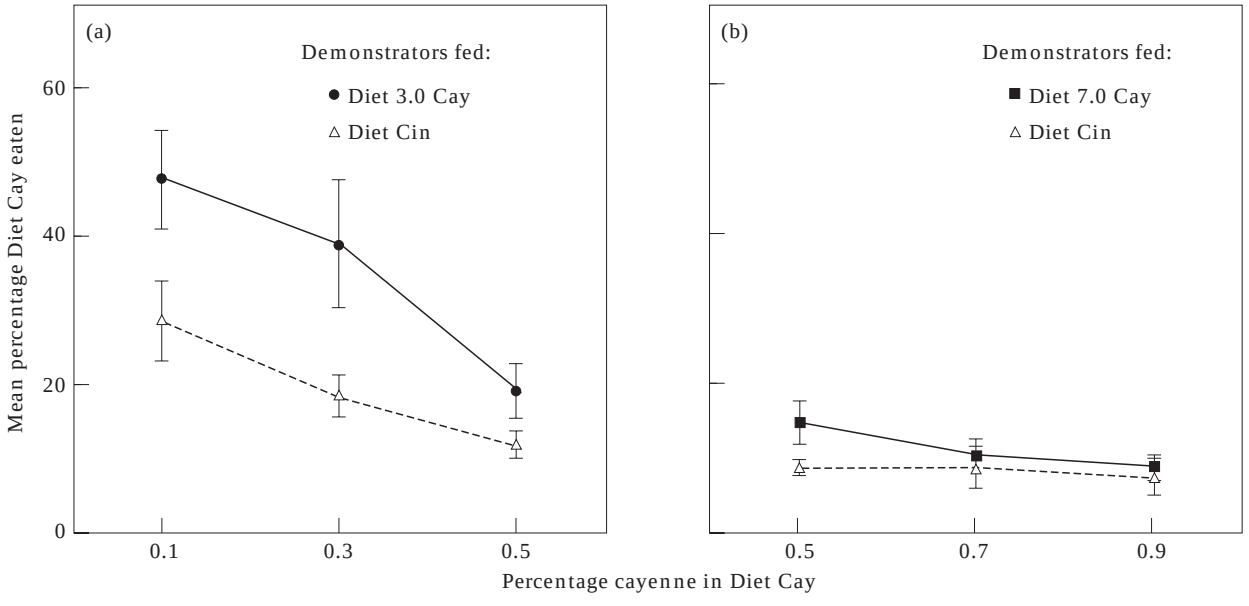

Figure 2. Mean (±SE) percentage of cayenne-flavoured diet (Diet Cay) eaten by observer rats that interacted with demonstrator rats fed either a cayenne-flavoured diet or a cinnamon-flavoured diet (Diet Cin) and then offered a choice between cinnamon-flavoured diet, and cayenne-flavoured diets containing different percentages of cayenne pepper. (a) Study 2; (b) study 3.

of subjects in the two studies differed only in the amount of cayenne pepper in the diets fed to demonstrators (Diet 3.0 Cay in study 2 and Diet 7.0 Cay in study 3). Examination of the food choices of observers in both studies 2 and 3 offered a choice between Diet 5.0 Cay and Diet Cin revealed no effect of the amount of cayenne pepper in the diet fed to demonstrators on the food choices of observers ($F_{1,31}$=0.621, NS), a statistically marginal effect on observers' food choices of whether their demonstrators had been fed cinnamon-flavoured or cayenne-flavoured diet ($F_{1,31}$=3.83, P<0.06) and no significant interaction between the two variables ($F_{1,31}$=0.44, NS).

Comparisons between study 1 and studies 2 and 3

Unfortunately, it was not possible to make comparisons between the results of study 1 and those of studies 2 and 3. We had to purchase new supplies of flavourings after we completed study 1, and when using natural flavourings, as we do, there is considerable variability in the palatabilities of different samples of the same flavouring.

EXPERIMENT 2

In experiment 2, we again examined the magnitude of social influences on choice of two diets as a function of their relative palatabilities. However, in this experiment, unlike experiment 1, we changed the relative palatabilities of the two diets by increasing rather than decreasing the palatability of one of them.

Methods

Subjects

A total of 128 experimentally naive, 42-day-old, female Long-Evans rats served as subjects, 64 in study 1, and 64 in study 2. All subject were purchased directly from Charles River Canada (St Constant, Quebec).

An additional 64 female Long-Evans rats, 49–56 days old, that had served as subjects in other experiments served as demonstrators in study 2.

Diets

We prepared four cinnamon-flavoured diets (Diet Cin, Diet Cin+2.5S, Diet Cin+5.0S, and Diet Cin+10.0S) by mixing, respectively, either 25, 50 or 100 g of granulated sugar with 1000 g of powdered Purina Rodent Laboratory Chow No. 5001 (Ralston Purina, Woodstock, Ontario) to which we had added 10 g of McCormick's Fancy Ground Cinnamon (McCormick Canada Ltd., London, Ontario). We prepared a cocoa-flavoured diet (Diet Coc) by mixing 20 g of Hershey's Pure Cocoa (Hershey, Pennsylvania) with 1000 g of powdered Purina chow.

Apparatus

The apparatus was the same as that used in experiment 1.

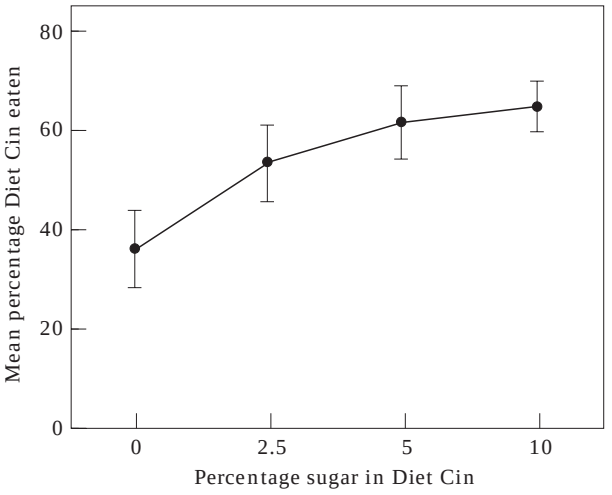

Figure 3. Mean (±SE) percentage of cinnamon-flavoured diet (Diet Cin) eaten by subjects in study 1 of experiment 2 offered a choice between a cinnamon-flavoured diet and a cocoa-flavoured diet as a function of the percentage of sugar in the cinnamon-flavoured diet.

Procedure

Study 1. We undertook study 1 to establish the palatabilities, relative to Diet Coc, of the four cinnamon-flavoured diets used in the experiment. We offered each member of four independent groups, each composed of 16 subjects, a choice for 24 h between weighed samples of Diet Coc and one of the four cinnamon-flavoured diets. At the end of the 24-h preference test, we weighed the food cups and determined the percentage of each subject's total intake that was cinnamon-flavoured diet.

Study 2. We undertook study 2 to examine the effect of interaction with a demonstrator rat fed Diet Cin+5.0S on the food choices of members of independent groups of eight rats choosing for 23.5 h between Diet Coc and either Diet Cin, Diet Cin+2.5S, Diet Cin+5.0S or Diet Cin+10.0S. To begin the experiment, we fed 64 demonstrator rats powdered Purina chow for 1 h/day for each of 2 consecutive days. Following a third 23-h period of food deprivation, we fed each demonstrator rat Diet Cin+5.0S for 1 h, then placed the demonstrator in the home cage of one of the 64 observer rats for 30 min. At the end of the period of interaction between demonstrators and observers, we removed all demonstrators from the experiment and offered each observer, for 23.5 h, a choice between weighed samples of Diet Coc and either Diet Cin, Diet Cin+2.5S, Diet Cin+5.0S or Diet Cin+10.0S. At the end of the choice test, the experimenter weighed the food cups in each observer's cage and determined the percentage of each subject's total intake that was cinnamon-flavoured diet.

Results and Discussion

Study 1

The relative amount of cinnamon-flavoured diet eaten by subjects offered a choice between cinnamon- and cocoa-flavoured diets was affected by the amount of sugar

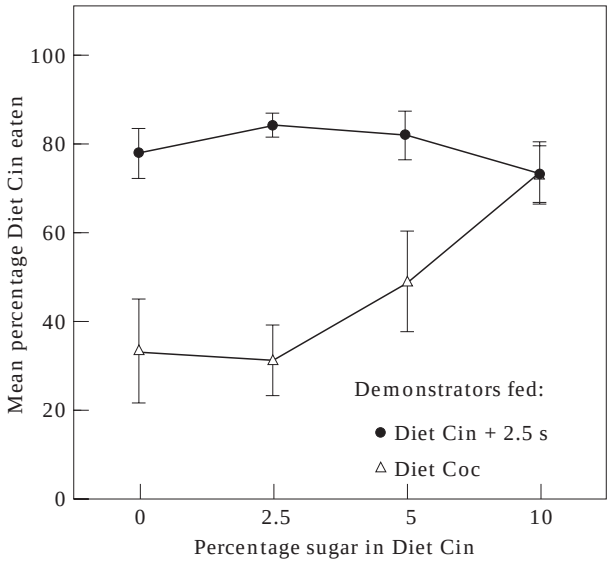

Figure 4. Mean (±SE) percentage of cinnamon-flavoured diet (Diet Cin) eaten by observer rats that interacted with demonstrator rats fed either a cinnamon-flavoured diet or a cocoa-flavoured diet (Diet Coc) and then offered a choice between the cocoa-flavoured diet and cinnamon-flavoured diets containing different amounts of sugar.

in the cinnamon-flavoured diet ($F_{3,60}$=3.11, P<0.04; Fig. 3); the more sugar in the cinnamon-flavoured diet, the more cinnamon-flavoured diet the subjects ate.

Study 2

The diet fed to demonstrators ($F_{1,56}$=33.12, P<0.001; Fig. 4), but not the amount of sugar in the cinnamon-flavoured diet offered to subjects during the choice test ($F_{3,56}$=1.62, NS; Fig. 4), affected the percentage of cinnamon-flavoured diet eaten by observers during the choice test. Most relevant to the issue of the effects of relative diet palatability on the social influences on diet choice, there was a significant interaction between the effect of the diet fed to demonstrators and the amount of sugar in cinnamon-flavoured diets offered to observers ($F_{3,56}$=3.90, P<0.02) on observers' diet preferences. The greater the disparity in the palatability of the diets, the less the impact of demonstrators on the food choices of their observers.

GENERAL DISCUSSION

Together, the results of studies 2 and 3 in experiment 1, and study 2 in experiment 2 strongly suggest that, as Dugatkin (1996) found in his experiment on social influence on mate choice in female guppies, social induction of preference is not seen when items offered for choice differ markedly in their initial attractiveness. (1) Social influence on the tendency of female guppies to affiliate with the less desirable of two males waned as the magnitude of the difference in the physical attractiveness of those males increased, and (2) social induction of ingestion of the less or more palatable of two foods waned as the magnitude of the difference in the palatabilities of those foods increased.

Taken together, the results of the present study, those of Dugatkin (1996), and those of Galef (1985) suggest a possible general rule: large differences in the response of naive individuals to two stimuli are correlated with reduced social induction of preference for one of those stimuli.

The present findings also parallel the results of several earlier studies on 'conformity' described in the literature of social psychology. In a classic study, Solomon Asch (1956), placed individual naive, human male subjects ('true subjects') into groups of seven confederates pretending to be naive subjects. Asch presented each group with repeated trials, on each of which, all eight individuals had to announce in turn and aloud which of three lines was identical to standard lines that varied in length from 2 to 10 inches (5.08–10.2 cm). On 12 of the 18 test trials given to each group, six confederates chose the same incorrect line as a match for the standard line before the true subject announced his choice (the seventh confederate announced his incorrect choice after the true subject announced his). True subjects making decisions in the presence of confederates made incorrect choices on roughly 25% of the trials, while subjects performing the same task in isolation made essentially no errors at all. Asch (1958, page 182) states, 'The degree of independence [of the judgements of true subjects] increases with the distance of the majority from correctness.'

While the behavioural processes producing conformity between true subjects and human confederates and between demonstrator rats and demonstrator guppies and their observers are surely different, the principle that social influences on behaviour grow weaker as the strength of personal judgements grows stronger seems widely applicable.

Acknowledgments

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