

Conservation-withdrawal: a primary regulatory process for organismic homeostasis

GEORGE L. ENGEL and ARTHUR H. SCHMALE

*Departments of Medicine and Psychiatry, University of Rochester, School of Medicine and
Dentistry, Rochester, New York*

Abstract Relative immobility, quiescence and unresponsiveness to environmental input together constitute a behavioural triad that occurs periodically and aperiodically among virtually every species of animal. We propose the term *conservation-withdrawal* to designate the underlying somatic homeostatic processes from which many regulatory variants adaptive for different species have evolved. In this paper we discuss the phylogenesis and ontogenesis of the conservation-withdrawal reaction with particular reference to the circumstances under which this pattern is evoked. We suggest that conservation-withdrawal encompasses the regulatory processes responsible for periodic rest and restitution and that these same processes also mediate shorter or longer episodes of unresponsiveness and arrest of activity at times or under circumstances where interaction with the environment has become impossible or unavailing. Distinctions are drawn between conservation-withdrawal as a primary biological process and the psychological patterns which may be expressive of, derivative from or reactive to conservation-withdrawal.

What we propose to discuss under the heading 'conservation-withdrawal' belongs in the category of a new look at some familiar behavioural phenomena, namely the triad of relative immobility, quiescence and unresponsiveness to environmental input, a behaviour noted periodically and aperiodically among virtually every species of animal. The term *conservation-withdrawal* is being used to refer to biological threshold mechanisms whereby survival of the organism is supported by processes of disengagement and inactivity *vis à vis* the external environment. This is a response which may be invoked either when input becomes excessive and beyond the organism's capacity actively to cope or when available input becomes inadequate to meet needs. The biological goal of conservation-withdrawal is to conserve resources and to assure the autonomy of the organism until environmental conditions are once again more compatible. We postulate that such regulatory mechanisms for protection

against environmental extremes characterize all forms of life and we place them at one end of an activity–inactivity continuum of the homeostatic processes serving survival. We assume such systems operate at every level of organismic complexity and that in higher organisms the nervous system progressively assumes chaperonage over these functions.

This is not a new concept. For example, Hoagland wrote as follows in 1928: ‘It may be said that in general an animal can react in one of two ways to stimuli which tend to influence its behaviour. The animal may respond positively to the stimulating object by making appropriate adjustments, such as of attack or retreat, or manipulative movements; or it may react in a second way which has been surprisingly overlooked by most students of animal behaviour: it may cease all movements and remain quiescent even in the presence of violently disturbing factors. This phenomenon is strikingly demonstrated by a great variety of forms ranging from planarians to man’ (Hoagland 1928). Hoagland did not suggest a term to designate this class of behaviour which he discussed in relationship to behaviours variously called by others ‘animal hypnosis’, ‘cataplexy’, ‘playing possum’, ‘death feint’, and ‘tonic immobility’, among other terms. Our interest in such behaviour was first stimulated by observing its abrupt occurrence in the infant, Monica, when confronted by a stranger (Engel & Reichsman 1956). Not aware of Hoagland’s earlier statement, we first formulated the concept as follows: ‘We suggest that there are two basic modes of response of living cells or organisms to changes in the dynamic steady state. The first is represented by irritability phenomena, the tendency of living organisms or cells to respond to internal or external changes by *activity*. This activity has as its objective the restoration of a dynamic steady state which is achieved through internal rearrangements or alterations in relation to the environment. We think of this as dependent on available energy... The second response, which comes about when energy sources are depleted, threatened with depletion, or for some reason unavailable, involves a reduction in activity, a husbanding of energy, and may include metabolic rearrangements or structural changes which insulate against the environment (e.g., encystment) or reduce metabolic requirements (e.g., hibernation). If this response fails, exhaustion or death may eventually ensue. These fundamental biologic patterns acquire mental representations and come to constitute basic ego mechanisms’ (Engel & Reichsman 1956, p. 446). Originally we used the term ‘depression–withdrawal’; subsequently ‘conservation–withdrawal’ was introduced to refer to the biological system involved and to avoid confusion with the more psychological term ‘depression’ (Engel 1962, 1965, 1970; Schmale 1972*a,b*).

Since this original observation on Monica the Rochester group has been

much concerned with considering the relationship between conservation-withdrawal, as a biological frame of reference, and various psychological phenomena such as helplessness, hopelessness, giving up, and depression (Schmale 1964; Schmale & Engel 1967; Engel 1968). We have used a phylogenetic and an ontogenetic perspective which postulates that there are biological anlagen intrinsic to the development of the nervous system which antedate and influence subsequent psychological development. We have been particularly interested in how conservation-withdrawal, as such a basic biological anlage serving survival, may be reflected in the behaviour and psychological experience of man (Engel 1962).

MONICA: THE FIRST OBSERVATION

In 1953 while studying the gastric secretion of an infant with a gastric fistula between her 15th and 21st month, we were astonished to observe a most unusual but stereotyped behaviour (Engel & Reichsman 1956). On each occasion that a stranger came into her view, Monica ceased all movement and averted her gaze (Fig. 1). If several glances in the next half minute or so confirmed his continued presence her arms and legs slowly sank with gravity and remained thereafter entirely motionless. Over the next several minutes her eyes appeared *no longer to be focused*, so that at times she seemed to be staring past or through the stranger. Then the lids would begin to fall, perhaps fluttering open a few times in the next few minutes, and within 10–15 minutes she would have quietly drifted off to what appeared to be sleep. This occurred even though she may have only shortly before awakened from a long sleep. Such a sleep-like state could last from a few minutes to as long as two to three hours and was as deep as that which occurred spontaneously in the laboratory on other occasions, as evidenced by the fact that aspiration of gastric juice through the fistula, a procedure to which she was thoroughly accustomed, could proceed without overt reaction on her part. On the other hand, unexpected stimuli such as noises or jarring might transiently alert her, sometimes even evoking a little cry. Only during the later phase of such a period might some mouthing or sucking movements appear but even these were infrequent in comparison to their occurrence during spontaneous sleep. Should she wake and find the stranger still present she would immediately close her eyes and resume the sleep-like state. Only when she found him no longer there, or in his place a familiar person, would she once again begin actively to re-engage with the environment, usually with a cry of recognition and eager looking and reaching toward the friend.

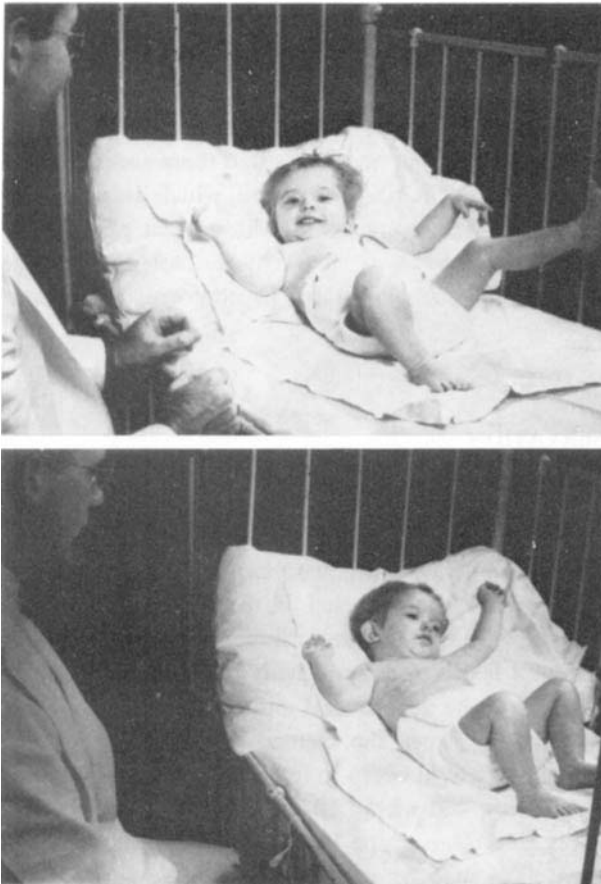


FIG. 1. *Top:* Monica relating actively with the familiar doctor. *Below:* In the presence of the stranger she lies motionless, her head and eyes averted, her limbs having fallen with gravity. (From Engel *et al.* 1956, with permission of the American Psychosomatic Society.)

During this withdrawal reaction gastric secretion ceased and became unresponsive to histamine stimulation while heart rate and respiration remained unchanged or slowed slightly (Engel *et al.* 1956).

Several factors no doubt contributed to the readiness with which this reaction was elicited in Monica. One was the pronounced limitation of mobility imposed by her physical underdevelopment, for at age 20 months, when the reaction was at its height, she was still unable to sit herself up, much less walk.

Also, from her sixth month onwards, her depressed mother repeatedly ignored Monica's crying and fed her through a fistula at her own convenience.

Ultimately, by the end of her first year, she had become a relatively withdrawn unresponsive baby. We postulate that Monica literally learned to bypass the active crying response when repeated experience revealed that it no longer brought relief. Rather than exhaust her already depleted resources, she instead fell back on the more economical conservation-withdrawal reaction, thereby conserving energy and reducing attention to the disturbing environmental input with which she no longer had any active means to cope. Cessation of gastric secretion may be seen as part of the physiological reorganization predicated on expectation of no nutritional input from the environment, just as the muscular hypotonia reflected no expectation of effective motor engagement with the environment. This bypassing of the more active reaction was evident not only in the general disposition toward lethargy, apathy and impoverishment of movement which generally characterized her upon admission, and which we referred to as a 'depression of infancy', but also in the distinctive response to the stranger which persisted long after recovery from this more global reaction. In brief, in this child the threshold for elicitation of conservation-withdrawal-type responses had been markedly lowered and the circumstances under which such responses occurred generalized to involve a variety of specific and non-specific inputs.

Since Monica, we have had the opportunity to study other infants exhibiting such behaviour and to appreciate the extent to which in greater or lesser degrees it represents a ubiquitous response pattern in infancy (Spitz 1945; Peiper 1963).

PHYLOGENESIS OF CONSERVATION-WITHDRAWAL

Examples of inactivity in response to unfavourable environmental conditions abound in nature. Some of these reflect environmental periodicities, others the chance vicissitudes of the environment. The periodic patterns are in general correlation with the march of operating physical influences through the circadian cycles and the seasons. Throughout nature circadian rhythms are reflected in cycles of relative activity and inactivity, which reflect alternations between predominantly catabolic and anabolic phases. In the catabolic periods the organism expends energy, actively interacting with the environment to extract the elements essential for life. Alternating are anabolic periods in which there is relative detachment from the environment while the organism transforms the supplies previously taken in for repair, renewal and growth.

Variations in the conditions of the physical environment also influence activity. The amoeba, for example, responds to small changes in the surrounding medium by increasing or by changing the direction of its movements.

With an intense enough stimulus the amoeba contracts irregularly and ceases to move. If the acting agent is sufficiently powerful the organism may remain contracted until it dies; otherwise it usually soon resumes locomotion (Jennings 1906). A wide variety of patterns of dormancy, some, like hibernation, highly specialized, assure survival of organisms during periods of excessive heat, cold, moisture, dryness or other unfavourable environmental changes. What is common to all these reactions is inactivity and insulation against the environmental influence (Allee *et al.* 1949). Many organisms move away from exposed strata to a marginally safe environment, for example by making burrows in pond mud, where even homoiothermic animals may remain relatively quiet, except for periodic search for food until outside conditions once again improve. In lower organisms encystment would appear to be a general adjustment to any adverse condition, being brought about by low or high temperatures, lack of food, presence of an unfavourable concentration of waste products, or lack of oxygen (Allee *et al.* 1949, p. 38).

The same system is utilized in response to psychological and social changes as well. Examples abound in nature of immobility and lack of overt reactivity in a wide variety of situations directly or indirectly involving other organisms, such as threat or attack. Various named ('animal hypnosis', 'sham death', 'tonic immobility'), this type of reaction has been noted across a host of species of vertebrates and invertebrates. As one ascends the phylogenetic scale the meaning of the provoking stimulus in terms of threat may become increasingly specific. Darwin was the first to ascribe survival advantage to this reaction by virtue of it rendering the organism less apparent or less interesting to predators (Darwin 1900, quoted by Ratner 1967). Thus many animals become quite immobile once the predator approaches within a certain distance and flight or fight are precluded (Ratner 1967). Specific physical characteristics of the near predator, such as the eye, may be a stimulus that evokes and prolongs the reaction (Gallup *et al.* 1971). Immobility once in the grasp of the predator may also have survival value if it invites a relaxation of the grip (Ratner & Thompson 1960).

The most effective means of inducing such an immobility reaction experimentally involve either restraint, particularly unfamiliar restraint, or sudden and intense or repetitive and monotonous stimulation (Ratner 1967). The reaction is marked not only by cessation of struggling and virtually total lack of movement but also by suppression or rapid habituation of the usual motor responses to such extremes of stimulation as electric shock, pin pricks, cutting, loud noises and bright lights. On the other hand, though not overtly reacting, the animal remains capable of detecting such stimuli, as evidenced by the autonomic responses that occur during such stimulation and by the fact that animals in

such a state may nonetheless be aroused transiently in response to a novel stimulus even of very faint intensity (Ratner 1967). Wendt's immobilized monkey, for example, unresponsive to a variety of insults, nonetheless alerted in response to footsteps on the floor above (Wendt 1936).

Both in nature and in the laboratory animals have been conditioned or have learned to respond with an immobility reaction to a variety of stimuli. Merely the sight or touch of the restraining chair may elicit complete immobility in some monkeys (Foley 1938).

Most observations indicate that immobility-type reactions are most likely to develop when the animal has limited freedom of movement or can develop no effective responses to deal with the threat (Pavlov 1927; Overmier & Seligman 1967; Seligman & Maier 1967; Seligman 1968; Seligman & Maier 1968; Gellhorn 1967; Masserman & Pechtel 1953; Cook 1939; Gannt 1953; Liddell 1956). Thus monkeys exposed to a motivational conflict may sit for hours hunched and unresponsive, vocalizing infrequently. Some have been noted to become so indifferent to all stimuli that they could be scooped up unprotesting on the blade of a shovel (Masserman & Pechtel 1953).

Transient and prolonged immobility patterns also may occur when animals are separated from a companion or a group (Hediger 1955; Fiennes 1968; Yerkes & Yerkes 1929). The most pronounced responses are noted in some infant animals upon separation from the mother or in isolation (Harlow *et al.* 1971; Hinde & Spencer-Booth 1971; Kaufman & Rosenblum 1967). Fig. 2, taken from Kaufman & Rosenblum, demonstrates the response of a pigtail monkey infant a few days after its mother had been removed from the colony. The infant sits hunched up, almost rolled into a ball, with his head down between his legs, rarely moving except when actively displaced. Such movement as does take place often is extremely sluggish, social gestures or response to social invitation rarely occur, spontaneous play behaviour ceases, and the infant appears uninterested in and disengaged from the environment. The resemblance to behaviour displayed by Monica is striking.

Defeated animals may become inactive. Barnett, for example, describes defeated rats in confined colonies as displaying slow movements, drooping posture and bedraggled appearance (Barnett 1963). Indeed, the submissive posture of many animals, including invertebrates, includes suddenly becoming motionless, averting the gaze and lowering the head or trunk, and even lying supine (Darwin 1872; Lorenz 1952; Hinde 1970; Reese 1962; Grant & Mackintosh 1963; Ewing 1967; Barnett 1963).

In sum, a vast literature documents the widespread existence throughout nature of relative immobility, quiescence and reduced responsiveness as a fundamental modality for protection against a wide variety of dangers or

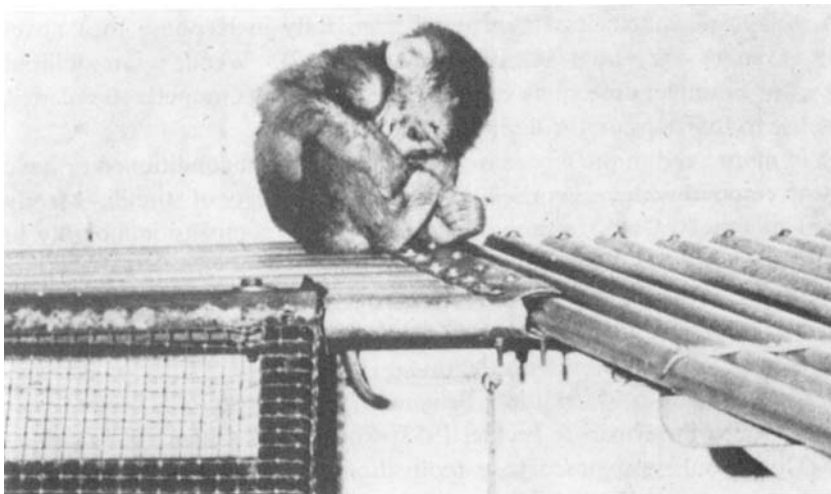


FIG. 2. An infant pigtail monkey two days after removal of its mother from the colony. (After Kaufman & Rosenblum 1967, with permission of the authors and of the American Psychosomatic Society.)

threats of danger from the physical or social environments. From the theoretical perspective we regard conservation-withdrawal as primarily serving an elemental survival function and specify as its identifying characteristics disengagement from active interaction with the environment, at both motor and perceptual levels, and husbanding of energy resources by reduction of activity and possibly metabolic rearrangements as well. This differentiates conservation-withdrawal type reactions from other patterns in which motor activity is suspended, as during periods of appraisal, concentration, scanning, listening, expectant waiting, silent vigilance, imminent flight or attack, or learned inhibition of motor activity (e.g. Bindra & Anchel 1963). Operational criteria remain to be delineated and some of the examples cited may well prove to have been improperly classified, but as extreme examples the behaviour of the monkeys described by Wendt (1936), Masserman & Pechtel (1953) and Kaufman & Rosenblum (1967) can be clearly differentiated from other immobility reactions commonly exhibited by monkeys, just as Monica's behaviour with a stranger was obviously very different from her motionless, silent watching of a child in the next crib or her quiet contemplative moods. On the other hand, as we shall discuss later (p. 70), we are less prepared to distinguish the quiet, reduced mobility associated with fatigue from conservation-withdrawal behaviour.

ONTOGENESIS OF CONSERVATION-WITHDRAWAL

The human infant clearly is equipped to respond with immobility and reduced awareness in circumstances of either understimulation or excessive stimulation. The crying fit is the prototype of the aroused, disturbed state and communicates to the environment that the infant is not capable within itself of alleviating or resolving its distress. Under ordinary circumstances crying ceases as the need, such as for food, sucking, or body contact, is met, whereupon the infant soon again quietens or lapses into sleep. But even when needs are not met crying does not necessarily go on indefinitely; the baby becomes quiet or returns to sleep long before exhaustion supervenes (Sullivan 1953; Engel & Reichsman 1956). Sometimes the crying fit can be abruptly ended and sleep-like quiet induced if the neonate is suddenly inverted or subjected to a quick falling motion, manoeuvres reminiscent of those used to provoke immobility reactions in animals (Peiper 1963, p. 506). Some neonates become lethargic and fall asleep during nursing if the nipple is withdrawn or becomes blocked (Ribble 1943; Fries & Woolf 1953). Infants in institutions, who are relatively understimulated compared to infants at home, are noted to be less active and to sleep excessively (Provence & Lipton 1962). With more pronounced social isolation and understimulation in institutions profound degrees of inactivity and withdrawal may be noted (Spitz 1945; Peiper 1963).

On the other hand intense stimulation, such as may occur with blood letting or minor surgical procedures without anaesthesia, such as circumcision, may induce sleep in neonates (Emde *et al.* 1971). Burton & Derbyshire (1958) described a one-year-old infant with secondary glaucoma who awoke, screamed in pain for over an hour and then abruptly fell into an unresponsive state from which he could not be aroused. When the eye was enucleated on the seventh day, without the need for anaesthesia, the child abruptly became normally alert and responsive.

CONSERVATION-WITHDRAWAL AND SLEEP

If conservation-withdrawal constitutes a homeostatic threshold mechanism to protect the organism against exhaustion, whether from inadequate supplies or overstimulation, it is difficult to escape the conclusion that sleep is part of the same mechanism. Certainly sleepiness and sleep are usual responses to such circumstances and the circadian cycles of activity and inactivity are, at least in higher animals, in fact cycles of wakefulness and sleep. Further, as we noted in Monica, the acute reaction commonly merges imperceptibly into sleep. Yet

with Monica, it was also clear that whereas the inception of spontaneous sleep was always preceded by the usual panoply of presleep behaviour, such as yawning and stretching, no such behaviour was ever seen to precede her conservation-withdrawal sleep. This observation alone suggests that while conservation-withdrawal may be conducive to sleep, and may even share some of the neural systems mediating sleep, it would be premature simply to equate the two.

But even this is an oversimplification, for two different sleep states have now been identified, *no rapid eye movement (NREM) or synchronized sleep* and *rapid eye movement (REM) or desynchronized sleep*. Some have suggested that conservation-withdrawal is more related to NREM than REM sleep (Emde *et al.* 1971). In the adult NREM sleep appears to be responsive to the fatigue of the day-long vigil and activity, for it is concentrated in the first half of the night and increases after exercise and after sleep deprivation, particularly after deprivation of deep (NREM) sleep (Hobson 1968; Backland & Hartman 1970; Agnew *et al.* 1964; Webb & Agnew 1965). Also excessive sensory stimulation may even induce or increase NREM sleep in adults and in infants. Oswald experimentally induced NREM sleep among adult volunteers subjected to synchronized, rhythmic electric shocks, loud rhythmic music or strong flashing lights, even with the eyes glued open, while Emde demonstrated increased NREM sleep in neonates after the trauma of circumcision without anaesthesia (Oswald 1960; Emde *et al.* 1971).

It has also been suggested that homeostatic functions are served by an interplay between NREM and REM sleep, each fulfilling different restorative functions (Roffwarg *et al.* 1966; Dement 1969; Ephron & Carrington 1970; Snyder 1966; Zanchetti 1967; Mink *et al.* 1967; Freemon & Walter 1970; Hobson 1969*a,b*; Johnson & Sawyer 1971). In this view NREM sleep provides needed rest for bodily repair and growth and for those neural structures involved in slow or plastic activities, such as learning and memory, while REM sleep exerts a periodic restorative effect on cortical tonus in preparation for activation of the organism. Viewed from such a perspective the question of whether conservation-withdrawal is related more to NREM or REM sleep loses its cogency. Instead the NREM-REM cycles may be seen as constituting phylogenetically recent acquisitions linked together to serve the more complex homeostatic needs of the mammalian brain for both metabolic and tonic restoration alternately, while the resources of the body as a whole are being restored and husbanded. In this perspective conservation-withdrawal is seen as phylogenetically the older mechanism and as such initiates the processes required for reduction of overall energy expenditure and responsiveness to stimulation, including the NREM and REM sleep cycles in the higher animals with more complex nervous systems.

THE NEURAL ORGANIZATION SERVING CONSERVATION-WITHDRAWAL

The phylogenetic perspective which considers encystment, 'suspended animation' and various dormancy patterns of unicellular and lower organisms as primitive prototypes of conservation-withdrawal implies that these functions are taken over by and specialized within the nervous systems of the more complex organisms. These would include mechanisms for motor de-efferentation to reduce motor outflow and activity; for sensory de-afferentation to raise the threshold for ongoing input through sense receptors while maintaining receptivity to change in input; and for internal regulation in the face of reduction or interruption of sources of nutritional and sensory input for longer or shorter periods of time. Hess and Gellhorn developed the concept of the ergotropic and the trophotropic systems as reciprocal systems integrating dynamogenic and hypodynamic functions respectively (Hess 1957; Gellhorn 1967, 1970). Ergotropic effects are associated with arousal, wakefulness, increased muscle tone and activity, and environment-directed activity in general, while trophotropic effects are associated with the opposite. Indeed, Hess spoke of the trophotropic system as constituting a mechanism for 'protection against overstress'. Further, the nervous system provided the means whereby the organism can be forewarned of circumstances signifying danger of exhaustion. In this view conservation-withdrawal may be seen as involving an innate, or preformed, reaction pattern, the conditions for the activation of which may be subject to learning.

BEHAVIOURAL EXPRESSION AND EXPERIENCE OF CONSERVATION-WITHDRAWAL IN MAN

To summarize the thesis so far, we propose that conservation-withdrawal constitutes a phylogenetically ancient regulatory mechanism for maintaining homeostasis of the organism. How does conservation-withdrawal manifest itself as behaviour and experience in man? We suggest that behavioural expressions of varying degrees of conservation-withdrawal are commonplace and are responsible for familiar gestures, postures and facial expressions that may occur fleetingly in everyday life as well as in more sustained fashion in the course of mood changes and during illness, somatic as well as emotional. The underlying impetus for their elicitation is 'giving up', a conscious or unconscious psychic appraisal, if only fleetingly, of no solution, no response available.

The most evident outward manifestation of conservation-withdrawal in everyday life reflects a sudden or a sustained decrease in muscle tone, especially



FIG. 3. A woman coming for the first time upon the earthquake destruction that had literally *eliminated all the familiar landmarks of her neighbourhood*. Note how the jaw hangs slightly open, the hand supports the face, the shoulders are rounded and the hips and knees are flexed, all conveying the impression that she might slump to the ground were she to let herself go.

of anti-gravity muscles. The sagging face and slack jaw, often supported by the hand, the turned-down corners of the mouth, the rounding of the shoulders, the slumping forward, and the flexing of the knees are all typical motor responses of a person confronted with something for which at that moment he feels himself to have available no response or course of action, as may occur with an irretrievable loss, unacceptable news, an impossible dilemma, a profound disappointment; or in more general terms either a too intense input which



FIG. 4. The same earthquake scene. Note the common features of the stunned people, the jaw slack (or lips reactively pinched together), the hand to the face, supporting the chin. Some are holding on to or supporting each other; some hold themselves.

cannot be assimilated or a deficient input which indicates unavailability of supplies. Such a response can be fleeting or sustained, partial or massive. In its extreme form the person may literally sink to the ground in a heap while in its lesser expression the person may seek physical support, by leaning on or holding on to someone or to himself (Figs. 3 and 4).

Subjectively the typical bodily sensations accompanying such a reaction are weakness, fatigue and loss of energy. Everyday idiom vividly portrays this. 'The strength (energy) just drained out of me'. 'I didn't have an ounce of strength'. 'His jaw fell' (surprise). 'He sat slumped and dejected' (disappointment). 'It hit me like a ton of bricks'. 'I felt crushed'. Downcast, hangdog, down-in-the-mouth, dejected (literally, 'thrown down') and depressed (literally, 'pressed down') all convey the difficulty felt in maintaining the upright position and the accompanying awareness of the underlying motor inhibition.

From such examples of everyday occurrences can be generated a whole series of more pronounced or more prolonged behaviours of similar origin. These may reflect a continuation or a repetition of the central appraisal indicating

'no supplies or no solution available' or 'no action possible', an appraisal which may or may not in fact be in accord with reality. The net effect, however, may be manifest and felt as intermittent or sustained disinclination toward and reduction in muscular activity or exertion, diminished muscle tonus, slowing of movements, feelings of weakness and fatigue, constriction of attention to and interest in the environment and decline in active interpersonal relating behaviour. Ultimately sleepiness and increased sleeping or apathy and detachment may ensue. Such behaviours typically wax and wane, reflecting the waxing and waning of the conservation-withdrawal response with the periodic judgments of 'no solution' alternating either with renewed attempts to cope actively or with changes in environmental circumstances. The extreme of the unremitting pattern occurs under conditions of the most profound deprivation and constraint, as may occur among inmates in concentration, or prisoner of war camps (Strassman *et al.* 1956). Equally profound but more transient reactions may be observed in response to disasters (Baker & Chapman 1962).

But conservation-withdrawal may also be activated in response to bodily processes, that is, to endogenous rhythms or enteroceptive inputs indicating the need for somatic conservation. We have already referred to the cycles of tiredness and sleepiness that recur regularly in a circadian rhythm, the built-in mechanism to assure renewal long before significant depletion of energy sources has occurred. Less appreciated, however, is the extent and frequency with which conservation-withdrawal may be activated by bodily processes associated with physical disease. Indeed, we suggest that the common so-called constitutional symptoms that regularly usher in or accompany many physical illnesses—that is, weakness, tiredness and fatigue, the urge to sit down, lie down or rest—are in fact of neurogenic origin. They are an expression of conservation-withdrawal invoked to protect the body and its components from uneconomical expenditure of resources in the face of real or threatened impairment of supplies consequent to the pathological processes, whatever they may be. Starvation is of course the prototypical situation calling for husbanding of energy; the appearance of the child victim of famine in Fig. 5 is remarkably similar to what we observed in Monica and other children and Kaufman and Rosenblum reported in the pigtail monkey (see Fig. 2).

As a central regulatory system responsive to both exteroceptive and enteroceptive inputs we also postulate signal or warning functions that forewarn the individual of a possible need to withdraw and conserve energy or that avert such a need by mobilizing available or present resources, coping devices, or defences. Many clinical data support such a formulation. One of the best documented is the longterm (now 20 year) follow-up of Monica, who in an impressively consistent fashion still displays a low threshold of response to

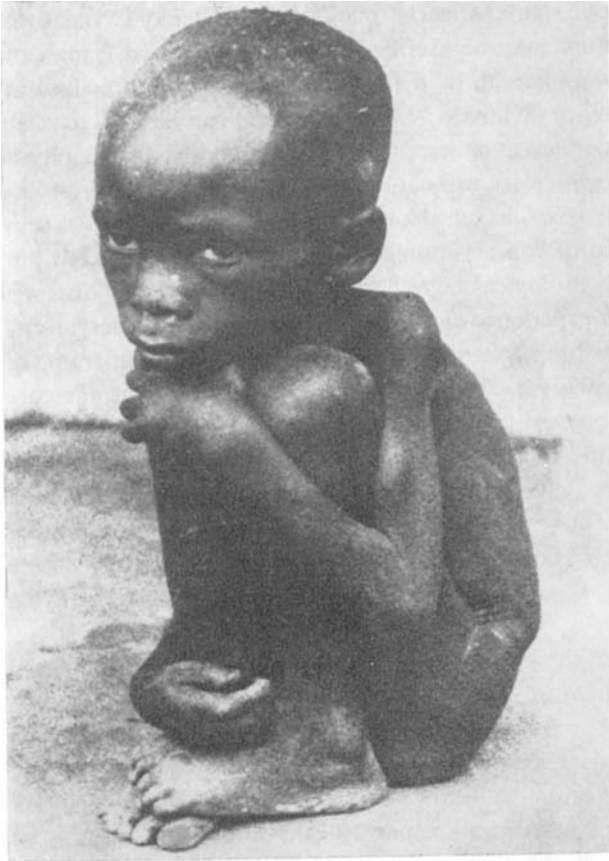


FIG. 5. A child victim of starvation.

situations reminiscent of those originally evocative of the conservation-withdrawal reaction. But now this response is minimized or averted by her ability quickly to mobilize behaviours that serve both to elicit help from the environment and to assure her that help is indeed always at hand. To a large extent many of these behaviours by now reflect character traits (Engel 1967, 1969).

CONSERVATION-WITHDRAWAL, GIVING UP AND DEPRESSION

Loose usage of the word 'depression' has contributed considerable confusion

to which we have added our share. Clearly much of the difficulty in our own writings and in the literature may be ascribed to having confused frames of reference. Conservation-withdrawal, by definition, must be conceptualized in a biological frame of reference (Schmale 1972*a*). The term can be used to refer to the threshold mechanism *per se* or it can refer to the bodily, that is physiological and biochemical, processes associated with it, including manifest appearance and behaviour. We have already discussed the circumstances conducive to the induction of conservation-withdrawal and have pointed out that these may include psychological as well as physical events. But once we begin to consider the inner experience of the person in whom the conservation-withdrawal mechanism has been activated we are introducing another frame of reference, the psychological. We can deduce, but cannot document, the core subjective experience of conservation-withdrawal to include feelings of decreased strength, energy and interest in the outside world, that is, essentially, awareness of these body changes. When the conservation-withdrawal response has been triggered enterceptively, as in the course of a physical illness or some pathophysiological process, some individuals may experience only these symptoms as the typical so-called constitutional symptoms accompanying illness.

On the other hand when the conservation-withdrawal response is triggered by a psychological or social event, including awareness of somatic disease, then the pathway involves first a psychological appraisal of 'giving up', with its concomitant affects of helplessness or hopelessness, which may then be followed or accompanied by conservation-withdrawal as the somatic response (Schmale 1972*a*). 'Giving up', a psychological response, may contribute feelings of 'depression' in the sense of 'blue', 'down in the dumps', 'discouraged', in addition to the conservation-withdrawal manifestations of fatigue, weakness, lack of energy and interest. Thus we differentiate between the subjective and manifest aspects of conservation-withdrawal on the one hand and the psychologically more elaborated expressions of 'giving up' on the other.

But we would also differentiate these non-specific 'depressive' manifestations of 'giving up' from the clinical syndromes of depression. These we consider to be psychologically more complex disorders of adaptation, some of which may involve distinctive neurobiological abnormalities as well (Schmale 1972*a,b*). Both conservation-withdrawal and 'giving up' manifestations may appear when the clinical syndromes of depression become ineffective as patterns of psychological adaptation, which may account for some of the confusion in differentiating these various depressive patterns. How and whether the neurochemical processes alleged to be involved in the syndromes of depression, particularly bipolar depression, are related to the conservation-withdrawal

system remains to be seen, especially if individual vulnerability to depression proves to have a biochemical determinant. But until more is known in those areas it would seem prudent to consider that the so-called animal models of depression evoked by various types of social isolation are in fact models of conservation-withdrawal and thus are not strictly comparable to human depression (Senay 1966; McKinney *et al.* 1971).

ACKNOWLEDGEMENTS

This study was supported by U.S. Public Health Service Grants, MH 14151, MH 11668, MH 07228 and MH 7521. Dr Engel is a Career Research Awardee of the Public Health Service.

References

- AGNEW, H. W., WILSE, M. A., WEBB, B. *et al.* (1964) The effects of stage four sleep deprivation. *Electroencephalogr. Clin. Neurophysiol.* **17**, 68-70
- ALLEE, W. C., EMERSON, A. E., PARK, O., PARK, T. & SCHMIDT, K. P. (1949) *Principles of Animal Ecology*, Saunders, Philadelphia and London
- BACKLAND, F. & HARTMAN, E. (1970) Sleep requirements and the characteristics of some sleepers. In *Sleep and Dreaming* (Hartman, E., ed.), pp. 33-43, Little, Brown, Boston
- BAKER, G. W. & CHAPMAN, D. W. (eds.) (1962) *Man and Society in Disaster*, Basic Books, New York
- BARNETT, S. A. (1963) *The Rat: A Study in Behavior*, Aldine, Chicago
- BINDRA, D. & ANCHEL, H. (1963) Immobility as an avoidance response, and its disruption by drugs. *J. Exp. Anal. Behav.* **6** (2), 213-218
- BURTON, I. & DERBYSHIRE, A. J. (1958) 'Sleeping fit' caused by excruciating pain in an infant. *A.M.A. J. Dis. Child.* **95**, 258-260
- COOK, S. W. (1939) The production of 'experimental neurosis' in the white rat. *Psychosom. Med.* **1** (2), 293-308
- DARWIN, C. (1872) *The Expression of the Emotions in Man and Animals*, Appleton, New York
- DARWIN, C. (1900) A posthumous essay on instinct. In *Mental Evolution in Mammals* (Romanes, G. J., ed.), pp. 360-364, Appleton, New York
- DEMENT, W. C. (1969) The biological role of REM sleep. In *Sleep: Physiology and Pathology* (Kales, A., ed.), pp. 245-265, Little, Brown, Boston
- EMDE, R. N., HARMON, R. J., METCALF, D. *et al.* (1971) Stress and neonatal sleep. *Psychosom. Med.* **33** (6), 491-497
- ENGEL, G. L. (1962) *Psychological Development in Health and Disease*, Saunders, Philadelphia
- ENGEL, G. L. (1965) Clinical observation. The neglected basic method of medicine. *J. Am. Med. Assoc.* **192**, 849-852
- ENGEL, G. L. (1967) Ego development following severe trauma in infancy: A 14 year study of a girl with gastric fistula and depression in infancy. *Bull. Assoc. Psychoanal. Med.* **6**, 57-61
- ENGEL, G. L. (1968) A life setting conducive to illness. The giving up-given up complex. *Ann. Intern. Med.* **69**, 293-300

- ENGEL, G. L. (1969) Ego development following severe trauma in infancy. *Bull. Phila. Assoc. Psychoanal.* **19**, 234-236
- ENGEL, G. L. (1970) Nervousness and fatigue. In *Signs and Symptoms* (MacBryde, C. M. & Blacklow, R. S., eds.), pp. 632-649, Lippincott, Philadelphia
- ENGEL, G. L. & REICHSMAN, F. (1956) Spontaneous and experimentally induced depressions in an infant with a gastric fistula. *J. Am. Psychoanal. Assoc.* **4**, 428-452
- ENGEL, G. L., REICHSMAN, F. & SEGAL, H. L. (1956) A study of an infant with a gastric fistula. I. Behavior and the rate of total hydrochloric acid secretion. *Psychosom. Med.* **18**, 374-398
- EPHRON, H. S. & CARRINGTON, P. (1970) On the functions of the sleep phases. In *Sleep and Dreaming* (Hartman, E., ed.), pp. 269-276, Little, Brown, Boston
- EWING, L. S. (1967) Fighting and death from stress in a cockroach. *Science (Wash. D.C.)* **155**, 1035-1036
- FIENNES, T. W. (1968) Ecological concepts of stress in relation to medical conditions in captive wild animals. *Proc. R. Soc. Med.* **61**, 161-162
- FOLEY, J. P. (1938) Tonic immobility in the rhesus monkey (*Macaca mulatta*) induced by manipulation, immobilization, and experimental inversion of the visual field. *J. Comp. Physiol. Psychol.* **26**, 515-526
- FREEMON, F. R. & WALTER, R. D. (1970) Electrical activity of human limbic system during sleep. *Compr. Psychiatr.* **11** (6), 544-551
- FRIES, M. E. & WOOLF, P. J. (1953) Some hypotheses on the role of the congenital activity type in personality development. *Psychoanal. Study Child* **8**, 48-62
- GALLUP, G. G., NASH, R. F. & ELLISON, A. L. (1971) Tonic immobility as a reaction to predation: Artificial eyes as a fear stimulus for chickens. *Psychon. Sci.* **23** (1B), 79-80
- GANNT, W. H. (1953) Principles of nervous breakdown—schizokinesis and autokinesis. *Ann. N.Y. Acad. Sci.* **56**, 143-164
- GELLHORN, E. (1967) *Principles of Autonomic-Somatic Integrations*, University of Minnesota Press, Minneapolis
- GELLHORN, E. (1970) The emotions and the ergotropic and trophotropic systems. *Psychol. Forsch.* **34**, 48-94
- GRANT, E. C. & MACKINTOSH, J. H. (1963) A comparison of the social postures of some common laboratory rodents. *Behaviour* **21**, 256-259
- HARLOW, H. F., HARLOW, M. K. & SUOMI, S. J. (1971) From thought to therapy. Lessons from a primate laboratory. *Am. Sci.* **59** (5), 538-549
- HEDIGER, H. (1955) *Studies of the Psychology and Behavior of Captive Animals in Zoos and Circuses*, Criterion Books, New York
- HESS, W. R. (1957) *The Functional Organization of the Diencephalon*, Grune & Stratton, New York
- HINDE, R. A. (1970) *Animal Behavior*, 2nd edn, McGraw-Hill, New York
- HINDE, R. A. & SPENCER-BOOTH, Y. (1971) Effects of brief separation from mother on rhesus monkeys. *Science (Wash. D.C.)* **173**, 111-118
- HOAGLAND, H. (1928) The mechanism of tonic immobility ('animal hypnosis'). *J. Gen. Psychol.* **1**, 426-447
- HOBSON, J. A. (1968) Sleep after exercise. *Science (Wash. D.C.)* **162**, 1503-1505
- HOBSON, J. A. (1969a) Sleep: physiologic aspects. *N. Engl. J. Med.* **281**, 1343-1345
- HOBSON, J. A. (1969b) Sleep: biochemical aspects. *N. Engl. J. Med.* **281**, 1468-1470
- JENNINGS, H. S. (1906) *Behavior of the Lower Organisms*, Macmillan, New York
- JOHNSON, J. H. & SAWYER, C. H. (1971) Adrenal steroids and the maintenance of a circadian distribution of paradoxical sleep in rats. *Endocrinology* **89** (2), 507-512
- KAUFMAN, I. C. & ROSENBLUM, L. A. (1967) The reaction to separation in infant monkeys: anacletic depression and conservation-withdrawal. *Psychosom. Med.* **29**, 648-675
- LIDDELL, H. S. (1956) *Emotional Hazards in Animals and Man*, Thomas, Springfield, Ill.
- LORENZ, K. (1952) *King Solomon's Ring*, Thomas Cromwell, New York

- MASSERMAN, J. H. & PECHTEL, C. (1953) Neurosis in monkeys: A preliminary report of experimental observations. *Ann. N.Y. Acad. Sci.* **56**, 253-265
- McKINNEY, W. T., SUOMI, S. J. & HARLOW, H. F. (1971) Depression in primates. *Am. J. Psychiatr.* **127** (10), 49-56
- MINK, W. D., BEST, P. J. & OLDS, J. (1967) Neurons in paradoxical sleep and motivated behavior. *Science (Wash. D.C.)* **158**, 1335-1337
- OSWALD, I. (1960) Falling asleep open-eyed during intense rhythmic stimulation. *Br. Med. J.* **1**, 1450-1455
- OVERMIER, J. B. & SELIGMAN, M. E. P. (1967) Effects of inescapable shock upon subsequent escape and avoidance responding. *J. Comp. Physiol. Psychol.* **63** (1), 28-33
- PAVLOV, I. P. (1927) *Conditioned Reflexes* (Anrep, G.V., trans.), Oxford University Press, London
- PEIPER, A. (1963) *Cerebral Function in Infancy and Childhood*, Consultants Bureau, New York
- PROVENCE, S. & LIPTON, R. C. (1962) *Infants in Institutions*, International Universities Press New York
- RATNER, S. C. (1967) Comparative aspects of hypnosis. In *Handbook of Clinical and Experimental Hypnosis* (Gordon, J. E., ed.), pp. 550-587, Macmillan, New York
- RATNER, S. C. & THOMPSON, R. W. (1960) Immobility reactions (fear) of domestic fowl as a function of age and prior experience. *Anim. Behav.* **8**, 186-191
- REESE, E. S. (1962) Submissive posture as an adaptation to aggressive behavior in hermit crabs. *A. Tierpsychol.* **19**, 645-651
- RIBBLE, M. A. (1943) *The Rights of Infants*, Columbia University Press, New York
- ROFFWARG, H. P., MUZIO, J. N. & DEMENT, W. C. (1966) Ontogenetic development of the human sleep-dream cycle. *Science (Wash. D.C.)* **152**, 604-619
- SCHMALE, A. H. (1964) A genetic view of affects with special reference to the genesis of helplessness and hopelessness. *Psychoanal. Study Child* **19**, 287-310
- SCHMALE, A. H. (1972a) The adaptive role of depression in health and disease. *Am. Assoc. Adv. Sci. Publ.* (Senay, E., ed.), in press
- SCHMALE, A. H. (1972b) Depression as affect, character style and symptom formation. In *Psychoanalysis and Contemporary Science*, vol. 1 (Holt, R., ed.), Macmillan, New York
- SCHMALE, A. H. & ENGEL, G. L. (1967) The giving up-given up complex illustrated on film. *Arch. Gen. Psychiatr.* **17**, 135-145
- SELIGMAN, M. E. P. (1968) Chronic fear produced by unpredictable electric shock. *J. Comp. Physiol. Psychol.* **66** (2), 402-411
- SELIGMAN, M. E. P. & MAIER, S. F. (1967) Failure to escape traumatic shock. *J. Exp. Psychol.* **74** (1), 1-9
- SELIGMAN, M. E. P. & MAIER, S. F. (1968) Alleviation of learned helplessness in the dog. *J. Abnorm. Psychol.* **73** (3), 256-262
- SENAY, E. C. (1966) Toward an animal model of depression: a study of separation behavior in dogs. *J. Psychiatr. Res.* **4**, 65-71
- SNYDER, F. (1966) Toward an evolutionary theory of dreaming. *Am. J. Psychiatr.* **123** (2), 121-142
- SPIITZ, R. (1945) Hospitalism. An inquiry into psychiatric conditions in early childhood. *Psychoanal. Study Child* **1**, 53-80
- STRASSMAN, H. D., THALER, M. B. & SCHEIN, E. H. (1956) *Am. J. Psychiatr.* **112**, 998-1003
- SULLIVAN, H. S. (1953) *The Interpersonal Theory of Psychiatry*, Norton, New York
- WEBB, W. B. & AGNEW, H. W. (1965) Sleep: Effects of a restricted sleep regime. *Science (Wash. D.C.)* **150**, 1745-1746
- WENDT, G. R. (1936) An interpretation of inhibition of conditioned reflexes as competition between reaction systems. *Psychol. Rev.* **43**, 258-281
- YERKES, R. M. & YERKES, A. W. (1929) *The Great Apes: a study of anthropoid life*, Yale University Press, New Haven
- ZANCHETTI, A. (1967) Brain stem mechanisms of sleep. *Anesthesiology* **28** (1), 81-99

Discussion

Levine: I understand the withdrawal part of the hypothesis but I don't understand the conservation part, because I don't know what is being conserved.

Engel: Conservation of energy can be achieved simply by reducing energy expenditure—that is, ceasing to be active when it serves no purpose. For example, Monica conserved energy when she stopped crying and fussing and remained quiet. The curled-up position sometimes assumed, both by animals and by people, suggests that it may also serve to conserve heat. In more long-term responses we might also expect to find evidence of metabolic rearrangements to allow the organism to use its own energy stores instead of requiring food from outside, especially when the reaction must be prolonged. The total cessation of gastric secretion, as observed in Monica, might reflect such a turning-off of the alimentary system, both to conserve energy and because ingestion is not going to be used for nutrition. Survival during encystment must call for profound reduction in energy utilization. Adolph (1971) has shown that newborn rats survive total oxygen lack by shifting to an anaerobic glycolytic mechanism to provide energy, including that needed for breathing. Regular breathing ceases but is replaced by periodic gasping at prolonged intervals, an effective device to save the energy that would have been expended fruitlessly by breathing in an anoxic environment while at the same time making it possible, by the gasp, to test whether oxygen has been restored to the atmosphere. Pretreatment with hypoxia greatly increases this anaerobic adaptation. To me, this demonstrates another aspect of the general capability of the organism to maintain homeostasis in the face of unavailability of supplies.

Levine: Monica is not a good example of conservation-withdrawal, because she has been *conditioned* not to cry; but you are postulating a phylogenetic mechanism which occurs in all animals and is innate and biological. There is an inconsistency here. If you place a rat in an open field and the rat freezes, do you consider this to be conservation-withdrawal? Its muscle tone does not suggest that it is relaxed; it may be extremely tense.

Engel: You are ignoring the other details of Monica's behaviour in dismissing it as due simply to her having been conditioned not to cry. That was only the first step, to learn that crying no longer brought a response from her mother, but it began when she was six months old and utterly helpless to tend to her own needs. What options did she have when she became hungry? She could have cried indefinitely, up to the point of literal exhaustion. But she did

not. That is the whole point of the concept of conservation-withdrawal, that a regulatory mechanism exists to take care of such an eventuality. She not only stopped crying, she became inactive and fell back to sleep even though not fed. Where does conditioning come in? I would regard conservation-withdrawal as an unconditioned response to certain environmental situations significant of either excessive or deficient input with which the organism, for whatever reason, cannot cope. In Monica the circumstances in which the reaction could be provoked became generalized to many conditions (e.g. the stranger) which in most infants do not elicit such a response, mainly because they have successfully used other responses. For Monica, exposure to a stranger represented but another input for which she had learned no more satisfactory response, and she had to fall back on the global emergency conservation-withdrawal response.

The rat freezing in an open field is not showing conservation-withdrawal. When we first observed the withdrawal reaction in Monica we wondered whether she was frozen with fear. Our main evidence against that was that muscle tone was markedly reduced, while heart rate and respiration were unchanged or slowed. Nor do I see conservation-withdrawal as the same as the 'stop' reaction described by Dr Gray (see pp. 95-116). On the other hand, the 'stop' reaction might be an initiating point, neurophysiologically speaking, for the conservation-withdrawal response. The animal can move in either direction: it may again become active in the sense of approach or flight-fight, or it may become inactive in the sense of conservation-withdrawal.

Levine: L. Rosenblum (personal communication) has shown that the isolated infant pigtail monkey, like the rhesus monkey, shows this withdrawal response but the bonnet monkey or squirrel monkey does not. How would your theory account for those so-called biological differences?

Engel: I see no contradiction here. As Kaufman and Rosenblum have pointed out, when the bonnet mother is removed from the group other adults provide mothering, which is not the case with the pigtail. Hence for the bonnet infant, removing the mother is not a sufficient or appropriate input for the conservation-withdrawal response. I assume there are species and genetic differences among animals in their propensity to develop this reaction, just as there are species and genetic differences in the tendency to show, say, flight or fight responses. Conservation-withdrawal is, so to speak, a second line of defence and therefore I would not expect it to be exhibited except under extreme or specialized conditions, unless generalized by learning as in Monica's case.

Storey: I have seen illustrations of immobile chickens and lizards; they were exposing their bellies and certainly not conserving energy. Nor was Monica conserving heat; her position was the opposite of curling up. And a

chicken, paralysed by a hawk, appears from its very abnormal position to have high muscle tone.

Hinde: I don't doubt that conservation-withdrawal has a certain unity as a syndrome, and it must have some biological basis; but it seems unbiological to draw a similar symptom from animals as diverse as the amoeba and the human child and say that it is in some sense the same. You have classed together 'dormancy', in which there is a total shutting off of responsiveness to all stimuli, immobility in fear, in which the animal is highly responsive but immobile, and tonic immobility and sham death, where responsiveness is highly specific. These are diverse phenomena that happen to have the common symptom of immobility and to put them in the same basket is misleading. The evidence that conservation-withdrawal has a biological basis could be of a different type. It is conceivable that sound evidence could be found, and I am not quarrelling with your conclusion, but to use such heterogeneous examples as evidence weakens your case.

Gray: There might be a mechanism common to most mammalian species, say.

Denenberg: What evidence is there even for that? We are already speculating about a common mechanism but no one has described any mechanism at all. No one has mentioned a learning mechanism, which is a possibility. Dr Engel has taken a rather superficial behavioural observation—lack of movement—and used that to draw a very broad conclusion. I see no logical basis for this.

Weiss: I agree that with a symptom as general as immobility one can't really frame a hypothesis clearly until one can suggest a specific mechanism or some more specific definition of the concept. The basic symptom of immobility does not carry enough descriptive impact to carve out a distinct and testable hypothesis. In this particular case, it seems that one must specify some correlate, possibly below the level of skeletal-motor behaviour, before one can see how, for instance, the immobile reaction of a white rat when it's afraid is different from an animal which is playing dead, which again differs from an isolated pigtail monkey which looks depressed.

Engel: Immobility is a consistent feature of the behaviour of conservation-withdrawal but it is by no means the only feature. Nor am I suggesting that all varieties of immobility are the same and that they all represent conservation-withdrawal. But one should not expect the behavioural expression of conservation-withdrawal to be identical in all species, any more than one expects flight-fight patterns to be the same in different species. Species-specific differentiations of flight patterns are noted in animals according to whether they fly, run, dive or swim. What is common to all my examples is that the immobility and inactivity occur in response to major changes or threats of changes in environmental conditions and that the reaction can be seen as serving survival

for the species. That the chicken or lizard appears rigid rather than limp is not to me sufficient grounds not to consider this pattern of behaviour to be a species-specific derivative of the basic conservation-withdrawal reaction.

Nor do I follow the argument that one cannot have an hypothesis without being first able to define the mechanism. And why must it be a 'learning mechanism'? I suggest that you can't know what mechanism to look at (or for) until you have a hypothesis. The hypothesis here is that conservation-withdrawal is a primary regulatory mechanism that is activated in certain circumstances. (From this one can begin to design studies of where learning and conditioning come into play.) When the organism has no active solution, it may go through a series of steps: one may be the 'stop' reaction; one may be watching and waiting, so to speak, to see what is going to happen; and the final one, if no active coping solution is possible, is conservation-withdrawal.

In looking back over phylogeny I was trying to tie in the global concept that virtually all animals go through cycles of activity and inactivity. These can be related respectively to periods in which the animal is actively engaging in and with the environment to extract something from it, and periods when the animal is less actively engaged with or even disengaged from the environment and its functioning more reflects internal processes. I am suggesting from this that in higher organisms an organization in the nervous system may have evolved to monitor these cycles of activity and inactivity and that this same CNS organization is also used in stress situations, the inactivity, disengagement and conservation of energy now being in the service of survival. The child that I discussed shows an example of a learning situation; she became conditioned to respond in this fashion to a variety of situations. Conditioning experiments in which the animal freezes may be a borderline area. Masserman & Pechtel (1953) described their monkeys in a situation of impossible conflict as ending up completely immobile and limp. I am suggesting that this is a basic response (conservation-withdrawal) which is different from both avoidance and fight and flight responses, and I carried this further to say that this has expression in man.

I think some of you are missing the point in that you are discussing conservation-withdrawal as though it were meant to refer only to a behaviour, whereas we are proposing it as a basic biological threshold mechanism meant to serve survival of the organism by disengagement and inactivity *vis à vis* the external environment. As such, manifest behaviour is but one expression, and one would expect species-typical variations and differentiations of such behaviour.

Henry: In a colony of mice that are free to interact, so that the behaviour is relatively normal but the mice cannot escape from a complex system, the sub-

ordinate mouse shows submissive behaviour. If a mouse or rat or tree shrew is introduced as an intruder into the situation, as Barnett (1963) and more recently von Holst (1972) have shown, the immobility becomes still more marked. There is no question from our experiments that the subordinate mouse shows much less activity than the dominant mouse. He remains isolated in one place and does not move around. One could say that he is conserving energy in the sense of biding his time, should an opportunity to escape arise.

Hinde: I concede that there may be an adaptive advantage in immobility in the presence of a stranger, because we know that movement in the presence of a predator or rival elicits attack. So I accept that the immobile child is showing an adaptive response. For the 'depressed' monkey, there may be some adaptive advantage in immobility. Superimposed on that are the thumb-sucking, self-hugging and hunched posture, which are possibly interpretable in terms of comfort through contact. The movements of the people in the earthquake that Dr Engel illustrated again show some elements of a submissive gesture and it may be that there are *ontogenetic* relationships between such a gesture and the depressed postures in childhood. But that is a different sort of relationship from a phylogenetic one.

Levine: There is a basic problem about the meaning to be attached to a given response. If a rat is placed in an open field and is left there for an hour instead of the usual three minutes, it will first show severe immobility—that is, 'freezing'. It next shows a lot of exploratory behaviour. Eventually it stops exploring and simply lies quiet and immobile. Or consider a male rat which is permitted to show free copulatory behaviour; in between copulations, it will be immobile. Do we interpret immobility in the same way in each situation?

Engel: No. In conservation-withdrawal, immobility is combined with reduced muscle tone (at least in man), relative unresponsiveness and reduced, or restricted or specific, attention to the environment. In such circumstances it is logical to expect that components of submissive and self-comforting postures would derive from the same phylogenetic-ontogenetic roots as conservation-withdrawal. Hence I find Professor Hinde's comment to be in concord, not in opposition.

Levine: The criteria you mention exactly describe the post-copulatory rat, yet if you introduce a fresh female the rat will copulate immediately, so the immobility can't be explained as having the function of 'conserving sexual energy'.

Engel: Monica also responded immediately when a familiar person came in. Expenditure of energy and attention to the environment were in abeyance but she was quite capable of instantly mobilizing activity once the disturbing environmental situation passed. In fact, that capacity to switch from one

pattern to another is precisely what led us to invoke the concept of a CNS mechanism which can be turned on or off as the occasion demands.

Zanchetti: I agree with Professor Engel that the conservation-withdrawal reaction shows more differences from than similarities to the 'stop' or passive avoidance behaviour that Dr Gray describes. The latter type of behaviour is exemplified by the reaction of an animal to an unconditioned aversive stimulus: the animal stops moving, but there is tension. The animal is ready to respond to the aversive conditioned stimulus which may follow. There are signs of sympathetic discharge. The withdrawal that Professor Engel described is more like the 'playing dead' behaviour of some mammals, such as the opossum and hedgehog, in dangerous situations. Indirect evidence from physiological experiments on cats by Folkow's group suggests that 'playing dead' behaviour may be connected with neural systems starting in the cingulate gyrus and relaying in the anterior hypothalamus. If those two regions are stimulated in the cat diffuse sympathetic inhibition occurs, affecting the heart rate and all vascular beds (Folkow *et al.* 1959; Löfving 1961). This system relays with the paramedial nucleus in the medulla, where afferent axons from the baroreceptors also enter the brain, so one system is potentiating the other (Löfving 1961; Hilton & Spyer 1968; R. Albertini & A. Zanchetti, unpublished findings). Unfortunately the opossum does not easily display the 'playing dead' reaction in the laboratory (B. Folkow, personal communication) so we can't yet study its cardiovascular manifestations directly.

Hofer: This discussion reflects the difference between the 'lumpers' and the 'splitters', and we all have our own bias! What worries me about Dr Engel's 'lumping' approach is the inclusion of reactions like sham death and tonic immobility of certain animals in the same conceptual category as the behaviour of Monica and of Dr Kaufman's monkeys. In tonic immobility in wild ground squirrels or chipmunks, although the heart rate is low, which might be said to be evidence of 'conservation', the respiratory rate is very high (Hofer 1970). These states, and more particularly sham death, are often terminated by sudden explosion into the most vigorous activity that I have seen in rodents. Often this occurs without stimulation from the environment: the latency of onset of the explosion into activity is random. One might even turn the concept round and see tonic immobility as a preparation for extraordinary activity rather than as the conservation of energy. I would guess that metabolic measures in such animals would be high rather than low; the animals may be gearing up rather than gearing down.

Tonic immobility, as seen in frogs and chickens, may have a lot to do with the vestibular apparatus and brainstem mechanisms which have very little to do with the social environment. Hoagland (1928) did some experiments in

which a man was bent over very far forward and then flipped rapidly back. He adopts a position something like that of the chicken showing tonic immobility, and this probably occurs through a brainstem rather than a cortical process. Decortication in rats brings this response out; it is not seen in the intact adult rat, although it is present in young rats (McGraw & Klemm 1969). I would like to separate out these kinds of responses from Dr Engel's general concept.

Aitken: The difference between species has been emphasized. I declare myself to be a 'splitter', and it seems to me that differences in response between individuals often far exceed similarities. We know from observations of natural disasters the difficulties in finding a common theme. The diversities of emotional and behavioural responses are striking. For men under occupational stress, such as aircrew, an enormous diversity of response has been my experience (Aitken 1969, 1972). So too much should not be concluded from observations made on one child, as reported by Professor Engel.

Lader: Professor Hinde mentioned the possible adaptive value of the conservation-withdrawal reaction and Professor Engel regards it as an emergency adaptive mechanism. As an example, he showed illustrations of the behaviour and expressions of earthquake victims. But it can be argued that this ('giving up') response after an earthquake is *maladaptive*: if outside relief measures do not reach an earthquake area within a few days, more people die of exposure and untreated wounds than die in the earthquake itself.

Sandler: I see the conservation-withdrawal reaction as a psychobiological response; that is, it is basically a biological response, but it can also occur as a response to psychological input. Professor Engel's human examples are mainly responses to an *evaluation* (through perception) of a particular painful situation—a strange doctor, a catastrophe; or a disaster with a lack of familiar landmarks. We see here a basic reaction to a psychological state characterized by a painful lack of safety through lack of familiarity, or by pain from some other source. The threshold for this reaction may be altered by fatigue or by the particular phase of some biological rhythm, but it is surely primarily a response to a psychological state, assessed by the mental apparatus. There appear to be different dimensions to the conservation-withdrawal response, but what is essentially being conserved is a feeling of safety through perceptual constancy.

Professor Engel clearly differentiated conservation-withdrawal from the clinical picture of depression. We should certainly not lump together all the descriptive pictures, although they may appear the same in different situations. This would be like putting together two quite different clinical syndromes, catatonic immobility and depressive retardation. Yet we know from clinical studies of people who have recovered from catatonia that part of the function

of the response—the ‘freezing’—was to maintain a perceptual constancy; they felt that any movement would lead to feelings of unsafety. I suggest that to Professor Engel’s description of the psychological, subjective experience which goes with this picture, one should add the psychological situation to which this response *is* a response, namely the particular threat to the person’s safety feelings—his feelings of unfamiliarity— and the resulting pain, coupled with a feeling of helplessness at not knowing what to do. This gives us a bridge to the clinical situation of depression. I see the depressive response as a basic psychobiological reaction to a situation of pain of one sort or another. We see it in physical disorders, where there is pain of somatic origin; and in malnutrition, where there is a general feeling of lack of pleasure. The picture of the malnourished child is exactly like Professor Engel’s picture of Monica showing conservation-withdrawal.

Grinker: Our studies of the response of obese patients to weight reduction show that only certain patients, those with obesity of juvenile onset, show what might be called ‘conservation’ (see pp. 349-369). With weight reduction these patients show symptoms of depression, distortions in time perception indicative of a slowing of internal body rhythm, and fatigue—responses which are similar to those occurring in individuals of normal weight undergoing experimental starvation. Would that fit into your picture of conservation-withdrawal, Dr Engel? Using this analogy, we could say that these patients are defending their obese weight.

Engel: I would need more data to be sure, but certainly what you describe is consistent with conservation-withdrawal. If obesity is an equilibrium state metabolically and psychologically for the juvenile-onset obese person, enforced food restriction might initiate conservation-withdrawal as an adaptation to threat of starvation at a much lower threshold in this individual than in the non-obese person. As we pointed out (p. 70), starvation is a paradigm of a situation calling for conservation-withdrawal.

Sachar: I should like to take up the ‘withdrawal’ part of the syndrome and point out the complicated system that has been observed in man, from newborns to adults, for tuning in and tuning out stimuli, almost rhythmically. Anecdotally, we all find ourselves at times feeling that we have reached a ‘saturation point, wanting to withdraw, to shut out, to cease to attend; needing to be off by ourselves. Daniel Stern (unpublished observations 1972) has studied the way the newborn child distributes his attention, from long gazes to short gazes, looking toward, looking away, and carefully and exquisitely regulating the amount of stimulation that he takes in through the visual system. If you are calling attention to a natural rhythm of life and saying that in certain situations this may be used massively and may involve other physiological mechanisms

as well, one might pay attention to that dimension of human behaviour without necessarily having to look for analogies in animal behaviour.

Hill: Pavlov observed that when a dog was exposed to a repeated stimulus that had no consequences, either adverse or pleasant, it went to sleep.

Gray: The kind of conservation-withdrawal concept that Professor Engel is talking about would surely not include sleep as a result of long exposure to indifferent stimuli. If there is an analogy in Pavlov's experiments, it is with the dogs he described which are lively *until* they are put in the experimental stand and then fall asleep. Pavlov noted that this was dependent on the individual character of the dog and happened only to certain dogs (Teplov 1964).

Wolff: I find it difficult to see why Monica should drop off to sleep in the presence of a stranger of whom she is said to be frightened.

Engel: In these particular circumstances Monica drifted gradually into sleep, or at least a sleep-like state, after a fairly prolonged period of immobility; this was quite different from her usual falling asleep sequence. I suspect that the mechanism of conservation-withdrawal has a lot to do with sleep. After all, sleep is a very good example of a biological situation in which there is both conservation, in the sense of not expending energy, and withdrawal. I think that sleep may be the prototype of conservation-withdrawal and that it may be one place to start to look for mechanisms.

Hill: It may be relevant that the clinical syndrome of sleep paralysis is associated with immobility, relaxed muscle tone and reduced response to the environment. Cataplexy is another clinical syndrome that is closely associated with the sleep mechanism.

Sachar: We must be cautious about describing sleep as a state of conservation-withdrawal since certain stages of sleep, namely the rapid eye movement (REM) phases, are associated with intense psychophysiological activation. We should not oversimplify the situation.

References

- ADOLPH, E. F. (1971) Physiological adaptation to hypoxia in newborn rats. *Am. J. Physiol.* **221**, 123-127
- AITKEN, R. C. B. (1969) Prevalence of worry in normal aircrew. *Br. J. Med. Psychol.* **42**, 283-286
- AITKEN, R. C. B. (1972) A study of anxiety assessment in aircrew. *Br. J. Soc. Clin. Psychol.* **11**, 44-51
- BARNETT, S. A. (1963) *The Rat: A Study in Behavior*, pp. 202-203, Aldine, Chicago
- FOLKOW, B., JOHANSSON, B. & ÖBERG, B. (1959) A hypothalamic structure with a marked inhibitory effect on tonic sympathetic activity. *Acta Physiol. Scand.* **47**, 262-270

- HILTON, S. M. & SPYER, K. M. (1969) The hypothalamic depressor area and the baroreceptor reflex. *J. Physiol. (Lond.)* **200**, 107-108P
- HOAGLAND, H. (1928) The mechanism of tonic immobility. *J. Gen. Psychol.* **1**, 426-447
- HOFER, M. A. (1970) Cardiac and respiratory function during sudden prolonged immobility in wild rodents. *Psychosom. Med.* **32**, 633-647
- LÖFVING, B. (1961) Cardiovascular adjustments induced from the rostral cingulate gyrus. *Acta Physiol. Scand.* **53**, Suppl. 184, 1-82
- MCGRAW, C. P. & KLEMM, W. R. (1969) Mechanisms of the immobility reflex 'Animal Hypnosis'. III. Neocortical inhibition in rats. *Commun. Behav. Biol. A* **3**, 53-59
- MASSERMAN, J. H. & PECHTEL, C. (1953) Neurosis in monkeys. A preliminary report of experimental observations. *Ann. N.Y. Acad. Sci.* **56**, 253-265
- TEPLOV, B. M. (1964) in *Pavlov's Typology* (Gray, J. A., ed.), pp. 3-153, Pergamon Press, Oxford
- VON HOLST, D. (1972) Renal failure as the cause of death in *Tupaia belangeri* (tree shrews) exposed to persistent social stress. *J. Comp. Physiol. Psychol.* **78**, 236-273