

Resolving Conflicts

The appropriateness of calling rheostasis into action when conflicts occur depends on what other options there are for settling matters. Some possibilities are introduced in the sections that follow through examples of conflicts that have deliberately been arranged and studied.

SWITCHING EFFECTOR MECHANISMS

Johnson and Cabanac (1982a) studied rats in a laboratory environment consisting of a “home” with access to a “restaurant.” The home was warm (25°C) but had no food in it. The restaurant was open for 2 hours a day; it was 2 m away from the home and it was cold, very cold (−15°C). The menu was limited to powdered food to prevent hoarding. The experimenters wanted to find out whether rats in this situation would eat less than normal or whether they would get cold. The answer was neither. The rats outwitted the experimenters, but in an instructive way. They did two things that enabled them to eat enough in a cold restaurant without themselves becoming hypothermic. They ate faster and they sat on the base of their tails and bodies, with their back feet off the ground, so that their unfurred extremities were off the bare grid floor. During the time required for a foraging trip, body temperature fell less than 0.5°C, although the skin temperature did drop from about 25° to 10°C.

This example is not trivial. It highlights the way in which, with a sufficient diversity and plasticity in effector mechanisms, it is possible to satisfy different motivations simultaneously. Diversity of effectors has been thought to be of value mainly in providing redundancy should one mechanism be impaired. Richter (1943) showed that behavioral responses often came to the rescue when physiological effectors were damaged. The adrenalectomized rat saves itself by drinking saline solution; the rat with deficient metabolism keeps itself warm by building an extra large nest. However, it is not true that behavior is only a second line of defense for occasions when physiological mechanisms fail.

Sometimes behavior is used right from the start in intact animals. For example, when little effort is required, squirrel monkeys (*Saimiri sciureus*) prefer to thermoregulate by pulling a chain that alters the ambient temperature. When counterweights are added to the device, making the chain hard to pull, then the monkeys rely more on autonomic responses; shivering and increased metabolism substitute for the behavioral response (Adair and Wright, 1976). There can, however, be little doubt that variety in defense has a back-up function.

Variety in defense is also valuable in other ways, as in enabling the appropriate type of defense to be mounted. The response to a hit-and-run attack may be unsuitable for withstanding a siege. For example, baroreceptor reflexes can restore arterial blood pressure in a matter of seconds. Baroreceptors, like other stretch receptors, adapt to prolonged stimulation. Chronic challenges to the maintenance of blood pressure are met in other ways, such as by activation of the renin-angiotensin system or adjusting the blood volume through altered renal excretion. When the sinoaortic baroreceptors are removed from dogs, their mean arterial pressure remains close to normal but the variability is much increased; the loss of the rapid neurally mediated defenses results in much greater changes in response to such minor disturbances as a person entering the room (Cowley et al., 1973).

In addition, multiplicity of defense mechanisms increases the scope for warding off potential conflicts by permitting switching among the array of available effectors (cf. Simon, 1986). Switching between effectors within a homeostatic system is known to occur in defense of a regulated variable when the cost of making particular responses changes. For instance, in a rat thermoregulating in a warm environment, saliva excretion and evaporative cooling increase when bar pressing to obtain cooling is made less rewarding. It seems plausible that the same switching mechanisms could be sensitive to the demands of other nonthermal homeostatic systems (Schmidt, 1984).

It is not always necessary to switch completely from one effector to another to ameliorate conflicts. Sometimes much can be done simply by altering the precise way in which a particular effector is used. For instance, in heat-stressed birds, breathing patterns change in ways that minimize conflicts between acid-base regulation and thermoregulation. Lacking sweat glands, birds depend greatly on panting for cooling, though at least some species also have mechanisms for cutaneous water evaporation (Arad et al., 1987). Respiratory rates in heat-stressed birds can increase by as much as twentyfold (Johansen and Bech, 1984). This would bring about large reductions on P_{CO_2} were it not for the fact that the tidal volume of each breath is less during panting respiration, so that it is largely air to and from the dead tracheal space that is circulated in and out of the body, rather than air from the gas-exchanging surfaces of the lungs. There are various different adjustments of normal breathing that help satisfy the demands of both thermoregulation and chemoregulation. This can be done by simple panting, or by yet shallower panting with occasional flush-out breaths for gas exchange, or by compound respiration (Fig. 2-1).

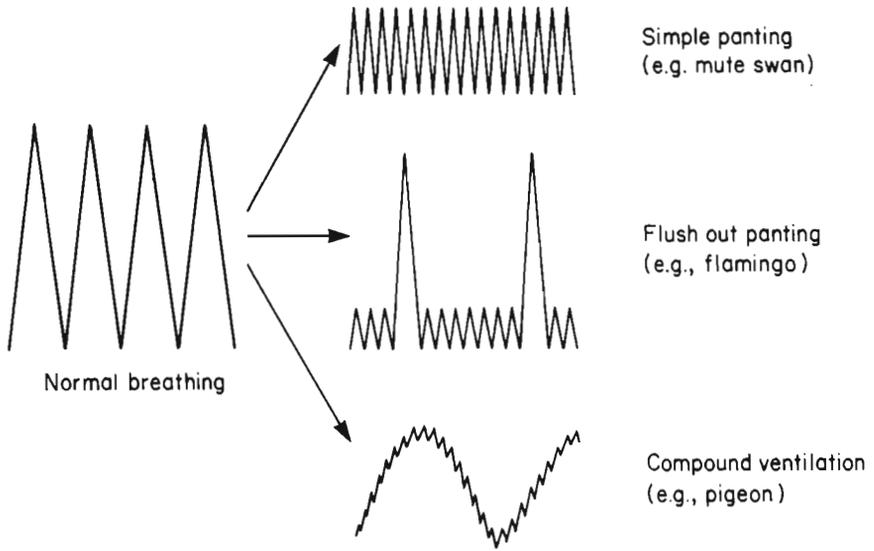


Figure 2-1. Diagrams of some different breathing patterns of birds exposed to high ambient temperatures. [From Johansen and Bech, 1984, *Breathing and thermoregulation in birds*. In *Thermal Physiology*, J. R. S. Hales (ed.), Raven Press, N.Y., p. 342.]

AVOIDING THE CONFLICT SITUATION

During intense physical activity, to function effectively the muscles require a high blood flow. The skin also requires a high blood flow to dissipate the heat produced. A conflict arises over cardiac output (Stitt, 1979). What happens is that the body becomes warmer, but at a certain point thermoregulatory needs dominate and exhaustion and collapse occur. The ensuing decrease in activity takes the animal out of the conflict situation.

The acceptability of taking this route—avoidance of the conflict situation rather than resolution of the conflict within the situation—is limited by the survival value of remaining in the conflict situation. A man may have to exert himself prodigiously to escape from a pursuing lion. The survival value of continuing to run, even though this puts muscles and skin into conflict over blood supply, may be very considerable. Often conflicts are inherent in living in particular habitats (e.g., the camel in the desert).

UNAVOIDABLE CONFLICTS IN THE LABORATORY AND FIELD

It may not be possible always to avoid the conflict situation or to resolve the conflict by switching effectors or modifying their action. Despite changes in breathing patterns, respiratory alkalosis does sometimes occur in heat-stressed birds (e.g., Calder and Schmidt-Nielsen, 1966). No regulatory system has an infinitely varied arsenal of defenses. In their experiments with a warm home and a cold restaurant, Johnson and Cabanac (1982b) were able to alter their

experimental situation in a way that prevented the rat from avoiding conflict by switching effectors. They simply increased the distance between the home and the restaurant to 16 m. When this was done, core temperatures of the animals were estimated to be about 1°C lower than when only short foraging trips were required; skin temperatures fell to near 0°C. Food intake also decreased by a few grams, but different testing conditions were introduced before it became clear whether this would have led to declines in body weight. As the distance between the home and the restaurant increased, rather than numerous quick meals, the rats took fewer and longer meals, despite the resultant hypothermia.

Similar experiments have been tried with growing tegu lizards, *Tupinambis teguixin* (Cabanac, 1985a). By using an animal that can maintain its body temperature only by making use of external heat, it is easy to make foraging excursions thermally challenging simply by placing food in a cold area, in this case at 0°C; another unprovisioned part of the test chamber contained a heat lamp. When lizards of this species were satiated, they left the area under the heat lamp when they warmed up to 37°C and returned when they cooled off to about 34°C. This shuttling to and from a heat source is part of normal thermoregulatory behavior. When the lizards had not been fed for a day, they stayed away from the heat lamp for longer periods, until their temperatures fell to around 32°C. Like the rats, when hungry they accepted a small reduction in body temperature. Attempts to accentuate this phenomenon by depriving the lizards of food for longer times were unsuccessful because the lizards did not increase their intake systematically as a function of deprivation duration, but instead grew at slower rates.

Unavoidable conflicts have been especially successfully studied in the pigeon, *Columba livia*. Rautenberg et al. (1980) placed birds in a warm air stream of 50°C or more. The birds could switch on cool 18°C air by pecking at a key. This behavior was necessary because evaporative cooling through panting was operating at maximal rates. With both the panting and the key-pecking behavior, body temperatures stabilized at about 42°C. In the next part of the experiment the pigeons were food-deprived enough to reduce their weights to 80%. They were then able to obtain food in the warm air chamber by pecking at another key. When given access to this second key, they initially neglected the cool air key and allowed their body temperature to rise to 43°C. Similar high temperatures were tolerated when dehydrated pigeons were offered the choice between working for water or for cool air.

So, with persistence, it is possible to study what happens when unavoidable conflicts are arranged. But how instructive are the results of such experiments? It may be asked whether such conflicts would ever arise outside the laboratory. Pigeons can normally fly away from excessively hot places. With the rats in the restaurant experiments, restriction on take-out orders is unnatural. Hoarding is a common behavior in rodents; in male rats it increases when body weight falls (Fantino and Cabanac, 1980). In being offered only powdered food, the animals were prevented from calling up one of their normal body weight defense mechanisms. Similar complaints could be raised about the lizard experiments. The animals used came from the Guianas, where ambient

temperature seldom falls below 20°C. Food at 0°C is something this population of lizards would never be faced with in its own habitat. Generalizing, it might be argued that if artificial conditions were eschewed, then animals could always avoid conflicts by switching between available effectors. A sufficient effector repertoire may have evolved for the niche to which a species is adapted but not for contrived laboratory situations.

There may be some cogency in this argument for particular cases. Nevertheless, there are examples in which clashes between regulatory systems do occur in natural circumstances. The camel's dilemma as to whether to use water to keep cool or to maintain fluid balance has already been mentioned (Chapter 1). Various incompatibilities between feeding and parental care are described in Chapter 4. It is not hard to imagine that an animal, after enduring adverse weather conditions or recovering from sickness, could be both hungry and thirsty at once—and possibly cold as well—with its different regulatory systems simultaneously crying for satisfaction.

A different but naturally occurring conflict is that between courtship of newts, which takes place at the bottom of a pond, and the regulation of blood gases, which requires surfacing to breathe (Halliday and Sweatman, 1976). A similar situation arises with the newborn hippopotamus. Its habit of suckling underwater (Verheyen, 1954) presumably entails some interaction between drives to feed and to breathe, although this has not been studied systematically. In such circumstances the conflict is over control of the behavior of the whole animal. In other cases conflict arises over the control of a particular effector. For example, vasoconstriction in the cold promotes thermal constancy but makes it harder to keep blood pressure constant (Wasserstrum and Herd, 1977b; Wilson and Fyda, 1985).

Even when laboratory environments impose unnatural constraints, they can still be instructive about the mechanisms of interaction between different regulatory systems. Here we come to a more serious limitation of experiments on this subject. They are a valuable starting point, but they do not go much beyond telling us that, in a particular situation, stability of one variable is not strictly maintained. No general rules are provided, no insights are offered into what determines when a particular system wins. What would have happened in the restaurant experiments if the rats had been made hungrier? What would have happened if the lizards had been forced to wait in a cool place long enough to make their temperatures fall below 32°C before they received any food? Perhaps after parametric work with a wide range of hunger and thermal discomfort, it might be possible to predict what an animal would do in particular circumstances.

Another approach is to think about evolutionary fitness. In terms of the contribution to future generations, the benefits minus the costs of the choice made should exceed those of the rejected courses of action. This approach encounters the theoretical problem that an animal might not, in fact, always make the optimal choice, and the practical problem of finding a common currency in which to compare the results of different actions. How does one actually compare the value of foraging with the risks of predation? Dynamic programming may offer some hope of progress on the common currency problem (McNamara and Houston, 1986).

A very different proposal is that, in a multidimensional space of different motivations, animals and people make choices that maximize sensory pleasure (Cabanac, 1985b). For instance, subjects in a cold room can keep warm by exercising, but this makes them tired. Different levels of exercise on a treadmill and of ambient temperature are imposed on the subjects, and their pleasure ratings for each combination are recorded. In other tests they are free to select either the treadmill slope or the ambient temperature. The choices they make correspond roughly to combinations that give maximal pleasure. This level of analysis concerns immediate proximate mechanisms governing the choice, and is not incompatible with analysis in terms of adaptive advantage and fitness.

Despite these interesting suggestions, the matter of finding valid rules of how animals actually behave in conflict situations is in a rudimentary state. At this stage it may, however, be worthwhile to consider some of the general ways in which conflicts could be allowed to proceed.

STRICT HIERARCHY

There could be a strict and unalterable hierarchy, with one system always taking precedence no matter what. This would surely be maladaptive. Suppose, for example, that water balance were top in the hierarchy, then a starving animal that had only a modest water deficit would look for water rather than food. On teleological grounds, strict hierarchy will not be considered further.

CONTINUOUS CONFLICT: INHIBITION AND DISINHIBITION

If there is no strict hierarchy, with one system always in the ascendancy, then the animal must alternate between trying to satisfy the demands first of one and then of another system. What determines when such shifts occur? To say that transitions from one behavior to another take place when the level of causal factors for one behavior come to exceed those for the other is a description that may help define the problem, but it is not explanatory. Thought has been given, however, to the ways in which the levels of causal factors for different behaviors can change relative to one another. McFarland (1969) distinguishes two basic changes. Inhibition occurs when the strength of causal factors for one behavior come to exceed those of another and so oust it from control of a final common behavioral pathway. Disinhibition occurs when the strength of causal factors for one behavior falls below that for another and so allows it to gain control. If there are successive disinhibitions, as shown in Figure 2-2d, this is called *chaining* (Cohen and McFarland, 1979). If there are successive inhibitions, this is called *competition* (Fig. 2-2c). This is perhaps an unfortunate term in that, in a general sense, in all cases shown in Figure 2-2 there is competition. Causal factors for both behaviors are always present but can only activate the behavior when they come to exceed the causal factors for other behavior. It is only the ways in which the causal factors change relative to one another that are different. In this book, the term *competition*, or *contin-*

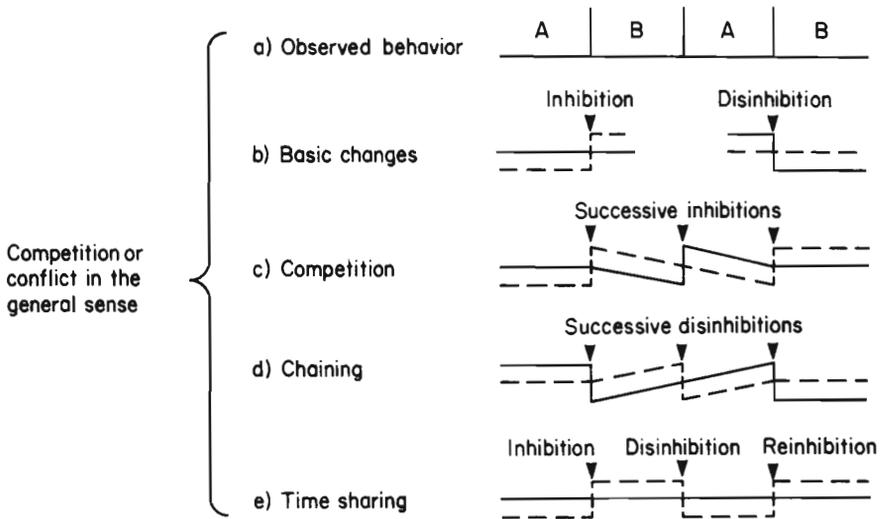


Figure 2-2. Some different possible explanations for the alternation between two behaviors, A and B, based on changes in the level of causal factors for the two behaviors. Solid lines show level of causal factors for behavior A; dotted lines show level for behavior B (adapted from Cohen and McFarland, 1979).

uous competition, is used in the more general sense, that is for situations in which causal factors for both behaviors are present and attempting to gain mastery, and not just for the specific case of successive inhibitions. The term *continuous conflict* is used in the same general sense.

TIME SHARING

Another way in which causal factors change relative to one another is by successive inhibitions and disinhibitions (Fig. 2-2e). This is called *time sharing* (McFarland, 1974). In time sharing there is a dominant and a subdominant activity, or, to use computer terminology, a foreground activity and a background activity. The subdominant activity occurs only when the strength of the causal factors for the dominant activity falls below its elicitation threshold. At that time the subdominant activity is permitted to occur. For example, suppose that an animal were both thirsty and hungry, and suppose that drinking were dominant. If the animal were given both food and water, it would first drink for a while. Then for some reason, perhaps the stomach becoming full of water, the causal factors stimulating drinking would decline, and the animal would pause. At that time the subdominant activity of eating would be allowed to occur. Eating would not occur earlier or later if the animal were more or less hungry because the strength of the causal factors acting on the subdominant activity do not influence when it occurs. After a while, perhaps because of water leaving the stomach, the causal factors stimulating drinking would strengthen again, and eating would be cut off.

Time sharing is different from strict hierarchy because it is accepted that there may be reversals between activities occupying dominant and subdominant roles (Cohen and McFarland, 1979). In a slightly thirsty but very hungry animal, eating might be dominant and occur first when the animal is offered food and water, whereas in a slightly hungry but very thirsty animal, drinking might be dominant and occur first. Time sharing has been proposed as an organizing principle operating over fairly short time spans when an animal alternates between two behaviors. In strict hierarchy no switching of behavior occurs until one system is completely satisfied, with a zero level of causal factors.

The essential idea in time sharing is that over the time span when one activity is dominant the strength of the causal factors operating on the subdominant activity has no effect on its occurrence. This is an operational definition. Whether it is met can be discovered by manipulating the causal factors for the behavior that is thought to be subdominant. It says nothing about the possibly different mechanisms that might underlie behavioral sequences meeting the operational definition.

There is some debate about what kinds of data constitute evidence for the existence of time sharing (Houston, 1982; McFarland, 1983). This applies in particular to interruption experiments. Suppose alternations between behaviors are organized as in Figure 2-2e. Then if the dominant activity is interrupted it should be resumed when the interruption ends. If the subdominant activity is interrupted, and if the interruption is short, then that activity should be resumed, but if the interruption is long, then the dominant activity should be resumed when the interruption ends. Various experiments by McFarland and his colleagues demonstrate such asymmetries between interruptions of different activities. For example, when male sticklebacks, *Gasterosteus aculeatus*, are housed in a tank containing a nest at one end and a female stickleback at the other end, they alternate between courting the female and swimming to the other end of the tank to maintain the nest in good repair. Suppose on a given day courting is the dominant behavior. Then if the male is trapped in the middle of the tank while on its way to court the female, when released it proceeds on toward the female. If it is trapped while on its way to tend the nest, it proceeds to the nest if the interruption is short but it returns to court the female after a long interruption (Cohen and McFarland, 1979).

Such data are consistent with time sharing, but they are not sufficient to meet the operational definition of time sharing. Houston (1982) has pointed out that it would be possible to generate similar data by competition between the causal factors responsible for the two activities, if one permits the levels of these factors to change during the interruptions. There may be positive feedbacks and delays in negative feedbacks. Depending on the time courses and interactions of such factors, the initial behavior sequences and how they are affected by interruptions could be determined by the level of the causal factors for *both* behaviors, rather than for just one (Houston and Sumida, 1985). Therefore interruption experiments are not an infallible test of time sharing, as McFarland (1985) has conceded.

Houston's (1982) criticisms weaken the evidence for time sharing mecha-

nisms, but they provide no evidence against their existence. Where there is asymmetry in the results from interruption experiments, and where there are additional data of other types, then time sharing remains a plausible explanation for the organization of the behavior. For instance, in experiments where a hungry rat also has the opportunity to mate, the causal factors for the subdominant activity have been directly manipulated. Sexual behavior in the male rat consists of a series of ejaculations separated by intervals. Brown and McFarland (1979) found that neither the frequency nor the patterning of sexual behavior was altered by increasing the duration of food deprivation from 0 to 48 hours. The rats fitted in eating between ejaculations. Thus manipulation of the causal factors for eating (i.e., increasing deprivation), did not affect when these intervals for eating became available. This suggests that the behaviors were organized on a time sharing basis, with eating as the subdominant activity. However, while time sharing may have been operating once the sexual behavior had begun, something else was occurring at the start of the tests because the hungrier rats took longer before their first interaction with the female; they were busier eating at the time. So by the time they began mating they had already taken the edge off their appetite. It is possible that more than enough time was available during the subsequent inter-ejaculatory intervals to satisfy the remaining hunger, even after 48 hours of food deprivation. It would have been interesting to see whether the patterning of sexual behavior would have been altered had food been offered only after sexual interactions had started.

Whether it turns out that time sharing is widespread, occurs in just a few circumstances, or is not to be found, the idea is an important contribution and has stimulated analysis of possible ways of organizing behavior in situations in which an animal alternates between the demands of two motivations.

LOWERING REGULATED LEVELS

A competition may be won by overpowering one's opponents. Another way of resolving a conflict is to persuade the other parties that they do not really want the disputed item. Lowering the regulated level of one variable, when conflicts arise, is somewhat akin to the persuasion method. It is a wise way to proceed. Attention is not diverted by the continuing struggle of one of the motivational systems for mastery; causal factors for the behaviors it controls fall to zero. Resources are not wasted in mounting costly defenses.

Yet, it may be objected, it is all very well to extol the wisdom of persuasion, to hint at its esthetic or even moral appeal, but if stability is as necessary as we have been led to think, then how can the body afford to lower the defended level of a variable without incurring damage? Here we come to one of Cannon's most neglected insights, the idea that the normal settings of defended variables are ones that give a margin of safety (1939). This is perhaps Cannon's most important contribution beyond elaborating what Bernard had already outlined. For example, blood sugar is usually kept at 90 mg/dl, but if it rises to 120 mg/dl after a meal, or if it falls to 80 mg/dl, there are no serious consequences; only if it falls to around 60 mg/dl do signs of neurological dysfunction become

evident (Brandes, 1977). Similarly, calcium in the blood is regulated at a level well above that at which convulsions appear. Body fat and body temperature also have safety margins, though in the case of temperature this is small on the upside. Systolic blood pressure may drop from 115 to 80 mm Hg without starving the tissues of oxygen. In fact, the blood pressure of healthy animals is by no means constant: mean arterial pressure in dogs kept in an outdoor run typically varies between 75 and 125 mm Hg over 24 hours (Broten et al., 1988). It should be cautioned that chronic deviations from the normally regulated values might be deleterious. This discussion refers to short or medium duration deviations, which are often well tolerated.

Cannon also considered the value of having a pair of organs, but safety deriving from spare capacity in the effector systems is different from that arising from the judicious choice of regulated levels. Overall, Cannon regarded the margin of safety as just that—safety against disaster. He quoted analogies about engineers who, after calculating the stresses that a bridge will have to endure, double or treble the strength of the supports, as a safety factor. Cannon's view of the body's safety margin was similar: its prime function was insurance against collapse. This is certainly appropriate for a physician but there may be more to it than that. Setting regulated levels somewhere between dangerously high and low limits permits flexibility in the defended levels and allows homeostasis to be used in a more creative dynamic manner. In particular, it makes altering of defended levels in conflict situations a viable option.

CHOICE AND COMBINATION OF REACTIONS TO POTENTIAL CONFLICTS

Three general approaches to conflict have been described. The first is to find some means of achieving one's end that does not involve conflict. The second is to wage battle under some set of rules that decides who is the winner at any particular time. The third is to persuade one's opponent, or oneself, that the item in dispute is not after all wanted that much. These correspond to (1) switching between effector mechanisms, (2) continuous conflict, and (3) alterations of defended levels, or rheostasis.

These three approaches to conflict are not mutually exclusive; they may be used in various combinations. Switching of effectors may go some way towards avoiding conflict, yet still leave a remnant to be decided by the strength of the relevant causal factors. Rheostasis may go some way toward avoiding conflicts, but if, despite lowered levels for defense, the value of the regulated variable falls lower still, then conflict may emerge.

There are circumstances in which one of the three strategies listed above probably would be emphasized. When there are severe limitations to how much the defended level of a variable can be lowered, continuous conflict will probably persist. For example, the male newt courting the female at the bottom of a pond can incur only so much oxygen debt; eventually it must rise to the surface to survive. There may perhaps be some changes in the thresholds of blood gas concentrations required to initiate breathing; with a female newt so

unresponsive to the male that the courtship sequence can never be completed, breaths in the male occur about once every 4 minutes compared to every 3 minutes in a non-sexual situation (Halliday and Sweatman, 1976). Measures of the volume of air taken at each breath and of blood gases are needed to determine if there is indeed a change in the defended levels of blood gases. But the main way that breathing and courtship interact is by a continuing competition. In highly sexed males, breathing occurs less often and is inhibited by the presence of a female. When the female is suddenly removed by the experimenter, breathing is disinhibited (Halliday and Sweatman, 1976). That males come up for air very soon after the female is removed in such tests suggests that strong motivations to breathe were present previously.

Another situation in which continuous conflict predominates is when two behaviors require the same final common behavioral pathways for achieving something relevant to a single motivational system. For instance, in the male stickleback, nest care and courting both require the animal's presence and attention. Nest care is stimulated, not damped down, by the sight of the female fish (Cohen and McFarland, 1979). As both are necessary for successful reproduction, decreasing the output of reproductive hormones would not be adaptive in this situation. Some kind of continuous conflict, with alternation between the two behaviors, seems inevitable. Whether this alternation is arranged by time sharing or by some of the other ways shown in Figure 2-2 is a secondary point. Time sharing is one way of avoiding going back and forth between two activities without ever spending long enough on one to achieve anything useful. However, it is not the only way to avoid dithering. If positive feedbacks are generated at the start of an activity, then dithering can be avoided even if there is competition between the causal factors for the two activities.

When there is an opportunity to anticipate a potential clash and minimize the threat by building up margins of safety in advance, then rheostasis may be preferred over a back-and-forth tug between the causal factors for alternative courses of action. For instance if food gathering is likely to detract from breeding, then fat may be stored in advance, and its regulated level can be turned down later during the reproductive season. Changes in regulated levels may also be appropriate when the dispute is not for a final common behavioral pathway but for a commodity like water, as in the camel when the defended level of temperature changes to avoid the need for using water. It is also tempting to think that a lowering of defended levels may be more common when the potential conflict is prolonged, whereas a continuous struggle may be more common over short time scales. However, it may be unwise at this stage to underestimate the speed with which regulated levels can change.

SUMMARY

Conflicts between different regulatory systems can often be avoided by selecting between an array of available effector mechanisms in a way that allows the demands of both systems to be satisfied. However, there are both natural and

contrived laboratory circumstances where conflicts cannot be defused in this way. In such situations there are two other not mutually exclusive possibilities:

1. Continuous competition (conflict): the regulatory systems continue to compete for response pathways with the outcomes settled by some as yet undefined rules. Transitions between incompatible behaviors could occur through various sequences of inhibition and disinhibition.
2. Lowering of defended levels in one system: this is an example of rheostasis and is often possible when there is some margin of safety between the level at which a variable is regulated and that at which survival of the organism is jeopardized.

PREVIEW

Before embarking on a survey of examples of rheostasis, there is a pause in the next chapter for clarifying terminology.