SECTION I

The Development of Bladder Control Behaviour and of Physiological Micturition

CHAPTER 1

How Children Become Dry

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Knowledge of how children become dry is essential to our understanding of children who are late in doing so, and of those who after having achieved dryness later revert to being wet. There is, however, still much mystery about how and why a child becomes dry.

Till now attention has largely been concentrated on the absence of dryness, but if medicine is for 'the promotion, maintenance and restoration of health' it is logical to look also at dryness itself. Hopefully, dryness being less explored than its converse, its study may yield some fresh and even useful ideas. How children become dry also deserves our consideration because it is an aspect of developmental paediatrics, the current study of which has already yielded considerable dividends and may yield more.

The word 'how', when applied to the development of dryness, can be taken in several senses. First, there is the numerical or epidemiological study of a population to find how the proportion of children who are dry in the day and in the night increases with increasing age. Second, the ethological 'how' is a report of the behavioural stages of the child's increasing control of micturition. Third, there is a physiological 'how', which is an attempt at understanding local and central mechanisms of bladder control, and the evolution of these in the first few years of life.

In this chapter, we examine each of these three 'hows'. We consider the underlying maturation of the central nervous system mechanisms essential for the emergence of dryness, and investigate the step from completion of the necessary maturation in the brain to the appearance of the behaviour. Hence we are led on to consider the child's motivations and attitude, and also the part played by training in the acquisition of day-time and night-time bladder control. The effects of teaching, learning, pavlovian and operant conditioning, the parents' conscious and unconscious toilet-training, and social and imitational training, are all discussed. We consider it reasonable to accept the idea that training is important in the development of day-time dryness, but we look sympathetically at the idea that night-time dryness emerges spontaneously, without teaching. We believe that average figures relating to a group of children can be misleading, and that the over-all theory of how children become dry must be able to accept the behaviour of minority groups of children if it is to be valid.

Finally, we attempt a brief survey of some of the associations of early and of delayed development of dryness, trying to look not only for factors which seem to promote diurnal and nocturnal bladder control, but also for factors which appear to inhibit the emergence of dryness, especially night-time dryness. These factors may

include what happens in the child's life, his feelings, and also the emotional ambience in which he lives, as well as how and when the parents approach toilet-training him.

We are primarily concerned here with how children become dry at night. Day-time dryness receives some consideration, but it is clear that the common tacit assumption that to become dry at night the child *must* be dry in the day is incorrect, even though in our culture the second commonly precedes the first.

Topics to be Presented

(1) Epidemiology:
- (a) general;
- (b) the sensitive period for emergence of nocturnal dryness.

(2) Ethology: the behavioural stages of development of day-time and night-time dryness.

(3) The mechanisms of bladder control.
(4) Bladder capacity.
(5) Maturation of nocturnal bladder control.
(6) Motivations for dryness behaviour.
(7) Toilet training.
(8) Nocturnal dryness as an inherent behaviour, predestined to emerge.
(9) Some factors associated with early and late development of dryness.

Epidemiology

Even at *age one*, some babies are dry at night. Figures of eight per cent in Sweden (Klackenberg 1955), and seven per cent (six per cent lastingly) in Baltimore (Oppel *et al.* 1968) have been reported. In the last study, more girls than boys, and more Negro children than Caucasian, became dry at night by one year of age.

At *two and a half years*, in the 1951 Minnesota study, 60 per cent were dry in the day, and 57 per cent were dry at night, while 41 per cent were reliably dry day and night. There was little difference between boys and girls at this age. Sixteen per cent of the children were dry at night when they had not yet developed day-time dryness (Roberts and Schoellkopf 1951).

At *age three*, in Sweden 87 per cent were dry (Klackenberg 1955), in Newcastle, England, 77 per cent (Miller *et al.* 1960), and in Baltimore 64 per cent (Oppel *et al.* 1968). Of the Baltimore children who were dry at three, three-quarters remained lastingly dry.

Figures at ages over three are likely to include, apart from children who have never been dry, increasingly important proportions of children who have lapsed from being dry at night. Oppel *et al.* (1968) do differentiate between these two types, and the distinction is worth making: for one thing, maturation must have occurred in those who have been dry at night; even if this is only for one night, some degree of maturation has occurred.

At *age four* years the percentages of boys and girls dry at night has been found to vary as follows.

Australia	Boys 62 per cent	Girls 60 per cent
Baltimore U.S.A.	Boys 69 per cent (Caucasian)	Girls 66 per cent (Caucasian)
Britain	Boys 86 per cent	Girls 89 per cent
Sweden	Boys 90 per cent	Girls 94 per cent

(These figures are quoted from Oppel *et al.* 1968.)

At *age five*, the over-all percentages dry at night were Baltimore, 72 per cent, U.K., 91 per cent, Sweden, 94 per cent.

Both for its interest and theoretical implications, we draw attention to the remarkable, if unique, series of children reported by Brazelton in 1962. This was a large series of 1172 children from middle class families in Boston, all in Brazelton's practice. By the age of five years, 98½ per cent of these children had become dry at night. This figure was stable, for among 1000 children over the age of five years in his practice several years later, only eight, which is less than 1 per cent, were not dry (Brazelton, personal communication). Toilet training was discussed with the parents from the birth of the child, but was not started until the children were two years old; the parents were coached to encourage the children and deal gently with them when they were not dry throughout the night.

Between the *ages of five and ten years*, in the Newcastle series (Miller *et al.* 1960), half of the 9 per cent not dry at age five became dry. On the other hand, 5 per cent lost the nocturnal dryness they had at five, so that the over-all percentage of children wet at night between the ages of five and ten years remained unchanged, namely 9 per cent.

In Oppel's Baltimore series, over half of the 28 per cent not dry at five years were dry at age ten. By age ten, 95 per cent had been dry, but, because some of them had lost the skill, only 84 per cent were dry at this age.

Several recent large series confirm Oppel's finding of lower levels of nocturnal dryness among U.S.A. children: for example, Dodge *et al.* (1970) found that 82 per cent of girls, and 76 per cent of boys among 1436 Texan children aged between six and ten years were dry at night, and Starfield (1972) reports a figure of 80 per cent among 1275 children aged '6 through to 13 years' seen at routine medical examinations in Baltimore.

The wide variations in figures from different countries, even within the western culture, make it important, in considering how children do or do not become dry at night, to differentiate between factors inherent and common to all human children and factors dependent on cultural patterns of rearing children.

Another way of looking at the epidemiology of dryness is to consider the percentage of children not yet dry at night who become dry at each successive year of age. It is not always easy to obtain figures, but Oppel *et al.* (1968) do provide them. The highest percentages were in the second year (36 per cent) and in the third (42 per cent). From the fourth to the eleventh years the percentages in this series averaged just over half the peak level.

Elsewhere in this volume, de Jonge (Chapter 4) estimates that, in each year from the age of five, of the children still without dryness at night, about 15 per cent become dry. (Curiously enough, in the Isle of Wight Survey—see Rutter *et al.* this volume

page 137—of 158 children who when first seen at the age of five were not yet dry, only four had become dry by the age of seven. This is only one tenth of the number one would expect from de Jonge's figure of 15 per cent per year).

One other epidemiological concept remains to be discussed, that of a 'sensitive' period for the emergence of the behaviour of dryness at night. A sensitive period for acquiring a particular behaviour is typified by a high rate of emergence of the behaviour during the particular period, and a lower rate of emergence in the periods preceding and following it. It has been suggested that the period between the ages of $1\frac{1}{2}$ and $4\frac{1}{2}$ years (especially the third year) is a sensitive (though not a 'critical') one for the acquisition of nocturnal dryness, and that it is followed by a period in which the chances of becoming dry are low (Davis 1965, Young 1965, Mac Keith 1968). Recon sideration of the data suggests (a) that there *is* epidemiological evidence of a *relatively* sensitive period, (b) that this period is probably from one to four years of age, and (c) that it is preceded by a 7 or 8 per cent emergence rate in the first year and is succeeded by a period in which the chances of nocturnal dryness emerging are 15 per cent per year; in the third year of life 40 per cent or more of children still wet become dry. Although the phrase 'sensitive' period has been commonly used in relation to learning a skill, we have used it here in a simple descriptive sense, because there seems to be no good reason for assuming that nocturnal bladder control is learned.

The Ethology of Dryness: the Behavioural Stages of the Child's Developing Day-time and Night-time Dryness

From birth, the child is dry for increasing periods. Reflex training, by the mother putting the child on a pot when she thinks he is ready to pass water, may be possible. Some infants at one month give a brief cry when they micturate. Duché's observations reported on page 24 suggest that some children of a few months wake shortly before passing water. A few children are dry at night before the age of one year.

At 15 months, the child points to wet pants and puddles. Soon after, he may wake at night and cry to be changed. He has a word which is used for both urine and faeces.

Between 18 and 24 months, most children report to the mother when they have dirtied their pants. By two years they use different words for urine and faeces.

Around the age of two years, they exclaim while voiding, and a little later become aware when the bladder is full, and shout or otherwise announce that they are about to pass water. At two and a half years of age, in the Minnesota study (Roberts and Schoellkopf 1951), 91 per cent of girls and 79 per cent of boys made known their need to micturate.

The next stage is that the child holds his urine for a time after he is aware that he needs to micturate.

The next stage is that he gets to an approved place and removes his pants before micturating. These preparatory measures will be easier if he can walk, has no pants or napkin on, and the potty is near him. Children who cannot yet walk or undress may have the ability to summon their caretaker to help them.

Having got to the pot and undressed, the child initiates micturition from a full bladder.

Three-year-old children commonly go to the lavatory by themselves, proudly announcing the fact to everyone. Sometimes they hold on too long, especially if preoccupied with their play.

By four years, the child is a connoisseur of water-closets, and reports with great interest on any new lavatory visited. By the age of five he has lost this tremendous interest.

By four the child starts shutting the door and by five sometimes requires privacy to be able to void. By this age he is usually able to initiate an emptying of the bladder at any degree of fullness, a skill limited to dogs and man.

The Mechanisms of Bladder Control

The bladder wall is of smooth, involuntary muscle. This *detrusor urinae* muscle envelops the bladder, and the fibres are said to form a functional internal sphincter. Probably the urethra is the important sphincter. If during micturition the perineal urethra is, by upward pressure, occluded, the urine proximal to the point of pressure empties back into the bladder (Vincent 1959).

The stimulus for contraction of the *detrusor urinae* is descent of the neck of the bladder (Muellner 1958, 1960; Vincent 1959). To initiate voluntarily a detrusor contraction, man makes a brief inspiration and then, holding the diaphragm steady, contracts the muscles of the abdominal wall. While the bladder neck is in the normal position, the rise of pressure outside the bladder neck prevents expulsion of the urine. But the raised intra-abdominal pressure is directed precisely towards the bladder neck. Meanwhile, the anterior part of the levator ani muscle, and the pubococcygeus muscle, which supports the bladder neck directly in women, and indirectly by being under the prostate gland in man, are relaxed. As a result of these two manoeuvres, the bladder neck descends, and its descent is the stimulus for the *detrusor urinae* to contract. The stream of urine can be interrupted by a voluntary contraction of the muscles of the floor, which raises the neck of the bladder. Vincent (1959) has shown that adults may differ widely in the skill with which they control their micturition.

The development of the neck of the bladder was studied by Hutch and Schopfner (1968), by taking lateral cystogram x-rays of 382 normal children aged four days to fourteen years. The ethical aspects of this work are worrying for it must be very difficult to protect the gonads from irradiation. They observed a progressive development of the anatomical position and the function of the bladder 'base-plate' formed by the trigone. Maturity of base-plate position and function is attained in most children between the ages of four and six years. This is two years after most children are dry at night, so the relationship between these radiological findings and the child's bladder behaviour is not clear. Only a longitudinal study would have shown whether children with immature bladder base-plate position are at risk for losing their nocturnal dryness. Among children who were not dry at night, there were significantly fewer with radiologically mature base-plate position.

In young babies, once the bladder is full, 'reflex' emptying occurs with a proud fountain of urine. By the age of two or three years, the infant becomes able to inhibit this emptying for a time.

By the age of three, the child can voluntarily initiate emptying of the full bladder. At this early stage, micturition is presumably initiated by a combination of the reflex emptying of a full bladder *plus* the as yet rather inefficient voluntary skill. Later, the human child can voluntarily lower his bladder neck, and so can initiate micturition from a partly full bladder.

Bladder Capacity

The child's daily urine output is relatively greater during the first six months, and declines steadily up to the age of five, both in absolute terms and in relation to the increasing bladder capacity.

The influence of bladder capacity on the development of bladder control was first emphasised by Muellner (1960, 1965), and more recently by Starfield and Mellits (1968) and Esperanca and Gerrard (1969). Muellner estimated bladder capacity by the volume of urine passed at one voiding. He stated that at two years this averages 84 ml, at four and a half years 195 ml, and at seven and a half years 225 ml. He further stated that a minimal capacity of 300 ml is needed to hold an entire night's output.

He said that there is a special period between the ages of two and four and a half years in which the bladder usually achieves normal capacity, and that children who retain the bladder capacity of a two-year-old beyond age two fail to develop bladder control. Troup and Hodgson (1971) found no difference in diurnal/nocturnal functional bladder capacity in children aged four to eleven years who had not yet developed nocturnal dryness.

Frequency of micturition will also be a function of bladder capacity. Conversely, anything causing frequency will reduce the bladder capacity as measured by Muellner's method. Vincent (1959, 1964) showed that pressing up the perineum immediately relieves frequency, even when this is of many years standing. 'Bladder capacity' is a real concept, but this evidence shows that it may well be a function of the bladder neck and not of the bladder itself.

In the Minnesota study (Roberts and Schoellkopf 1951), of children aged two and a half years, 9·5 per cent had high frequency, passing urine hourly, 80 per cent passed urine every two or three hours, and 8 per cent did so at intervals of four hours or longer. Frequency of day-time micturition showed some, but no close, association with lack of bladder control through the night. Some children with diurnal frequency were dry at night. Their day-time 'bladder capacity' was no index of their night-time capacity. Perhaps the horizontal position in bed affects the bladder neck-plate and hence the functional ability to hold a night's secretion of urine.

Stein (1885), Hagglund (1965) and Starfield and Mellits (1968) have described training regimes for children over five who have not yet become dry. Hagglund (1965) employed forced drinking; Starfield and Mellits (1968) got the child to hold his or her urine for as long as possible once a day for six months, and on this regime one third of children became dry. In a study of buzzer conditioning for inducing development of nocturnal dryness, Young and Morgan (1972) found that 'overlearning', by getting the child to drink two pints (40 ounces = 1 litre) of liquid in the last hour before retiring, reduced the number of relapses after buzzer training.

An adequate bladder capacity is clearly necessary for the child to be dry at night. How do we find whether an individual child has a large enough bladder capacity? Diurnal frequency is an index of day-time functional bladder capacity, but, since little children who pass urine hourly in the day can be dry through the night, diurnal frequency is not a reliable index of an individual child's nocturnal capacity. We end up by finding that the evidence that a child has a bladder large enough to be dry at night is that he is dry at night.

Small nocturnal bladder capacity can influence the development of dryness at night, but in any individual child it is difficult to measure this variable and hence to identify the part it plays in preventing a child from becoming dry at night.

Maturation

A distinction is necessary between maturation and development. 'The process of maturing.... is a process of developmental morphogenesis' (Gesell and Ilg 1943). Maturation is a concept of an orderly destined process of growth and elaboration of structures and functions within the central nervous system (CNS). It is inherent, is in the deoxyribonucleic acid (DNA), is in the genes, is genetically determined, *i.e.* by inheritance. It cannot be accelerated by environmental influences; it can be delayed by injury to or defective development of the brain.

Development is the emergence of a succession of behaviours. It 'depends on maturation of the nervous system' (Illingworth 1968). The existence of a behaviour is of course evidence that maturation of the necessary underlying CNS mechanisms has occurred. It is often but not always the only evidence.

Once a behaviour has emerged, the skill with which it is used may further improve with time and practice.

If a behaviour has been taught, its emergence is commonly attributed to the teaching or practising. However, this may be an error. Around the age of seven months, infants come to be able to balance themselves stably while sitting. It is possible, before the child has had any teaching or practice, to elicit the impending balancing responses. For example, if the child is held in mid-air in vertical suspension and the trunk is inclined to one side, the infant tilts his head and moves his upper and lower limbs in ways that correct the movement of his centre of gravity. The same is true of the 'parachute' or propping responses. These too can, by suitable stimulation, be elicited before anyone has attempted to teach them, and before the infant has practised them.

We distinguish between primary and secondary archaic (or primitive) motor responses. The primary ones are present at birth; they include the placing, righting and primitive walking responses. The secondary ones include balancing and propping responses. They are not present at birth, but they are, like the primary responses, inherent and predestined. They emerge as maturation takes place in the central nervous system.

We know of no way of finding out, in any child at any particular age, whether the CNS mechanisms necessary for bladder control have matured, other than by investigating records of his bladder behaviour since birth. If he has had a dry night, then the necessary mechanisms are present, and the basic necessary maturation has

happened; if he has had a month of dry nights, then surely maturation has been fully completed. It might be reasonable to suggest that some children require a further month or so after the first dry night for maturation to be fully completed; it is much less acceptable to suggest that completion of maturation may take several years.

Even at birth, some of the skills necessary for eventual dryness are present. Although urine is secreted continuously, the infant collects it for a period, during which he is dry. The child also has the skill of emptying a full bladder and, if he is a boy, in a way such that it goes away from him. The maturation necessary for some of the items needed for control of micturition has therefore occurred by the time of birth.

If we consider the analogy of dryness and walking, we might well recall that while the child walks at 18 months, his skill in walking improves, probably by further motor maturation, as well as by practice, to the age of seven. Vincent (1959) found variations in the day-time micturitional skills of adults. It is difficult to say whether this is true of nocturnal bladder control.

But it is still practical to consider the sum of all the mechanisms necessary for the appearance of night-time dryness, and to ask at what age this matures. The evidence of maturation is night-time dryness. We can produce tables of the ages at which children have their first dry bed, and certainly when this has happened maturation of the basic brain mechanisms has occurred, even if the maturation is not fully complete.

If any child is not dry at night, it may be that this is because his mechanisms have not yet matured. Many distinguished authorities have stated that any absence of nocturnal bladder control persisting after the age of five is due to delayed maturation of the necessary mechanisms (Barbour *et al.* 1963, Illingworth 1968, Bakwin and Bakwin 1972). But this explanation is, to our mind, difficult to reconcile with a considerable body of evidence. Much of this consists of clinical impressions and armchair argument, but not all. For example, Miller *et al.* (1960) record that, among the five-year-old children who did not have nocturnal bladder control:

20 per cent had intermittent dryness;

29 per cent had had periods of dryness, most of which had begun soon after the second birthday and lasted three to nine months; and

50 per cent, though rarely dry, had had odd dry nights.

Among the Baltimore children studied by Oppel *et al.* (1968), 28 per cent were not yet dry at five years, but a third of these children had been dry at an earlier age.

If occasional dry nights indicate that maturation of the basic necessary mechanisms has occurred, then, on the evidence of the data presented by Miller *et al.* (1960) and Oppel *et al.* (1968), in practically all and certainly in nearly a third of cases, delayed maturation is not *the* cause of frequent bedwetting in five-year-olds. Hector Charles Cameron (1919) in his book *The Nervous Child* says that 'the *usual* [our italics] history is that control was partially acquired in the second year'. He also notes that, when removed to a hospital for observation, children who were not dry at home promptly became dry; this is good evidence that maturation had occurred.

Young men in approved (boarding) schools frequently lack nocturnal dryness, but on the nights spent in the sick bay they are always dry (Stein and Susser 1967). In other words, the cause of their bedwetting cannot be delayed maturation of the necessary mechanisms. Such observations are the clinical experience of many doctors who see children. Young (1965) comments that the high rate of success achieved with conditioning treatment (the buzzer method) in children who at age seven years or so are not yet dry at night is good evidence that in the majority of such children maturation has, in fact, already occurred. We conclude that in children *over the age of five years* delayed maturation is unlikely to be responsible for more than a very small proportion of failures to be dry. Our view is further supported by Brazelton's (1962) series in which 98½ per cent were dry at five. (See Mac Keith (1972) for the possible implications of Brazelton's observation in relation to delayed maturation as a cause of failure to be dry after the age of five years.)

It has been suggested (Mac Keith 1972) that the idea that maturational delay plays an important rôle in the origins of failure to be dry at night in children over the age of five may have arisen from a verbal confusion. The failure is stated to be 'a developmental disorder'. But this is an ambiguous statement. On the one hand it is a descriptive statement that a child of, say, six years old is, in his bladder behaviour, like a much younger child. This is an accurate and unarguable statement. On the other hand, the statement may be interpreted as saying that the *cause* of his failure to have the bladder control usual at age six is disordered development (*i.e.* delay in maturation of the central nervous system). For such an aetiological interpretation we think good evidence is lacking.

In Chapter 15 of this volume, Douglas reminds us that among boys in whom nocturnal bladder control has not yet emerged at age fifteen, delayed puberty is commoner than in controls. There is also some evidence that among children over five who are not dry at night, a degree of immaturity of the electroencephalogram (EEG) is not uncommon. In these children the brain maturation necessary for nocturnal bladder control may well have occurred *relatively* late, *e.g.* in the fourth rather than in the second or third year. If their parents had been expecting dryness by the age of two or three, such a *relatively* late maturation could have evoked parental handling which produced anxiety in these children. When at age four maturation did occur, this anxiety could have prevented the emergence of nocturnal dryness, so that, at and after the age of five years, despite maturation having occurred, the child was not dry at night. (See also section on 'negative factors' on page 18.)

In conclusion, using the criteria of having had dry nights, we suggest that maturation occurs in some children before the age of one year, in a great many in the second and third years, and in some more in the fourth year; even in those children who at age five or more are not yet *consistently* dry at night, maturation has probably occurred, although in a very few cases it *may* not have done so.

Among children *under the age of five*, we think late maturation *is* sometimes an important factor in determining whether and when a child develops nocturnal dryness, but that it acts indirectly. 'Parental expectations in toilet training are often unrealistic, and this is a preventable source of parent-child conflict.' (Stehbens and Silber 1971). As we have noted, relatively late maturation, *e.g.* at age four, may evoke from the

child's parents patterns of behaviour which can strongly influence the emergence of continuing dryness at night. Among children *over the age of five*, delayed maturation is only rarely responsible for delayed dryness at night.

Motivations

In general, animals do not deposit their excreta in their dwelling place. Cats find a place where they can cover up their stools, and lions leave the den when they want to void. Nor do they soil themselves during sleep. Even fledgling birds do not foul their nests, and from the moment of birth newborn piglets go away from the sow to deposit their urine and faeces at the edge of the sty, doing this without any training from the sow (see letter from Robert Laird at end of this chapter). Perhaps the fledglings and piglets deserve no credit for this behaviour, but presumably their motivation is that they feel unhappy if they cannot act on an inherent tendency. On the other hand, the training of puppies and kittens by some is active and punitive; in other cases, puppies are trained by being tied to their baskets for increasingly long periods, during which they hold their water, before being taken outside the house to release it.

The human child learns that in his culture excreta are considered unpleasant, and that the acquisition of day-time and night-time dryness wins social approval. There is considerable variation about the implied and overt attitudes of English mothers (Douglas and Blomfield 1958, Newson and Newson 1965), but in general the human child is taught these things. Sears *et al.* (1957) found that, among men in the armed forces who did not have nocturnal bladder control, more subjects came from homes where bedwetting was not considered unpleasant and hence had acquired less motivation to dryness. Presumably some children become too-little motivated, some suitably so, and some so strongly so that failure to be dry produces anxiety, which, in turn, inhibits the emergence of the skill.

Peterson (1971) has proposed that failure of bladder control at night has unpleasant results for the child, and that this may be an important conditioning factor. If so, this conditioning stimulus should be the greatest when the child is not in nice thick cosy napkins (diapers). The suggestion would be difficult to prove. For one thing, leaving off the napkins may flatter the child by implying confidence in him and so induce dryness. But, more important, the feeling of unpleasant coldness is not closely associated in time with the voiding; it takes time for the comfortably warm poultice to become cold and aversive. This discomfort is too far separated in time to be a likely major factor in motivating the child either consciously or unconsciously.

In this as in other skills, the desire to imitate older children and parents may motivate children. So may the desire to achieve mastery of a new control of the body. But parental approval and disapproval are also factors which from age 18 months are likely to carry great weight as far as motivation is concerned.

Toilet Training

Training for day-time dryness is more than simply a matter of teaching children to postpone micturition, they have also to acquire social skills, *e.g.* they must also learn to discriminate between socially approved and non-approved toilet situations (Lovibond 1964). A satisfactory model of the development of dryness must encompass

this social training, as well as the facts of physical maturation, and awareness of the need for, and the ability to inhibit, reflex micturition. The aim of training is presumably to produce a child who has control of micturition and has not become emotionally disturbed as a result of the training.

What mothers do when toilet training their children can clearly be regarded as a type of conditioning process. The child is conditioned to associate a full bladder with a pot, usually by a word which the mother uses to describe the voiding process, and in most cases is praised for compliance and incurs some degree of disapproval for lapses. In an urban community in the U.K., the Newsons (1965) found that two types of training, restrictive and permissive, existed. In the restrictive type, the mother attempted to impose a pattern of micturition, and regarded the child as wilfully disobedient if he did not conform; in the permissive pattern, the mother did not blame the child for failures, but took the blame on herself.

The time at which the mother starts this process varies according to social and cultural beliefs. The advice of the baby authorities is not always followed. Whilst Spock was stating that the optimal training time was at 18 to 24 months, Sears *et al.* (1957) found that, in the community they studied, half the mothers began the toilet training before the child was nine months old. In 1946 in the U.K., 60 per cent of children in the National Survey were being 'potted' within two weeks of birth (Douglas and Blomfield 1958). It seems that many believe that the later 'training' starts, the quicker it is completed; but, of course, if it starts earlier, the child may be younger when he becomes dry in the day—even though 'training' has taken longer.

Whether or not the training given plays any part in the process of acquiring day-time control of the bladder is an issue that has been the subject of a great deal of argument. In theory, conditioning could supplement neural maturation in the development of cortical inhibition control over reflex micturition (Lovibond and Coote 1970), but this is not easy to prove. We need to analyse the nature of any training given. We still know very little about the nature of various methods of toilet training in present-day society; much of the published information is of very limited value, being sketchy and based on retrospective accounts given by mothers which are notoriously unreliable (Wenar and Coulter 1962). An exception has been provided by the Newsons (1965).

In short, we still know too little of what mothers actually do when they are said to be 'training' their children, so that it is impossible to say what aspects of the training contribute towards, or act against, the emergence of bladder control. It is unlikely that this badly-needed information will be forthcoming, as long as research workers continue to rely on the interview as the major source of their material; it is difficult to see any reasonable alternative to going into people's houses and studying toilet training practices by 'on-the-spot' observation of mothers and their young children. It is difficult to evaluate the existing research evidence regarding the efficacy of training. Most studies contra-indicate that training is helpful (Klackenberg 1955, Lovibond 1964), but the data should be interpreted with caution, since it may well be that research workers have been asking the wrong questions. More details of the what and when and how of toilet training are needed, including information as to whether a mother is coercive or permissive in her management of it.

Learning theory is most helpful in providing a carefully documented framework within which we can investigate the development of social skills that children must acquire if they are to achieve dryness in the day and in the night. Children have to learn to identify toilet situations correctly, and they have to adopt the appropriate posture for micturition. In many children, the discrimination of a toilet situation will be made without explicit teaching (Lovibond 1964), and the same is perhaps true of other social skill aspects of the development of continence. If we are to understand *how* children learn 'spontaneously' it is perhaps necessary for psychologists to draw more heavily on studies of social learning. We can then examine the parental influences that may facilitate or act against the acquisition of bladder control in young children.

But first it is necessary to define what is meant by social learning. It is assumed that the behaviour of a child is primarily under the control of reinforcing contingencies supplied by the environment (Skinner 1953). Thus if we are to reach an adequate formulation of *how* parents influence the development of day-time dryness, we should begin by looking at the rôle of their giving rewards and punishments for eliminatory behaviour which is appropriate (*e.g.* asking to go to the toilet, inhibiting urination until the right moment, and so on) and inappropriate (*e.g.* precipitous emptying of the bladder). It is more than likely that these parental influences are usually by way of subtle expressions of approval and disapproval. According to this formulation, it would be expected that the development of day-time bladder control would be facilitated by systematic parental rewards given when children asked to go to the toilet or when they were able to delay micturition until the appropriate time and place. Based on observations of their own young children, Pumroy and Pumroy (1965) have indeed provided some support for this analysis of continence development. In addition, several studies have shown that retarded children can be toilet trained through carefully planned reward systems (*e.g.* Hundziak *et al.* 1965, Van Wagenen *et al.* 1969).

Another very potent form of learning is suggested by the careful study of imitation in children. It has been shown that, with the provision of exemplary models, individuals are able, through observation, to acquire complex behaviours in large segments or in their entirety, without having to undergo a laborious trial-and-error process (Bandura 1971). It is clear that imitation provides an acceptable explanation for many aspects of the acquisition of day-time continence. For example, children may learn appropriate behaviour by observing how other children look for or ask to go to the toilet, adopt the correct posture for micturition, and undo clothing.

To summarize, there is ample opportunity for the child to learn day-time bladder control in the absence of any systematic attempts to 'potty' train. A learning theory analysis would suggest that further research might profitably be directed towards the systematic observation, in the home, of the mother-child interaction, during the period when continence would normally be expected to appear. On the basis of a great deal of carefully documented research, we may expect to find that various aspects of social learning are important, whether or not they are all-important.

Some research workers have postulated that quite separate learning mechanisms are the basis of day and night-time bladder control, while others have argued cogently that it is unnecessary to assume that nocturnal inhibitory control over the bladder involves additional conditioning processes (Jones 1960). In the case of nocturnal

continence, feedback from the distended bladder may become an effective discriminative stimulus for full arousal, in a way that is analagous to the selective response of human subjects to external stimulation during sleep (Oswald *et al.* 1960, Zung and Wilson 1961).

Another explanation of dryness at night (considered in the next section) is that it depends not on learning but on maturation alone. It should be noted here that Blomfield and Douglas (1965) found that, where earlier training had been given, a higher proportion of children developed earlier dryness at night. This could be looked on as evidence that training does contribute directly to acquisition of nocturnal bladder control. Alternatively, if it is believed that night-time continence emerges through maturation alone (see next section), the earlier dryness at night in Blomfield and Douglas's study could be explained by assuming that early training provided 'stimulus and opportunity' which, for those children in whom maturation occurred early, provided suitable conditions for the 'spontaneous' emergence of the behaviour of nocturnal bladder control.

Nocturnal Dryness as an Inherent Behaviour Predestined to Emerge

In discussing maturation, we distinguished between *maturation*, an inherited, inherent, predestined process in the nervous system, and *development*, the sequence of appearance of behaviours.

Behaviour is the person's response to stimuli received from within or from outside. Some behaviours are present at birth, Some appear later, and of these some are inherent and some are learned. Because a skill appears after a child has been given teaching, it is not necessarily true that the skill was learned; it might have appeared spontaneously.

The newborn piglet walks; the human neonate cannot walk (in the absence of any ability to balance, primary walking has no obvious usefulness). There is a good deal of evidence that in many species flying or walking develops just as fast whether or not it is preceded by a preliminary phase of practising. This concept has been reviewed by Albrecht Peiper (1963), who suggests that, in man, walking is an inherent behaviour which develops spontaneously. He quotes Koehler (1953): 'one does not learn movement patterns characteristic of the species but not present at birth; rather one has to wait until the needed structures are fully developed, and then the full ability is suddenly there'.

The newborn piglet not only walks, but he also has control of the excretion of his urine and faeces, for without any training from the sow he goes away from the lying area to the edge of the sty to deposit his faeces and urine in a 'socially acceptable place' (see Appendix, page 22). In the human child, is the basic behaviour of controlling the bladder through the night a learned behaviour or an inherent one which, in the large majority of children, is destined to appear by the age of five? Does it improve after its first appearance (as walking does), or is the full ability suddenly there?

Some children certainly become dry at night without any 'training' for this, *c.f.* the 7 per cent of children who become dry at night (6 per cent of them lastingly) before the age of one year (Klackenberg 1955, Oppel *et al.* 1968). Apart from the use

of 'example and precept', teaching commonly utilizes rewards and punishments. To be efficient these have to be closely linked in time with the child's success or failure, and this is difficult to achieve in the case of nocturnal enuresis. Because of this and because of the difficulties involved in teaching a sleeping child, it seems *a priori* unlikely that nocturnal bladder control is taught. This is confirmed by observations of Klackenberg (1955), Sears *et al.* (1957), Cust (1958), Dimson (1959), Lovibond (1964), and Newson and Newson (1965). One of the commonly implied and, indeed, sometimes specifically stated (for example by Muellner) ideas is that night-time dryness is a carry-over from the taught skill of day-time control. This is certainly untrue of children who become dry at night before they are dry in the day, and they can be a sizeable proportion (Roberts and Schoellkopf 1951). We think that dryness at night comes by maturation, and not by training. This is not a new idea (Spock 1946, Bowley 1949, Mowrer 1950). Mowrer recognised that, in the absence of any specific continence training, human children would 'sooner or later acquire sphincter control during sleep as well as at other times'.

If nocturnal bladder control is a behaviour that emerges spontaneously once the necessary maturation has taken place, then a possible explanation of why some children do not become dry at night until they reach the ages of six, eight, ten or twelve years is (provided that they have not had a dry period earlier) that the necessary maturation does not take place until they are six, eight, ten or twelve years old. But if it is accepted that in 98½ per cent of children maturation has taken place by age five (Mac Keith 1972), this explanation will apply only rarely. It therefore becomes necessary to postulate and look for factors which, despite maturation having occurred, have prevented or are preventing the emergence of the expected behaviour. This topic is further discussed in the section on 'negative factors' (page 18).

Some Associations of Early and Late Development of Nocturnal Dryness

Family History

Hallgren (1957) found that, in children over the age of five, lack of bladder control by day *and* by night was not associated with a family history in the proband's sisters, though it was in the brothers. On the other hand, if the lack was of nocturnal control only, then a family history was commonly present in the proband's parents, brothers and sisters. For diurnal delay in control alone, there was no excess in the proband's brothers, sisters or parents.

He also showed that, when the father and mother both have a history of delay in bladder control, there is increased risk of the marriage breaking down. Since children in disturbed families are at greater risk for late acquisition of dryness (Miller *et al.* 1960), non-genetic familial factors will have to be distinguished from inherited ones. A history of late acquisition of nocturnal bladder control by a wet child's parents indicates factors which are transmitted from parent to child, but the transmission is not necessarily genetic. For example, parents who grew up in problem families are at risk for repeating the errors of child care which they themselves suffered, and hence their children are at risk for not becoming dry by age five. Genetic factors can presumably act by influencing the age of maturation of cortical inhibition at night, or perhaps by influencing the evolution of nocturnal bladder capacity.

Social Class

Miller *et al.* (1960) showed the existence of a class gradient, and so, with one or two curious exceptions, did Blomfield and Douglas (1956). Generally, bed-wetting is more common in social classes IV and V.

This has also been found in Germany and Sweden (Stein and Susser 1967). These authors found that the difference between middle class and manual workers' families is not present before the age of five, and increases with increasing age.

Family Relationships

Good family relationships promote the development of dryness, while parental deprivation, deficient physical care and social dependence are associated with a failure to develop dryness under the age of five (Miller *et al.* 1960, Stein and Susser 1967). Miller *et al.* (1960) showed that the over-all proportion of children dry by the age of five was 91 per cent, but that in disrupted and problem families it was 78 per cent.

The Newsons describe 'restrictive' mothers, for whom the child's 'refusal' to become dry is disobedience and defiance which must be checked, and 'permissive mothers, who take on themselves the blame for their children's late development of dryness. Stehbens and Silber (1970) note that parents' expectations in toilet training are often unrealistic, and that this is a preventable source of parent-child conflict, and hence of delayed appearance of bladder control.

Training

In general, care and management in relation to bladder control is called 'training' in children aged less than five years, and 'treatment' in children over five years.

We have noted that before a behaviour can emerge, maturation has to take place in the central nervous system. What bridges the gap between the organism becoming able to respond and the emergence of the behaviour? Here we can only ask questions, some of which have already been asked in the section on toilet training. These questions may be asked equally, but separately, about the emergence of either day-time or night-time bladder control.

(i) Is teaching needed? Do its advantages outweigh its disadvantages?
(ii) Is practice needed?
(iii) Once maturation has occurred, is it enough to provide 'opportunity'?
(iv) Are opportunity and stimulus needed?
(v) What is the nature of such 'stimulus'?
(vi) Is the child's pleasure in exercising a new skill sufficient reward for reinforcement?

To look first at nocturnal control: we have put forward once more the 25-year-old idea that this is one of the things that 'the bladder learns by itself', without training. If this is accepted, it follows that becoming dry at night does not involve positive training, or teaching, or conditioning, but only freedom from negative factors which prevent the emergence of this behaviour. Conversely, we have suggested that failure to become dry at night by the age of five years is due to negative factors which have interfered with, or are interfering with, the emergence of the desired behaviour.

It is during these final stages of development towards complete control of the bladder that the training in cleanliness adopted by the mother may constitute either a positive or a negative factor: positive in the sense that she can wisely adapt her measures in accordance with the signs of maturity that the child spontaneously displays; negative when she is too ambitious in trying to get the child to be dry at an early stage, which often implies that it is too early a stage. Premature training in cleanliness involves so many risks of provoking the adult to adopt an attitude to the child which may prove harmful to their relationships and possibly to the development of the child's personality. It is better to avoid doing too much and to depend more on the spontaneous maturity of the normal child. (Klackenberg 1955).

Positive Factors for the Development of Dryness

The positive factors for encouragement of the predestined emergence of nocturnal dryness add up, in brief, to providing a warm and 'positive' atmosphere in the home from which negative factors are absent.

The helpful positive ambience is presumably provided by mothers who are, to use the Newsons' adjective, 'permissive', that is mothers who, when their child is not yet dry, do not see him as wilfully naughty, but who, absolving him, take the responsibility onto themselves. The 'child oriented system of toilet training' described by Brazelton (1962), on which 98½ per cent of children were dry by age five, provides just such a positive ambience. (The preventive implications of his achievement are evident). Furthermore, we think that the 'spontaneous' emergence of dryness after the age of five years probably results largely from the removal of factors, such as parental anxiety, which are preventing the appearance of the normal behaviour.

Negative Factors for the Development of Dryness

Pre-school children are less likely to be dry by the age of three years if they are depressed or anxious (Frommer *et al.* 1972). Miller *et al.* (1960) found that, in comparison with other children, children whose early childhood had been spent in severely disturbed families were more than twice as likely to fail to develop nocturnal dryness by age five (Miller *et al.* 1960). Of 320 children over the age of five who were not yet dry, 83 per cent had been subjected to potentially anxiety-provoking episodes in the first three years of life (Young 1965). Douglas (1967*b*) found that 'stress in early childhood was clearly associated with enuresis later, even on the restricted recording of stressful events'. He also found (Douglas 1967*a*) that 'physical and mental stress between the ages of two and three years causes a statistically significant increase in persistance of bedwetting after the age of four years three months'. (Douglas's important data are reviewed by him in Chapter 15 of this volume.)

Cust (1958) reported that, among children over the age of five who were not dry at night, a history of illness in the third year of life was considerably more common than among controls who were dry (see also Mac Keith (1968) for a review of this topic).

The success of Brazelton's (1962) carefully introduced regime of toilet training, which was aimed at reducing the child's anxiety about his failure to be dry, suggests

that, as well as the chronic family stresses described by Miller *et al.* 1960, and the transient ones noted by Cust (1958), Young (1965) and, most notably, by Douglas (1967*a* and *b*), there is an important group of stresses, in the third and later years, which derive from the reactions of certain children to their toilet training.

In the section above on epidemiology (see page 14), evidence was noted that the second and third years of life form a (relatively) sensitive period for the emergence of nocturnal dryness. From some of the data given here, it appears that what the growing child is 'sensitive' to in the second and third years of life, so far as concerns the emergence of nocturnal bladder control once maturation has occurred, is not positive factors like teaching or training, but the absence of negative influences which can inhibit the emergence of nocturnal bladder control. 'Habits are vulnerable while they are being acquired', and 'if a habit is arrested because circumstances are unfavourable, it tends not to be resumed after the optimal period has passed, even when circumstances have returned to normal' (Davis 1965). How such stresses inhibit the emergence of dry behaviour is far from understood. Perhaps further study of how similar stresses can lead to a loss of nocturnal dryness might give some clues to follow.

Conclusions

In summary, we conclude that children become dry at night in the following way. At birth some partial mechanisms are already present. In the next four years, maturation takes place in the central nervous system, making the behaviour of nocturnal bladder control possible. This behaviour is not dependent on training or learning. It is destined to emerge during the first four years, provided nothing acts at the time of maturation to inhibit its emergence. Such negative factors may be transient or continuing stresses, amongst which unsuitable toilet training is probably important. The emergence of nocturnal bladder control cannot be accelerated, but it can be retarded. A few children become dry at night by the age of one year, a large proportion in the second and third years. There is a proportion who do not become dry at night by age five; this proportion ranges from 1½ per cent in Brazelton's 1962 series, through 10 per cent in Scandinavian and British series, to 15 or 25 per cent in U.S.A. and Australian series.

In children under the age of five, but not in older children, delayed maturation is one of the factors leading to delayed appearance of nocturnal dryness. It acts by evoking parental behaviour which is negative for the emergence of the desired behaviour. Genetic factors probably play a part by affecting either the age of maturation of necessary mechanisms or the development of nocturnal bladder capacity. Children in families of manual workers and children in problem families more commonly fail to develop dryness at night by age five.

In children over five, once the more obvious organic disorders have been excluded, by taking a history, doing a urine analysis, and watching the child micturate, removable causes of persisting failure to become dry are less likely to be identified by intensive, painful or dangerous examinations for rare organic abnormalities (which even if present may not in fact be responsible for the failure to become dry at night) than by consideration of the attitudes of the parents and the child to the failure to be dry and to each other. The child over the age of five who is still not dry at night is,

in this respect, different from most of his peers, and has a behavioural delay, indeed a disability; but he is not ill in the sense of having any organic disorder underlying his symptom.

Coda

'The elaboration of a new concept of the pathogenesis of a familiar but idiopathic disease is always exciting, one way or another. Sometimes, as in the penicillin story, the scientific brotherhood marvels at how the obvious could have escaped it for so long. Alternatively, if the new concept is not instantly palatable to all interested parties, the community may be split into adherents and doubters, with strong views on either side. The heat generated by such fission can be an important catalyst of scientific progress: the doubters are upset sufficiently to inspire them to try to disprove the validity of the proposal, while the believers hasten to prove and extend the new concept. This dual process invariably generates new knowledge.' (Goldbloom 1971)

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For Appendix see page 22.

APPENDIX

One of the authors wrote to Mr. Robert Laird of the Animal Husbandry Department, West of Scotland Agricultural College, asking him for information concerning the excretory habits of piglets. Mr. Laird's reply is reproduced, with his kind permission, below.

Dear Sir,

We acknowledge receipt of your letter concerning the excretory habits of piglets.

As you rightly say, they learn very early to defaecate and urinate in a corner of the pen, distant from the lying area. The sow plays little or no part in this learning, as piglets whose dam is confined in a farrowing stall also learn equally early. It has, however, been reported (Hafez *et al.* 1962) that piglets 'reared without their dams' have a seemingly random pattern of elimination and are continually dirty.

Instinct would appear to be the main teacher. Piglets tend to lie close to a source of heat, *e.g.* an infra-red lamp, and they tend to go to the furthest point from this heat source to defaecate and urinate. In our experience, this is not necessarily the same area as that in which the sow deposits her dung and urine.

In pens where the sow is also free to move about, the sow and litter will use the same area for excretion. This area will most likely be at the furthest point from the heated creep area to which only the piglets have access.

If, on the other hand, a piglet is weak or ill, it will foul its lying area. This fouling, no doubt because of odours and wetness, may encourage other piglets to do likewise. It is important, therefore, to break such habits before they become established.

Older pigs also have a tendency to defaecate and urinate at the furthest point from a supplementary heat source, and this may create problems if space heaters are incorrectly positioned in relation to the lying area of the pen. Where there is no heat source, the location of the supply of food and water will influence the excretion pattern, and pigs will excrete near the source of water. Pigs will use a dunging passage, where provided, because of the odours and wetness, but pigs with bad habits may foul a corner of the lying area. Where no dunging passage is provided and part of the pen is slatted, pigs have a tendency to dung and urinate at one end of the longer dimension of a rectangular pen, presumably because they are then able to lie as far as possible from the dunging area. This again raises problems as to pen design.

Unfortunately, a small percentage of pigs do not conform to these standards, and it may be worthwhile from a management point of view when pigs are moved to carry some dung to the new pen and place it in the area where they are expected to defaecate and urinate, so as to get them 'educated' correctly.

We hope that these comments will be of interest. They are based on our own observations.

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