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Environmental enrichment can improve poultry welfare and productivity by decreasing harmful behaviours, like fear or feather pecking. Having shown that chickens used an environment more when it was enriched, we then identified specific preferences in order to design more effective enrichment. First, we found that televised stimuli were attractive to chickens, that their regular presentation reduced fear, and that the images should incorporate movement, brightness, colour, and moderate complexity. Projecting them onto the walls might be a practicable strategy. Second, farmers reported that playing the radio reduced aggression, improved the birds' health and increased productivity; this is also one of the easiest ways of enriching the farmers' environment. Third, our findings that the presence of a familiar odourant reduced chicks' fear of novel places, birds and food suggest that olfactory therapy could minimize certain behavioural problems. Finally, providing chickens with bunches of string promoted foraging and exploration, sustained lengthy interest, and reduced potentially injurious inter-bird pecking and feather damage in the laboratory and at a commercial farm. Clearly, extraneous stimulation is important to chickens. The provision of appropriate visual, auditory, olfactory and tactile enrichment is likely to improve their quality of life.

Public awareness of the conditions under which intensively farmed animals are routinely housed increased dramatically with the publication of Ruth Harrison's book *Animal Machines* (Harrison, 1964) and resulted in a vociferous and growing concern for their welfare/well-being. Such concern led, via various government committees and numerous publications, to the establishment of the UK Farm Animal Welfare Council (FAWC) in 1979. Briefly, this organization recommended that the UK Welfare Codes should be structured to permit farm animals to have five basic rights or freedoms. These included: "freedom from hunger and thirst; freedom from discomfort; freedom from pain, injury and disease, freedom to express normal behaviour; and freedom from fear and distress (Webster 1994; FAWC, 1997). In this paper I will not attempt to review the substantial body of literature on the ethics of animal welfare and intensive farming or on the advances made in areas outwith the sphere of environmental enrichment for poultry, but readers who wish to delve will find much useful material in books by Rollin (1981), Webster (1994), Mepham, Tucker and Wiseman (1995), Singer (1995), and Spedding (2000). I will, however, echo Siegel's (1993) sentiment that from a moral point of view, "the ability to husband more chickens or turkeys because of technological advances does not reduce the obligations that humans have to these (and other) animals".

A necessary first step in determining whether comparative psychology has contributed to our efforts to improve the welfare of farm animals is to strive for a definition of the discipline. For the sake of brevity I will focus only on relatively recent descriptions. First, we must accept that comparative psychology is a truly interdisciplinary field (Papini, 2002). Indeed, it emerged historically at the intersection of ethology, psychology, behavioural ecology, evolutionary biology, anthropology, taxonomy, physiology, neuroscience, embryology and genetics (Gariepy, 1998; Greenberg & Haraway, 1998; Papini, 2002). According to Immelmann and Beer (1989) comparative psychology has emphasized environment-dependent features of behaviour, especially of perception, habit and learning. Dewsbury (1992) went on to suggest that comparative psychology embraced studies of the genesis (evolutionary and developmental), control (external and internal factors), and consequences of behaviour in a wide range of species. In a subsequent definition, Gariepy (1998) also included the evolution of behavioural complexity and diversity as well as the relative contributions of nature and nurture to the organization of behavioural systems. More recently, Papini (2002) illustrated the myriad relationships between "the main research areas of comparative psychology and a variety of disciplines in the social and biological sciences" in a succinct and particularly elegant schematic.

Many of the features of comparative psychology identified above are central to research in the field of farm animal welfare. More specifically, considerable attention has focused on improving our understanding of the internal and external factors governing the development and reduction of behavioural and physiological states that are known to seriously damage the welfare and productivity of farmed animals. As far as poultry are concerned, two behaviours that are particularly problematic are fear and feather pecking.

Firstly, heightened fearfulness, (i.e. the propensity to be easily frightened by a wide variety of potentially alarming events), and the expression of inappropriate fear responses can cause substantial harm to the birds' welfare and their productivity. The range of deleterious effects is shown in Table 1 and some are described in greater detail below. Sudden or enforced exposure to novelty and the risk of predation are powerful fear-elicitors for most animals. Despite countless generations of domestication and the associated increase in docility, chickens can still be easily frightened by sudden changes in their environment and by exposure to human beings who they may perceive as predators (Suarez & Gallup, 1982; Jones, 1996); this is particularly true for birds that are housed in relatively impoverished, invariant surroundings. Sudden, intense or prolonged fear can lead to injury, pain and distress. For instance, if the birds show violent escape or other inappropriate panic responses they can damage themselves either by running into obstacles or by piling on top of each other; this can result in birds at the bottom of the pile being suffocated or suffering claw-inflicted injuries (Mills & Faure, 1990; Jones, 1996, 1997). Broken bones, bruises and scratches can lead to chronic pain, infection, physical debilitation and death. Such injuries can also cause carcasses to be downgraded with the associated economic loss. The cost of just one type of frightening event is well illustrated by the fact that the UK Ministry of Defence compensated poultry farmers for fear-related losses caused by low-flying aircraft to the tune of £700,000 in 1995 (Jones, 1996).

Table 1
Harmful Effects of Heightened Fearfulness and Inappropriate Fear Responses in Poultry.

- Injury (scratches, broken bones), pain or death
- Wasted energy, increased feed costs
- Behavioural inhibition, withdrawal and depression
- Reduced ability to exploit resources
- Reduced egg production
- Eggshell abnormalities, poor hatchability
- Decreased growth
- Poor food conversion efficiency
- Delayed sexual maturation
- Downgraded eggs and carcasses
- Significant economic losses

Productivity is also negatively related to underlying fearfulness. Thus, fearful birds generally show poorer growth and food conversion efficiency, lower reproductive performance, an increased incidence of egg shell abnormalities, compromised hatchability, and reduced product quality (Barnett, Hemsworth, & Newman, 1992; Craig, Craig, & Dayton, 1983; Roque & Soares, 1994; Hemsworth & Coleman, 1998; Jones, 1996, 1997, 2001a). Furthermore, animals that are predisposed to be easily frightened cause management problems because they are difficult to handle and they are often less able to adapt to changes in their environment. Despite these recognized consequences of fear, little effort has been devoted to placing precise cash values on fear-related production losses; this may simply reflect an understandable reluctance to extrapolate from the results of small-scale laboratory studies and the difficulties in gaining access to commercial records because of their confidential nature. However, in studies carried out on a large number of Australian farms we found that chickens' fear of human beings accounted for 20% of the variation in egg production by commercial layers (Barnett et al., 1992) and for 28% of the variation in food conversion efficiency in meat-type broiler chickens (Jones, Hemsworth, & Barnett, 1993). Extrapolations from these findings carried out over 6 years ago suggested that the elicitation of fear could cost the UK broiler industry an additional £5 million on the feed bill each year and the egg industry twice that amount in reduced egg production (Jones, 1996).

Moreover, since fear exerts a progressively inhibitory effect on all other behavioural systems (Archer, 1976; Jones, 1987a, 1996), its elicitation is considered likely to compromise the birds' ability to interact successfully with each other or with the stockperson, to adapt to changes in their environment, and to utilize new resources.

Secondly, traditional battery cages for laying hens will be banned throughout the European Community from 2012 but the increased risk of damaging feather pecking is seen as a major obstacle to the widespread adoption of so-called welfare-friendly alternative systems, like percheries, aviaries or free range. Feather pecking occurs when one bird pecks at and pulls out the feathers of another (Blokhuis, 1989; Savory, 1995). To the best of my knowledge, no precise financial cost has been determined for the expression of this behavioural vice. However, severe feather pecking can substantially reduce profitability because de-feathered birds that are reared in cool climates lose heat faster, have greater energetic needs and, therefore, cost more to feed (Leeson & Morrison, 1978; Tauson & Svensson,

1980). Feather pecking also has potentially catastrophic implications for the birds' welfare for at least three reasons: i) they may suffer pain when they are pecked (Gentle, 1986); ii) the occurrence of pecking-related feather loss increases susceptibility to injury, particularly if subsequent panic reactions cause trampling and clawing (Jones & Hocking, 1999); iii) feather pecking and the removal of feathers can cause bleeding from the skin or follicles and may thereby lead to cannibalism and the painful death of target birds. Feather pecking is particularly problematic in alternative housing systems because it is much more difficult to control when the birds (laying hens, broiler breeders, turkeys, pheasants, guinea fowl, ducks) are kept in large flocks. The remedial measures (beak trimming; low light) that are currently used have associated welfare problems. For example, cutting off the tip of the beak can cause chronic pain (Gentle, 1986) and keeping the birds under low light intensities not only impoverishes the visual environment but it can also result in malnutrition if chicks have difficulty in seeing the feeders (Deaton, Reece, McNaughton & Lott, 1981) and in the development of eye abnormalities, such as dim-light bupthalmos and retinal detachment (Manser, 1996).

Clearly it is imperative to identify effective, ethically acceptable and practical methods of reducing harmful behaviours, like fear, feather pecking, cannibalism and aggression, from the birds', the farmers' and the public's viewpoints. It is important to note that feather pecking, cannibalism and aggression are distinct behaviours that are thought to reflect different motivational states (Keeling, 1995). It must also be emphasized that although the importance of aggression in the domestic fowl has been somewhat downplayed it is actually becoming a significant problem in some breeds (King, 2001). For example, aggressive pecking can lead to substantial injury in broiler breeders, perhaps because they are maintained on a restricted feeding schedule (King, 2001).

The above findings have not always been taken into account in the development of husbandry practices or in the design of breeding programmes and housing systems. Indeed, chickens are still frequently housed in barren, monotonous environments; these provide little to occupy their interest and they can exacerbate the development of undesirable and abnormal behaviours. On a positive note though, this situation provides ample opportunities for improving the birds' quality of life and its productivity by making appropriate and often simple changes to their environment or to their background genome. Indeed, advances in the welfare of poultry and other farm animals can often be made by: a) establishing selective breeding programmes for desirable traits, such as docility and adaptability, and against deleterious ones like hyper-aggression, feather pecking and cannibalism, b) determining the effects of manipulating the animals' environment in order to identify beneficial and practicable ways of improving their welfare, and c) reducing fear of humans by changing the nature of man-animal interactions.

Briefly, genetic selection is becoming increasingly regarded as a quick and reliable method of promoting welfare-friendly characteristics and of removing harmful ones across whole populations (Craig & Swanson, 1994; Mench, 1992; Jones, 1996; Jones & Hocking, 1999). More specifically, selective breeding for reduced fear and feather pecking and for appropriate levels of underlying sociality is considered likely to improve the welfare and, probably, the productivity of farmed poultry (Craig & Muir, 1998; Faure & Mills, 1998; Jones, 1996; Muir, 1996; Jones & Hocking, 1999; Jones & Mills, 1999). This type of genetic strategy

could conceivably provide relatively rapid solutions for certain behavioural problems, as long as there are no associated undesirable effects and that any consequent reduction in productivity is either minimal or counterbalanced by demonstrable economic advantages. The latter benefits could include premium prices for welfare-friendly products or other financial gains made through the reduction of stress-induced impairment of growth, reproductive performance or product quality. Therefore, in collaborative studies with colleagues in France and North America we have developed genetic lines of Japanese quail showing contrasting levels of underlying fearfulness, adrenocortical responsiveness, sociality (motivation to be near companions), or growth; we have then used birds from these experimental lines as tools to investigate the mechanisms underpinning these traits as well as their associated behavioural, physiological and morphological consequences (Faure, Bessei, & Jones, in press; Jones & Hocking, 1999; Jones, Marin, Satterlee, & Cadd, 2002b; Jones & Mills, 1999; Jones, Satterlee, & Marks, 1997; Jones, Satterlee, Waddington, & Cadd, 2000; Satterlee, Cadd, & Jones, 2000). Encouragingly, these studies revealed that underlying fearfulness was reduced in Japanese quail by selection for just one behavioural measure (attenuated tonic immobility reactions), one physiological reaction (reduced plasma corticosterone response to brief mechanical restraint) and one production parameter (growth). Studies like these may help to identify suitable selection criteria for future breeding programmes. For instance, our findings that selection for reduced adrenocortical responsiveness to mechanical restraint was associated with decreased fearfulness, a non-specific attenuation of adrenocortical sensitivity to stressful stimuli, greater sociality, increased developmental stability, accelerated puberty and improved egg production (Jones et al., 2000; 2002b; Marin, et al., in press; Satterlee et al., 2000; Satterlee, Marin, & Jones, 2002) strongly support our contention that selective breeding for reduced fearfulness, for decreased stress responsiveness, and for appropriate levels of sociality could-and probably should-be used to provide welfare-friendly and practical solutions to some of the main behavioural problems facing the poultry industry (Faure et al., in press; Jones & Hocking, 1999; Jones et al., 2000; Satterlee et al., 2000).

For present purposes though, I will now focus primarily on studies that were designed to assess the effects on welfare of manipulating the birds' physical environment; these were carried out either at the Roslin Institute or in collaboration with my colleagues elsewhere. Forty years ago, Denenberg (1962) pointed out that environmental factors exert profound effects on the immature organism and that it is possible to dramatically change an animal's behavioural and physiological capabilities through the appropriate manipulation of environmental dynamics. These statements apply to all animals, including the domestic fowl (Jones, 1987a, 1996; Wemesfelder & Birke, 1997). Indeed, chickens actively seek stimulation (Mench, 1994; Newberry, 1995; Rogers, 1995; Jones, 1996). For example, hens housed in pens that contained sufficient resources still spent a proportion of their time exploring an empty area adjacent to the pen (Nicol & Guildford, 1991). The fact that much of the exploratory behaviour that chickens show is voluntary and interactive supports the viewpoint that it should be regarded as an integral part of their behavioural development. Furthermore, depriving animals of "sufficient" amounts of extraneous stimulation can engender apathy and boredom (Wemesfelder & Birke, 1997) and increase the expression of damaging behaviours, like fear, feather peck-

ing, aggression and social withdrawal (Huber-Eicher & Wechsler, 1998; Jones, 1987a, 1996, 2001a). The identification of practicable changes to housing and husbandry procedures can also help to improve poultry welfare significantly and rapidly because an animal's development is shaped by its environment and experience as well as by its genome. For instance, environmental enrichment has been reported to increase the birds' behavioural repertoire, to reduce underlying fearfulness, to lessen feather pecking, to decrease the incidence of trauma and injury when battery cages are depopulated, and to improve the overall health and productivity of the flock (Braastad, 1990; Gvaryahu, Ararat, Asaf, Lev, Weller, Robinzon, & Snapir 1994; Huber-Eicher & Wechsler, 1998; Jones, 1996, 1987a; Jones, Harvey, Hughes & Chadwick, 1980; Jones & Waddington, 1992; Reed, Wilkins, Austin, & Gregory, 1993; Vestergaard, Kruijt, & Hogan 1993). Moreover, environmental enrichment further reduced fear responses in lines of quail that had been selected over several generations for decreased fearfulness (Jones, Mills, & Faure, 1991). The increasing trend towards incorporating various types of cage furniture, such as nest boxes, dust baths and perches, is often referred to as environmental enrichment. Indeed, it forms the basis of various types of so-called "enriched cages" for laying hens (Appleby & Hughes, 1995; Elson, Walker & Short, 2001; Tauson & Holm, 2001). This strategy is generally considered likely to improve the birds' health and welfare by satisfying some of their behavioural needs, e.g., for partial seclusion while laying an egg, for a suitable substrate with which to dust-bathe and clean the feathers, and for roosting. However, in the present paper I concentrate on enrichment in its more traditional sense. This involves increasing the complexity and stimulus value of the home environment and thereby promoting animal-environment interaction. This type of enrichment is normally achieved by providing the birds with conspicuous, manipulable objects, although there is also scope for incorporating pictures, diverse feeds, sounds and smells (Jones, 1996; Jones & Roper, 1997; Newberry, 1995; Mench, 1994).

In this paper I describe selected studies of chickens' responses to extraneous visual, auditory, olfactory and tactile stimulation. Attempts to assess the effectiveness of environmental enrichment for domestic or captive animals are often hampered by the absence of complete ethograms and time budgets for feral counterparts and the consequent lack of a baseline for comparison. However, we can at least partially overcome this difficulty by using surrogate measures, such as approach/avoidance responses to putative enrichment stimuli, the frequency and duration of contact, and the animals' patterns of response with repeated exposure (Renner, Feiner, Orr, & Delaney, 2000). Our studies posed five main questions. First, do chickens find an enriched environment attractive? Second, could video playback be used as a tool to identify influential attributes of selected stimuli and thereby guide the development of visual enrichment procedures? Third, might the stockperson be able to provide a simple and beneficial source of auditory enrichment by simply switching on the radio? Fourth, can we improve the welfare of chickens by exploiting their sense of smell and the potentially fear-reducing properties of familiar or imprinted odourants. Fifth, can we identify the types of physical / tactile stimuli that are capable of sustaining chickens' interest and diverting potentially injurious pecking away from their companions. This paper describes the answers to each of these questions and discusses their implications for the development of practicable and effective environmental enrichment for poultry.

Do Chickens Find Enriched Environments Attractive?

The attractive properties of various types of flooring for the domestic fowl, such as wood shavings, artificial turf, sand, straw or wire, have been examined in some detail, often in choice experiments (Dawkins, 1981; Hughes, 1993; Petherick, Seawright & Waddington, 1993). However, all these studies had focused on determining the effects of changing just one feature of the birds' environment. No effort had been made to determine if chickens actually preferred an environment that incorporated a variety of conspicuous artificial objects to a non-enriched one.

Although there is some debate concerning the interpretation and value of preference tests (see Fraser & Matthews, 1997) it has been proposed that, "if the various stimuli are equally healthful or neutral, the observer may be able to draw conclusions about those stimuli to which the animal prefers being exposed" (Bayne, Hurst & Dexter, 1991). I subscribe to the notion that the results of simple preference tests provide useful building blocks for more stringent, in-depth study. For example, rather than just offering the birds a straightforward choice between an enriched and a non-enriched environment, we adopted a more critical approach by asking if we could alter previously established environmental preferences by the introduction of potentially enriching stimuli (Jones & Carmichael, 1999a). Pairs of domestic chicks were reared in wooden boxes from 1 day of age and their position in one or other of the seemingly symmetrical halves of the box were noted at each of 32 visual scans carried out every day for 10 consecutive days. We calculated the cumulative sightings over the first 5 days in order to establish which was the least preferred half in each box; such preferences proved to be particularly striking (see below). When the chicks were 6 days of age three "enrichment objects" (a length of rubber tubing, a bunch of white strings, and a plastic table-tennis ball spotted with various colours) were introduced into the least preferred half of the cage. Each of these items was suspended from the top of one of the walls so that it swung freely if it was pecked, pushed or pulled and they remained in the box until the study ended 5 days later. We found that the chicks avoided the half of the box containing these objects immediately after their introduction. However, such neophobia had waned after 24 hours and an overall numerical trend ($p = 0.13$) towards increased usage of the enriched half became apparent over the ensuing 4 days.

Our observation that virtually all the chicks had established strong preferences for one side or the other of the home cage by the time they were 5 days old sounds an important cautionary note for the design of studies intended to assess environmental preferences. In other words, the existence of unknown side preferences could confound laboratory and on-farm studies of chickens' attraction towards and their consequent use of specific resources. Similar preferences for one side of a symmetrical cage have also been reported in rhesus monkeys (Bayne et al., 1991) and in laboratory rats (Calcagnetti & Schechter, 1992).

Although increased usage of the enriched half failed to reach significance ($p = 0.13$) in our study (Jones & Carmichael, 1999a), this tendency may still have reflected a positive choice (Duncan, 1978). Furthermore, within this trend, a highly significant shift in preference to the enriched half was shown by 20% of the chicks (Jones & Carmichael, 1999a). These findings are consistent with reports that lay-

ing hens readily looked through a spy-hole in the otherwise occluded front of the cage in order to view another hen or just the outside area (McKenzie, Andrew & Jones, 1998), and that chicks of a broiler (meat-type) strain moved readily through a gate in the wall of their home pen into an adjoining area if it contained novel objects (Newberry, 1999). Collectively, they suggest that chickens do find enriched environments attractive.

Are Chickens Attracted to Video Images and Can their Responses Guide Environmental Enrichment?

Televised images are now being increasingly used as tools to study behaviour and cognition in a wide variety of mammalian, amphibian, crustacean, reptilian, and avian species, including chickens (Clarke & Jones, 2000c; D'Eath, 1998). Video playback offers numerous benefits, including the standardization, controllability and ease of manipulation of presented stimuli. The biological relevance of this approach for the domestic fowl was demonstrated when exposure to video images of feeding or dust-bathing conspecifics was found to induce adult hens to show similar behaviours, presumably via social facilitation (McQuoid & Galef, 1993; Keeling & Hurnik, 1993). Furthermore, chickens exhibited appropriate anti-predator responses when they were shown televised images of ground or aerial predators (Evans & Marler, 1991; Evans, Macedonia, & Marler, 1993) and a video of a threatening conspecific delayed feeding in viewing hens (D'Eath & Dawkins, 1996).

At Roslin, we have examined chickens' responses to biologically neutral stimuli like screensavers, (images that are normally used to delay the degradation of a computer screen). Screensavers were used because we wished to minimize any potentially confounding connotations of feeding, social attraction or predation. Chicks that were housed either individually (Jones, Larkins, & Hughes, 1996) or in small groups (Jones, Carmichael, & Williams, 1998) rapidly became attracted to and showed progressively increasing interest in video images of screensavers when these were presented at one end of their home cages for brief periods on each of up to 11 consecutive days. The chicks spent more time near a familiar screensaver than a blank, illuminated television screen when they were subsequently tested in an unfamiliar two-choice runway apparatus, and a moderately novel screensaver was preferred to the familiar one (Jones et al., 1996). These results demonstrated that the chicks remembered the videos and that moderate novelty was attractive. Similarly, when a video of the "Fish", Apple Macintosh screensaver was presented to individually caged adult laying hens for 10 min on each of 20 consecutive days it attracted positive interest by the third day, i.e. the hens spent much of the test period with their heads out of the cage and looking at the screen (Clarke & Jones, 2000a). Such interest was then sustained for as long as 8 days and although it waned gradually thereafter it was fully restored when an unfamiliar video ("Doodles") was presented on day 21 (Clarke & Jones, 2000a).

Chicks were also strongly attracted to a familiar screensaver when it was incorporated in an open-field (novel environment) test situation (Clarke & Jones, 2000b), thus reinforcing the runway data described above. Furthermore, those chicks that had received regular exposure to video stimulation in their home cages

showed less pronounced fear responses than controls when they were tested individually in a totally unfamiliar arena even in the absence of the familiar video image (Clarke & Jones, 2000b). This finding suggests that regular exposure to video stimulation may have reduced the chicks' underlying fearfulness.

Collectively, our findings suggested that video playback might represent a form of environmental enrichment because of its fear-reducing effects and its ability to sustain interest. We have since dissected selected images into their component features in order to determine the specific attributes of abstract video stimuli that influence their attractiveness to chickens. We accomplished this by simultaneously presenting groups of chicks with two video images differing in just one of the selected features for brief periods on each of 10 consecutive days; in each case the television monitors were placed at opposite ends of the chicks' home cage. The birds exhibited significant preferences for videos displaying certain features (Table 2).

Table 2
Relative Attractiveness of Selected Features of Video Images.

•   Moving (2 cm/s) > Static
•   Bright (38 lux) > Dull (18 lux)
•   Coloured > Black and White ("Greytone")
•   Complex (Fish) > Simple (Bouncing Square)
•   Cartoon > Screensaver (Fish)

Note. *The first four pairings were of screensavers.*

Thus, the chicks spent significantly longer near bright rather than dull (38 versus 18 lux), moving rather than still, and coloured rather than black and white versions of the Fish screensaver video (Clarke & Jones, 2000c). They also preferred a relatively complex "Fish" screensaver to a simple one of a bouncing square (Square) and a more complex cartoon ("The Simpsons") rather than the "Fish" programme. The expressed preferences were strongest when chicks were exposed to complex stimuli ("Fish", cartoons). Since attraction to a novel compound stimulus increases when it shares common features with a familiar one (Bateson & Horn, 1994) it might be argued that the chicks' preference for complex images may have reflected the fact that they contained several of the properties shared with their siblings, such as colour, movement, and complexity.

Repeated exposure elicited progressively more interest in the video images, regardless of their content, in all of our studies. The apparent strength of this motivation to explore extraneous stimuli presents a powerful argument for providing chickens with appropriate types of environmental enrichment. The video images were presented outside the birds' cages in the above experiments. We also know that adult hens will readily look through spy-holes in order to view an unfamiliar area or other birds (McKenzie, Andrew, & Jones, 1998), that the expression of abnormal behaviour was reduced in individually housed monkeys when they were kept in a room with a view (O'Neill, 1989), and that video stimulation is already used to enrich the lives of captive primates (Platt & Novak, 1997). Collectively therefore, these reports strongly support previous recommendations (Jones, 1996; Newberry, 1995) that we should enrich the environment outside as well as inside an animal's cage.

We must bear in mind that the chicks were presented with video images for relatively brief periods each day in the above studies and that adult hens gradually lost interest if the same image was shown repeatedly. From a practical point of view, it is important to determine whether the birds' interest could be sustained for longer or even indefinitely if a video screen remained switched on permanently while showing a wide range of images that changed frequently.

Clearly, video technology provides a useful laboratory tool for investigating chickens' perception and regulation of their visual world. By enabling us to identify the birds' preferences for certain features of selected types of stimuli it may guide the development of enrichment procedures. For instance, our findings suggest that visual enrichment stimuli should incorporate movement, brightness, colour, and moderate complexity in order to be effective. I am not suggesting that television sets should be incorporated in poultry houses; that would clearly not be practical. On the other hand, it is conceivable that the projection of selected video images onto the walls or roof of a poultry shed might represent an affordable and manageable source of diverse and changing stimulation that might, in turn, benefit poultry welfare. This notion has received positive feedback from several poultry farmers but the premise remains to be tested.

Is Playing the Radio Beneficial?

A number of anecdotal reports that have appeared in trade journals suggest that playing music to chickens helps them to "thrive" (e.g., Anonymous, 1994). However, the potential use of taped music or radio broadcasts as beneficial forms of auditory enrichment has received virtually no empirical attention. This apparent neglect almost undoubtedly reflects the fact that attempts to assess the effects of auditory stimulation are confounded by its diffuse nature. For example, meaningful statistical analysis is hampered by the difficulties involved in separating control from experimental treatments and by the attendant problem of obtaining sufficient replicates. Despite such difficulties, Ladd, Albright, Beck, and Ladd (1992) reported that playing radio music to laying hens reduced the ratio of circulating heterophils to lymphocytes, which is a recognized index of stress (Gross & Siegel, 1983; Jones, 1989; Maxwell, 1993).

Growing interest in these reports prompted a joint survey with the National Farmers Union. A sample of over one hundred poultry farmers in the United Kingdom was randomly selected and we then determined how many of them played the radio to their birds and what benefits, if any, they had perceived. Forty six percent of the farmers surveyed were found to routinely play music to their flocks (Jones & Rayner, 1999). Of these, 96% claimed that music calmed their chickens, 52% felt that the birds were less aggressive, 20% reported healthier birds, and 16% claimed that their hens laid more eggs. Thus, both welfare and economic benefits were apparent. Encouragingly too, 90% of those farmers who had not previously played the radio to their flocks said that they would do so after they had seen the results of the survey. Overall, the farmers claimed that playing easy listening and chart music resulted in the most beneficial effects but that jazz and heavy metal were the least popular. Interestingly, unlike heavy metal music that was found to elicit barking and agitation, playing classical music had a calming effect on kennelled dogs at a rescue shelter (Wells, Graham, & Hepper, 2002). Of course, these findings proba-

bly tell us more about the farmers' and the caretakers' likes and dislikes than the animals' listening preferences. It must also be borne in mind that our study relied upon the analysis of anecdotal rather than empirical data. However, in this context it must be emphasized that the use of on-farm surveys is becoming increasingly accepted because of the significant constraints on the application of rigorous experimental procedures at commercial establishments.

Although we have relied thus far on the analysis of anecdotal evidence it is conceivable that we could place this phenomenon on a firmer, empirical footing. Firstly, for instance, the effects of exposure to music on selected behavioural, physiological and production measures could be investigated either in the laboratory or on farm if access was available to sufficient numbers of sound-attenuated rooms or poultry sheds to satisfy statistical requirements. Secondly, by using operant conditioning paradigms in the laboratory we could determine whether or not chickens choose to hear the radio; if they did we could establish the precise amount and the type of auditory stimulation that they prefer by giving them the opportunity to switch it on and off. For example, individually-caged birds could be taught to control the on / off switch by pecking at one of two dedicated keys or by simply crossing from one side of the cage to the other and thereby breaking a photobeam. The identification of individuals that pecked at the on and off keys when chickens were housed in groups might also determine whether such auditory stimulation is attractive to the majority of the flock or only to a small minority. Of course, we might then be faced with having to make a greater good type of decision.

There are several possible explanations for the apparent benefits of playing the radio. Some or all of these interpretations might also exert additive or interactive effects. Firstly, listening to the radio might amuse and calm the stockpersons and thereby improve their care of the animals. Secondly, those farmers who play music to their animals may do so because they are more concerned about their welfare and, as a consequence, they might adopt better practice in general and thereby promote greater productivity. Thirdly, the birds' need for stimulation (Mench, 1994; Newberry, 1995) might be at least partially satisfied by the provision of additional and varied sounds. Fourthly, and probably most likely, playing the radio could help the birds to learn that unfamiliar sounds are not necessarily dangerous. This mechanism is thought to underpin many of the fear-reducing effects of more traditional forms of environmental enrichment (Gvaryahu et al., 1994; Jones, 1996; Reed et al., 1993). Such an effect could, in turn, reduce the likelihood that the birds would panic when they heard sudden, unfamiliar or loud noises, such as a person sneezing or shouting, the clang of a dropped bucket, the noise of a car door being slammed, or the roar of a low flying aircraft. Interestingly, while turkeys panicked upon their initial exposure to simulated aircraft overflight noise they soon habituated with repeated stimulation (Book & Bradley, 1990).

In conclusion, switching on the radio is probably the easiest and most practicable way of enriching the environment for the chickens and for the farmers.

Can we Reassure Chickens by Providing Familiar Odours in Otherwise Unfamiliar Situations?

Chickens possess a moderately well developed olfactory system but, surprisingly, the existence of a functioning sense of smell was regarded as either to-

tally lacking or very poor for many years (Wood-Gush, 1971; Fischer, 1975). However, there is now compelling behavioural and neurobiological evidence that olfaction plays an influential role in the chicken's perception and regulation of its world (Jones & Roper, 1997). For example, odours associated with predators, conspecific blood or specific aversants caused alarm, avoidance and disgust responses; chickens were able to use odours as discriminative stimuli in conditioning paradigms; and they were generally attracted to odours with which they had become familiar (Fluck, et al., 1996; Jones & Black, 1979; Jones & Gentle, 1985; Jones & Roper, 1997; Marples & Roper, 1996; 1997; Rogers, 1995; Stattelman, Talbot, & Coulter, 1975; Vallortigara & Andrew, 1994).

The fact that chickens can regulate their behaviour in response to odourants could have important implications for their husbandry, welfare and productivity. For example, chickens may encounter a range of unfamiliar stimuli, such as novel places, objects, food, smells, birds and people during their lifetime. As described above, exposure to novelty is often frightening, the elicitation of fear can seriously damage productivity, and the expression of inappropriate fear responses can cause injury or death (Jones, 1996; 1997). Other issues causing concern include the fact that many chickens are reluctant to venture out from familiar, sheltered areas into unfamiliar or exposed ones, including free range, and that they are generally hesitant to utilize unfamiliar resources, to accept new food, or to approach and interact positively with strange birds. Clearly, practical solutions are required for these sorts of problems. We reasoned that if chicks formed attachments to certain odourants (see Jones & Roper, 1997) then incorporating these smells in otherwise unfamiliar situations might serve to reassure the birds.

We have shown that chicks preferred the familiar soiled substrate from their home cage to clean wood shavings or to those soiled by a strange chick when they were tested in a novel Y-maze (Jones & Faure, 1982; Jones & Gentle, 1985). The shavings taken from the home and the stranger's cages were visually similar, at least to the human eye, and their presentation under wire floors that prevented them being pecked minimized any gustatory influences. Similarly, chicks that had been reared individually with a perforated tube containing soiled litter from the nests of adult hens subsequently preferred it to an unscented tube in an unfamiliar two-choice test situation (Burne & Rogers, 1995). The chicks' preferences for familiar substrates in both these studies were probably based on naturally occurring olfactory cues, perhaps those associated with excreta or other bodily secretions.

Table 3
Summary of Chicks' Responses to Familiar Artificial Odourants.

Breed	Odourant	Medium	Attraction?
Australorp	Garlic	Perforated tube	NO?
Sussex x Warren	Clove oil	Perforated tube	YES
Thornber	Orange oil	Wood shavings	YES
Thornber	Geranium oil	Wood shavings	YES
ISA Brown	Vanillin	Petri dish	YES

Chicks' preference for familiarity has also been shown to embrace artificial smells, i.e. pure odourants (Table 3). Thus, chicks that had been exposed to a particular odourant throughout rearing were strongly attracted to a source of the same odour when it was presented in an otherwise unfamiliar environment (Jones

& Carmichael, 1999c; Jones & Gentle, 1985; Vallortigara & Andrew, 1994). This phenomenon was common to chicks from four breeds, to three methods of presentation, and to at least four artificial odourants.

It had been claimed that chicks that were exposed to perforated tubes containing crushed garlic during rearing failed to become attached to this odourant (Burne & Rogers, 1995). However, closer examination of the same data (see Jones & Roper, 1997) suggested that an attachment to garlic did appear but that it was simply weaker and took longer to develop than did that towards the odour of nesting material. Unless an odourant causes trigeminal irritation, is intrinsically unpleasant or associated with toxicity, I suspect there might be no limit to this phenomenon.

The presence of a familiar odourant (geranium oil) also increased vocalisation, locomotor activity, environmental pecking and preening when chicks were tested individually in a novel and hence frightening environment (Jones & Gentle, 1985). Because fear is negatively associated with activity and vocalization (Boissy, 1990; Jones, 1996), this finding suggested that the presence of the familiar odour decreased the intensity of fear-induced behavioural inhibition. We recently reexamined the reassuring properties of a familiar odourant (vanillin) using a new index of fear-reduction. Chicks were reared in groups in wooden boxes with dishes of vanillin placed underneath each wire grid floor. Vanillin was chosen because we knew that chicks readily form attachments to it, it is not associated with toxicity, it has no discernible irritating properties, and it is inexpensive and easily available (Jones & Carmichael, 1999c).

At 8-10 days of age, the chicks were tested once only in pairs of familiar cage mates in a novel environment (open field) containing a central food supply placed on top of the wire floor and with a dish of either vanillin or a colour-matched, odourless food dye placed under the wire floor and directly beneath the food dish. The chicks moved apart significantly sooner and further when this novel test arena contained vanillin rather than the odourless control (Figure 1); they also tended to walk sooner and to pace, preen and peck at the environment more often (Jones, Facchin & McCorquodale, 2002). Furthermore, more pairs moved apart or fed in the presence of vanillin. These results suggest that the familiar odour reduced fear in the open field because frightened chicks would be expected to disperse and to feed only when their fear levels had waned sufficiently (Suarez & Gallup, 1983; Vallortigara, Cailotto, & Zanforlin, 1990; Jones & Mills, 1999). The familiarity value of this olfactory cue is the most likely influential variable because vanillin possesses no anxiety-reducing properties per se, i.e., there were no detectable effects when chicks with no previous experience of vanillin were tested in the open field in the presence or absence of this odourant. Regardless of the underpinning mechanisms, our results strongly suggest that the presence of this familiar odourant reassured the chicks in this otherwise unfamiliar test situation.
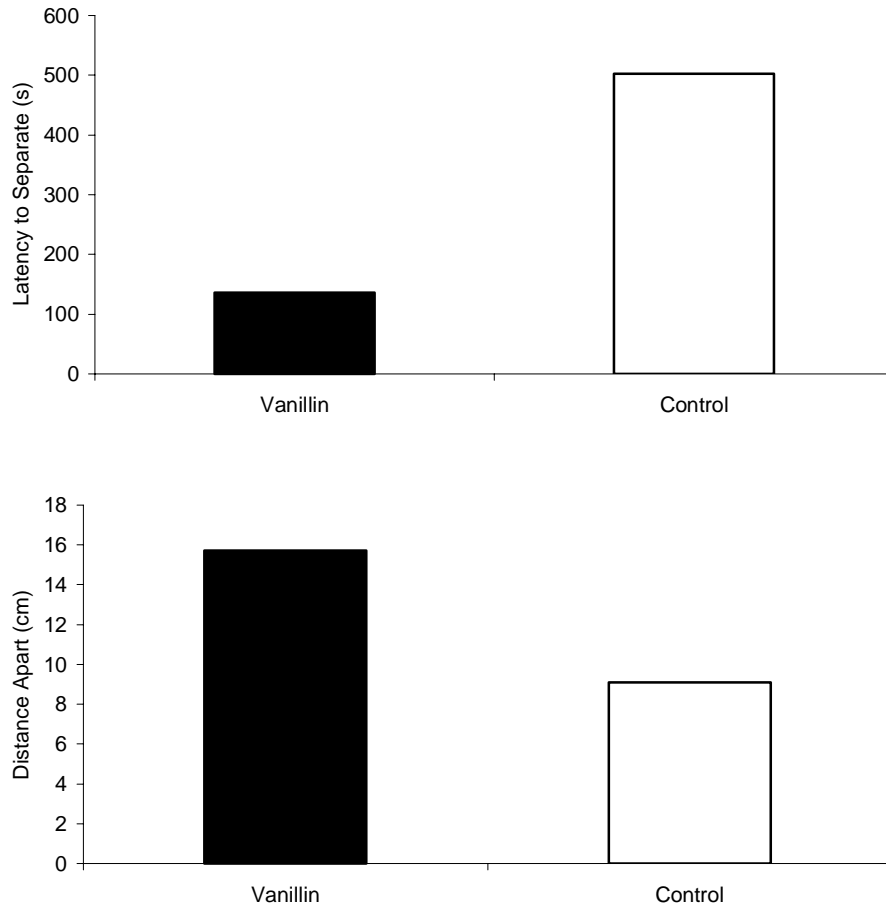
Figure 1. Latencies for pairs of chicks to move 20 cm apart and their social dispersal scores (mean distance apart) when tested in a novel environment in the presence or absence of a familiar odourant.

Chickens can differentiate between cagemates and strangers at an early age (Marin, Freytes, Guzman, & Jones 2001; Rajecki, Ivins, & Rein, 1976; Vallortigara, 1992) and since they may be occasionally exposed to unfamiliar birds in new surroundings under modern farming practice this could lead to xenophobia, aggression and distress (Jones, 1996). Therefore, we asked if the presence of a familiar odourant (vanillin) would increase social affiliation when two unfamiliar pairs of chicks were tested in a novel arena (Jones & Redman, 2002). Each pair of chicks was placed at opposite sides of the open field at 8 or 9 days of age; a dish below the wire floor contained either vanillin or a colour-matched odourless solution of food dyes. The members of each pair were familiar to each other but strangers to the other pair. We tested pairs of chicks rather than individuals in order to facilitate assessment of xenophobia rather than just separation anxiety. The results are shown in Table 4.

Table 4
Social Affiliation Behaviours when Pairs of Unfamiliar Chicks were Tested in an Open Field in the Presence or Absence of a Familiar Odourant (means $\pm$ standard errors).

Measure	Odourant	No odourant	p =
Latency to approach (s)	64.8 ± 10.5	166.5 ± 43.5	0.03
Latency to touch (s)	91.3 ± 11.7	205.5 ± 42.5	0.02
Distance apart (cm)	16.2 ± 0.5	20.2 ± 0.5	0.02

The strangers approached each other and made physical contact sooner and then stayed closer together during the 10-min observation period when the familiar odour of vanillin was present (Jones & Redman, 2002). There was no evidence of inter-bird pecking in either treatment group. Our findings indicate that the inhibitory effects of enforced exposure to the novel environment on activity and social affiliation were weakened by the presence of the familiar smell; it may have also reduced the chicks' fear of strangers.

The diet is generally changed at various stages during a chicken's development, for instance, chicks and adults may be fed starter or layer diets, respectively, and this can involve changes in the consistency, texture, taste, odour or colour of the feed (Murphy, 1977). A reluctance to accept an unfamiliar food is often apparent (Jones, 1986; Vilarino et al., 1998). Such hesitancy to feed may occur because food habits have become fixated, the birds may temporarily fail to recognize the new diet as food, or the novel features may frighten them. Whatever the mechanism, even a transient reluctance to accept the new feed may damage egg production and eggshell quality and cause the birds to redirect their pecking towards the drinkers or other birds leading to diarrhea, wet droppings and feather pecking, respectively (Vilarino et al., 1998).

Chicks are sensitive to odourized food (Jones & Roper, 1997). However, previous studies had only focused on olfactory neophobia; the presence of a novel odour markedly retarded the birds' acceptance of both familiar and unfamiliar diets (Jones, 1987b; Marples & Roper, 1996; Turro, Porter, & Picard, 1994). Interestingly, salivary pheromones were thought to have mediated the preferences shown by bobwhite quail for familiar feeders (Frings & Boyd, 1952). Therefore, I asked if a form of olfactory imprinting could be used to accelerate acceptance of a new diet (Jones, 2000). Chicks were housed in pairs and reared on a diet of starter mash from the first day of age. A piece of filter paper was attached to the back of each food dish with invisible tape and 5 drops of vanillin were applied to it twice a day. The chicks were then acclimatized to a daily regime of brief food withdrawal and return. At 8 days of age they were presented with the same food in an unfamiliar form (crumbs) after the dishes had been treated with either vanillin or water. The presence of the familiar odourant accelerated feeding and increased the chicks' consumption of the novel food over a 30-min test. These findings suggest that domestic chicks' attraction to familiar odourants could be exploited to minimize some of the problems caused by dietary change. One might also speculate that "olfactory therapy" may combat the long-term dietary conservatism shown by some household birds, such as canaries (Marples & Kelly, 1999). This approach seems practicable because odourants/flavourants are already routinely incorporated in many livestock feedstuffs. Furthermore, the fact that just a modest change to the diet induced a reluctance to feed in the control chicks used in the above study (Jones, 2000) suggests that the remedial effect of associating a familiar odour with

an unfamiliar food might be even greater if the novel features of that food were more pronounced.

In conclusion, our findings confirm that chickens regulate many of their behaviours in response to odours and that they are quite capable of forming olfactory memories. We have shown that the presence of a familiar odourant attracted the birds, decreased fear-induced behavioural inhibition, increased social dispersal, reduced fear of strangers among chicks placed in unfamiliar surroundings, and accelerated chicks' acceptance of a novel diet. Collectively, these findings support the hypothesis that familiar odourants can act as reassuring agents when chickens encounter otherwise unfamiliar and potentially distressing situations. The mounting evidence for the formation of olfactory memories in the chick embryo (Turro-Vincent, 1994; Rogers, 1995; Sneddon, Hadden, & Hepper, 1998) illustrates the need to identify the developmental stages at which attachments to odourants are most strongly established. Using artificial odourants to minimize behavioural problems seems practicable for several reasons. For example, many odourants are widely available, they are not overly expensive, they are easy to apply, and, because of their volatility, they are likely to be perceived by all members of the flock. By making new environments and intuitively beneficial resources more attractive to the birds, and by reducing their fear levels, such olfactory therapy could lead to significant improvements in poultry welfare and productivity. This phenomenon might also generalize to include other species; indeed, familiar and reassuring fragrances are already being used to alleviate anxiety in human beings (Lehrner et al., 2000) and they are thought to exert antidepressant effects in rats (Komori et al., 1995).

Can we Develop Enrichment Devices that Sustain Long-Term Interest and Reduce Harmful Inter-Bird Pecking?

Can we Identify Influential Attributes?

Environmental enrichment for poultry has become a topic of worldwide interest but there has been little effort to standardize the various approaches. For example, the various research teams have used a wide array of objects and pictures as enrichment stimuli; these have included drawings, silver paper, buttons, rubber tubing, shoestrings, flowers, childrens' toys, baubles, balls, bells, wooden blocks, branches, stones, chairs, motorized devices and commercially available toys. Their incorporation into the birds' home cages was primarily intended to decrease the incidence of potentially harmful behaviours, such as fear, feather pecking, aggression, and apathy and to reduce underlying distress. However, many of the so-called enrichment stimuli were either ignored by the birds or they elicited little interest, perhaps because they offered no obvious reward (Gao et al., 1994; Jones & Rayner, 2000; Sherwin, 1993). Furthermore, the results of enrichment studies carried out in different laboratories have sometimes lacked consistency. For instance, the provision of plastic rods, operant feeders, and a commercially available enrichment item (Agri-Toy) actually increased aggressive pecking among laying hens housed in floor pens (Lindberg & Nicol, 1994), though the authors attributed this finding to frustration caused by the operant feeder. Such apparent inconsistencies might simply reflect the fact that enrichment stimuli have often been chosen

according to cost, availability and human preconceptions of what a chicken might find enriching rather than a critical consideration of the birds' actual preferences and predispositions. Not unexpectedly, there is growing agreement that the design of enrichment devices requires more critical thought (Jones, 1996; Newberry, 1995; Mench, 1994). However, as Webster (1994) pointed out, it may be reassuringly easy to assert that sentient animals should not be kept in barren enclosures but it is less easy to decide precisely what to do for the best.

There is substantial evidence that the ability to exert some degree of control over the environment is of biological and psychological importance to animals (Markowitz & Line, 1989; Mench, 1994; Sambrook & Buchanan-Smith, 1997). A logical extension of this argument suggests that the amount of control that an animal can exert in its attempts to either avoid or seek stimulation may influence the effectiveness of enrichment procedures. For example, laboratory primates made much more use of devices that they could control and that responded to them in some way (Markowitz, & Line, 1989) and rearing rhesus monkeys in controllable rather than uncontrollable environments led to reduced fear and increased exploration (Mineka, Gunnar, & Champoux, 1986). Thus, while televised images and radio music sustained chickens' interest and exerted several beneficial effects (see above) they offered the birds little controllability. For these reasons, we have screened a number of intuitively attractive stimuli with which the birds could choose whether or not to interact and that would respond to the chickens in some way, primarily movement, if they were pecked or nudged.

More specifically, in view of the hypothesis that feather pecking occurs as a result of misdirected environmental pecking (Blokhuis, 1986, 1989), I believed that a possible remedial measure would be to develop a sufficiently attractive inanimate target that might serve to redirect pecking behaviour away from other birds. Furthermore, hens that had been given blue-dyed food during the first few days after hatching and then provided with blue key-stimuli on the floor during adulthood pecked more at the floor and showed less preening and improved plumage, probably indicating less feather pecking (Braastad, 1990). My train of thought was reinforced by a recent argument that chicks of two lines showing high and low levels of feather pecking were predisposed to direct exploratory pecks at animate and at inanimate stimuli, respectively (van Hierden et al., 2002). Therefore, our primary objectives were: (a) to systematically establish chickens' specific pecking preferences when they were presented simultaneously with a range of stimuli, (b) to thereby identify practicable enrichment devices that would reliably attract and sustain the birds' interest, and (c) to rigorously test their effectiveness in reducing the amount of damaging inter-bird pecking. Our overall approach involved a series of experiments.

The first step involved determining chickens' responses to different types or classes of stimuli. A number of pecking devices were introduced simultaneously and in various combinations into the home cages of pairs of ISA Brown or Lohmann Brown chicks either for brief daily periods from 6-10 days of age or continuously over that period. Preference was defined as the tendency for the chicks to peck sooner and more often at one device than the others. The selected stimuli were always suspended from the tops of the cage walls with clear nylon fishing line (of high breaking strain) so that they were approximately 2.5 cm off the floor. The chicks consistently pecked substantially more at bunches of string (white

polypropylene baling twine) than at Christmas tree baubles, beads, tubing, lengths of chain, or feathers taken from other chicks (Jones, Carmichael, & Blokhuis, 1997; Jones, Carmichael, & Rayner, 2000; Jones & Carmichael, 1999b). A marked preference for string was apparent in all our studies and it was common to both the ISA and Lohmann Brown strains. The chicks expressed progressively greater interest in each of the presented items but this was particularly true of string. The attractive nature of string may have reflected its resemblance to stimuli that might be regarded as inherently supernormal, e.g. grass, straw, twigs, or worms. Indeed, the provision of long-cut straw significantly increased foraging behaviour in chicks (Huber-Eicher & Wechsler, 1998). However, in our studies we observed that the birds manipulated the string in quite a different way to the other stimuli. As well as the pecking and pulling that was directed at all the devices, the birds often drew the string through their beaks and sometimes teased the strands apart; some of these actions resembled preening or feather sucking behaviours. Therefore, a more realistic interpretation for the attractive properties of string is that its manipulation may have provided more positive feedback than the other stimuli. This suggestion is supported by our recent finding that chicks' interest in string lasted longer than did that in commercially available enrichment devices (PECKA-BLOCKS, Breckland International Ltd., UK) when these stimuli were presented continuously in the home cage from 5 to 12 days of age (Jones & Ruschak, 2002). Furthermore, bunches of string were manipulated so much by laying hens at a commercial farm that they soon resembled a ball of wool rather than eight separate lengths of twine (see below and Blokhuis et al., 2001).

Now that string had been identified as the most attractive type of stimulus, the next step involved establishing whether certain component features of this stimulus, (e.g., size. colour, complexity, movement), were more influential than others. We began by examining the effects of stimulus size because the dimensions of a pecking device could conceivably influence the nature and frequency of chicks' responses to it (Rogers, 1995). On the one hand, large objects might attract greater attention because they were more conspicuous, but on the other hand, they might be perceived as threatening and thereby elicit fear and avoidance. However, when we varied the length and width of the string devices between 4 and 16 cm we found that all combinations were equally attractive (Jones et al., 2000).

Next, because chickens have tetrachromatic vision, colour was considered likely to be an important attribute of any enrichment device (Rogers, 1995). However, there was little agreement concerning chickens' colour preferences, indeed they have been reported to vary even when the type of stimulus remains the same (Hes & Gogel, 1954; Hurnik, Jerome & McMillan, 1997; Roper & Marples, 1997). Therefore, we presented chickens simultaneously with bunches of differently coloured string. Both young chicks and adult hens showed distinct and stable colour preferences; they pecked sooner and more often at bunches of white string than at yellow, red, orange, green or blue ones (Jones & Carmichael, 1998; Jones et al., 2000); though yellow was pecked almost as much as white string. It is considered unlikely that the relatively greater brightness and, hence, visibility of yellow and white string was responsible for the chicks' attraction to them for several reasons. The home cages were well illuminated, chickens can discriminate between colours in near-darkness (Lashley, 1916), and the observed increase in pecking at red, green and blue strings with repeated presentation would not have been expected if

the chicks had found them difficult to see. The inconsistencies in colour preferences reported by different laboratories probably reflect differences in the types of stimuli (food, water, beads etc.), the experimental contexts and the genotypes and ages of the chickens used. Our findings are consistent with previous suggestions: (a) that chickens find blue food and blue objects aversive (Jones, 1987a, 1987c; Taylor, Sluckin, & Hewitt, 1969; Wood-Gush, 1971), (b) that red often serves as an unlearned warning signal and specific releaser for avoidance of insect prey (Roper, 1990), and (c) that social learning was apparent when observer hens saw demonstrators pecking at red but not at green food, thus indicating an unlearned aversion to red (Sherwin, Heyes & Nicol, 2002).

Animals are thought more likely to interact with their environment if it is visually and structurally complex (Chamove, 1989). We therefore reasoned that chicks might find a combination of the two previously most favoured colours (white and yellow) to be even more attractive. Pair-housed chicks were presented simultaneously and repeatedly with size-matched devices consisting of yellow, white, white + yellow, or a combination of yellow, white, green, red and blue strings (Jones et al., 2000). The chicks pecked sooner and substantially more at the monochromatic bunches of string (white or yellow) than at multi-coloured ones and these preferences were apparent on each of five daily observations.

Another form of complexity was examined in our next experiment. It is generally recognized that chicks have a strong propensity to peck at small, three-dimensional spherical objects (Dawkins, 1968; Rogers, 1995) and that shiny items are often particularly attractive, perhaps even supernormal stimuli (Rheingold & Hess, 1957). Unexpectedly though, incorporating four small silver beads into bunches of white string significantly reduced pecking (Figure 2 and Jones et al., 2000). Both plain and beaded devices elicited progressively greater interest with repeated exposure but the preference for plain string was evident on each of 5 test days. When considered in combination with our previous observation that monochromatic devices elicited more interest than multi-coloured ones, this finding could be explained in terms of a preference for simple rather than more complex stimuli in domestic chicks. However, a more likely interpretation is that the beads rendered the devices less attractive by interfering with the chicks' ability to manipulate the string and to tease the strands apart.

It is generally thought that moving stimuli are more likely to stimulate play than stationary ones in many animals (Newberry, 1995). Furthermore, caged hens pecked more at moveable feathers than at fixed ones (Cloutier et al., 2000). I used two methods to determine whether chicks' interest in white string would increase with occasional movement (Jones, 2001b). First, the devices in adjacent cages either remained separated or they were linked so that pecking or pulling at the device in one cage moved the adjoining one. Second, the experimenter moved the devices in half the cages remotely at 1-minute intervals whereas the others remained static. In each case, the devices were introduced for 10 minutes on each of 5 consecutive days. String attracted progressively greater interest in both cases but the chicks pecked consistently more at the static than the moving devices (Jones 2001b), perhaps because unpredictable movement elicited slight alarm and avoidance (Jones, 1996).

Collectively, the above findings clearly demonstrate that chicks and adult hens are particularly attracted to stationary bunches of plain white string.
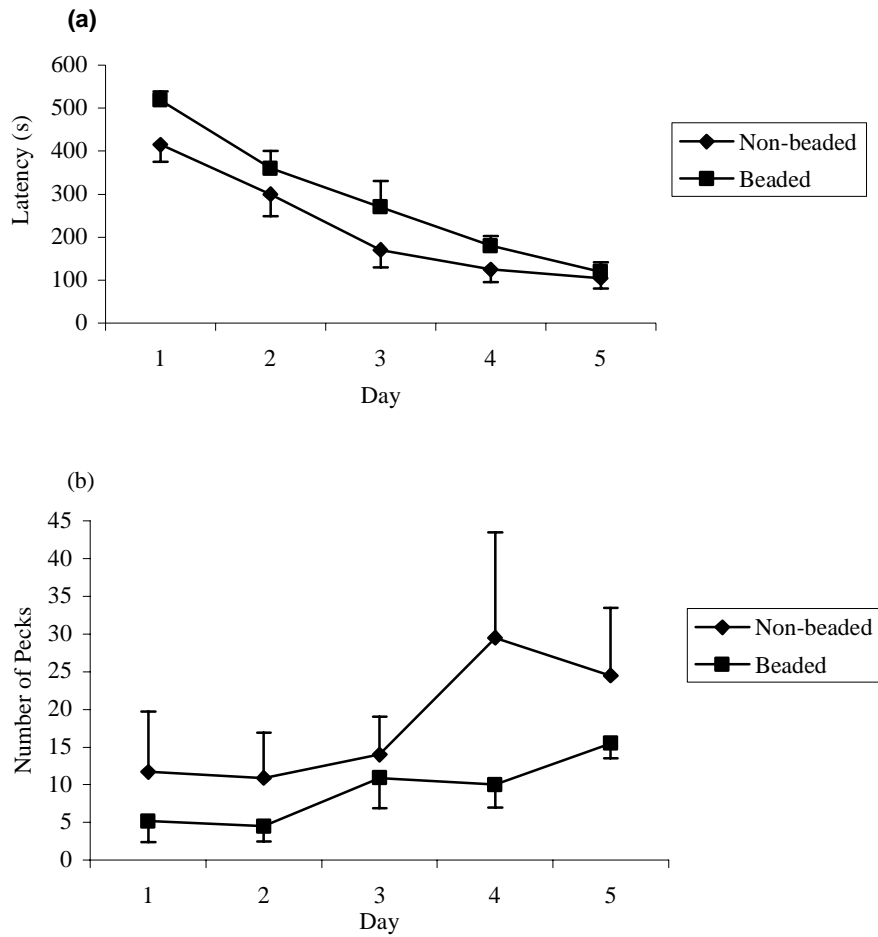
(a)

(b)

Figure 2. (a) The latencies to peck and (b) the numbers of pecks directed at beaded and nonbeaded string devices by the focal bird in pairs of chicks.

Can String Sustain Long-Term Interest?

In order to be effective, environmental enrichment stimuli should be capable of retaining the animals' interest over lengthy periods as well as enhancing their behavioural repertoire and reducing the occurrence of abnormal or harmful behaviours. In reality though, many enrichment devices are soon ignored (Jones et al., 2000; Mench, 1994; Newberry, 1995; Sherwin, 1995). On the other hand, chicks had shown progressively more pecking at the string devices in all the short-term (to 5 days) studies described above. Bunches of string also sustained the interest of floor-housed laying hens throughout the course of a 14-day exposure period (Jones et al., 2002a). Furthermore, Lohmann Brown chickens that had been housed from 1 day of age in groups of three in floor pens containing bunches of white string, chains and lengths of beads were still pecking at the string even after they had been continuously exposed to it for 17 weeks (Jones & Rayner, 2000). Conversely, they had virtually ceased pecking at the chains and beads after only 10 days. The virtual absence of severe feather pecking in these groups and in those housed in control pens that contained no enrichment stimuli precluded test of our

hypothesis that environmental enrichment would reduce the expression of this behavioural vice. Our observation that environmental pecking (primarily at the wood shavings on the floor) increased dramatically whereas gentle feather pecking decreased over time in both treatment groups (Jones & Rayner, 2000) illustrates the likely importance of providing chickens with a suitable foraging substrate and suggests that these birds may have become more interested in their physical environment than in each other as they grew.

In the context of promoting long-term interest we might also consider developing an integrated management system that could automatically detect any waning of interest in the enrichment devices and then raise them briefly or move them to a nearby location in an attempt to rekindle interest.

Can String Devices Reduce Interbird Pecking?

Now that the attractive properties and influential attributes of string devices had been established, we asked if their provision could reduce the incidence of interbird pecking in three separate experiments.

First, since trimming birds' feathers to reveal the white downy plumage below elicited feather pecking and sometimes cannibalism (McAdie & Keeling, 2000), we investigated whether adult laying hens housed in groups of five in floor pens would still peck at bunches of plain, white string in the presence of such a competing stimulus. We removed one hen from each pen at 23 weeks of age and trimmed her rump feathers. We then either suspended two string devices from a perch in the home pen immediately before her return or presented no such devices. The absence of severe feather pecking or aggressive head pecks meant that we were once again unable to determine if the provision of string would reduce the occurrence of these potentially injurious behaviours. However, the birds pecked sooner and significantly more often at the bunches of string than at either the trimmed or untrimmed hens. Furthermore, the string devices were still being pecked two weeks later (Jones et al., 2002a).

Second, we housed groups of chicks from an experimental line that is genetically predisposed to show high levels of feather pecking (Blokhuis & Beuving, 1993) in floor pens containing wood litter and then exposed them to one of four treatments. These included the provision of two bunches of string continuously from 1, 22, or 52 days of age, for just 4 h daily from 1 day of age, or not at all (control). When the birds were observed at 56 and 57 days of age, we found that severe feather pecking was totally absent in those birds that had received access to string from 1 day of age (continuously or for 4 h per day) whereas 0.4 and 1.2 severe pecks per h were seen in the control treatment in which string was introduced at 52 days or not at all (controls), respectively Blokhuis et al., 2001; McAdie et al., in press). The incidence of gentle feather pecking was significantly and strikingly lower following provision of string at one day rather than at 52 days of age or not at all (12, 150, and 145 pecks per h, respectively). Interestingly, the continuous presence of string from the first day or its introduction for just 4 h per day were equally effective in reducing interbird pecking. Placing the string devices in the pens when the birds were 22 days old resulted in intermediate levels of feather pecking (McAdie et al., in press). Moreover, the string sustained substantial pecking interest throughout its period of incorporation in all the treatment groups.

Third, we exposed groups of caged Lohmann LSL laying hens that had not been beak trimmed to 1 of 4 treatments at a commercial farm in Sweden. The treatments included: (a) the birds were given string devices continuously from 1 day of age, (b) the devices were present from 16 weeks onwards, i.e., when the birds were transferred from rearing to laying cages, (c) the devices were present for 1 day per 4 weeks, or (d) they received no devices at any time. Group sizes changed as the birds were moved from brooding to rearing to laying cages but the ratio of one pecking device per three birds remained constant. Feather condition was then scored when the hens were 35 weeks old using an accepted method (Bilcik & Keeling, 1999). It was particularly encouraging to find that the amount of pecking-related feather damage was significantly reduced in those birds that had received access to string (Figure 3, Blokhuis et al., 2001; and McAdie et al., in press). At first glance, our observation that this effect was apparent regardless of when the devices had been provided seems inconsistent with previous suggestions that early exposure was necessary for chickens to imprint onto pecking stimuli (Huber-Eicher & Wechsler, 1997; Vestergaard, 1994) and with our previous finding that early enrichment (from 1 day of age) was the most effective in birds from the high pecking line. However, this apparent discrepancy may simply reflect differences in the birds' genetic backgrounds and/or in the housing systems (floor versus cage). A more likely explanation is that chickens can revise their pecking preferences; this is supported by a recent report that hens that were given access to wood shavings only in adulthood showed less feather pecking than did those that had been raised and housed entirely on wire floors (Nicol et al., 2001). It is also conceivable that any stimulation, regardless of its brevity or the age at which it is applied, might be enough to decrease feather pecking in the relatively barren environment of a commercial battery cage. Interestingly though, despite their regular renewal the devices were significantly more frayed at the end of the commercial trial, thus indicating greater usage, if the birds had been exposed to string from 1 day of age (McAdie et al., in press).
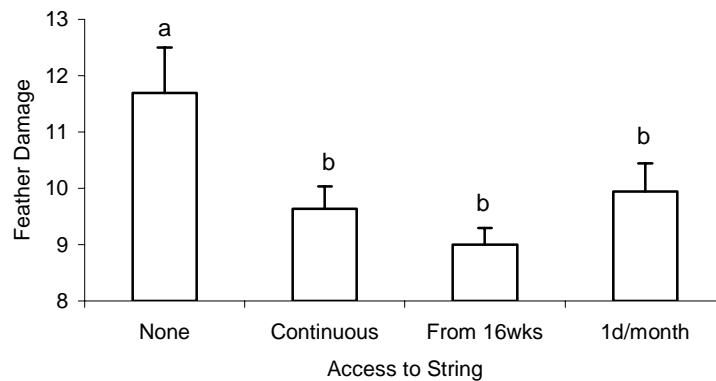

Figure 3. Effects of providing access to string continuously from 1 day of age, from 16 weeks, for 1 day every 4 weeks, or not at all on pecking-related feather damage at 35 weeks in laying hens housed in groups in battery cages at a commercial farm

What are the Practical Considerations?

Clearly, string devices are attractive to chickens of all ages and their presence can reduce feather pecking behaviour and pecking-related feather damage. Furthermore, the beneficial effects of this type of environmental enrichment are unlikely to be confined to particular genotypes or housing systems because string sustained the interest of birds from four different strains (ISA Brown, Lohmann Brown, Lohmann LSL, and a high-feather- pecking White Leghorn) and three types of housing (individual cages and floor pens in the laboratory as well as group cages at a commercial farm). String has the added advantages of low cost and ready availability. Bunches of string could also be easily installed in and removed from brooding, rearing and laying cages by clipping them to the roofs of the cages so that they were suspended over the food trough. Suspending the devices from a web-like system of ropes that could be raised and lowered as required would minimize the likelihood that they might interfere with management practices or with depopulation when birds are kept in large groups on the floor. Regardless of the technology, the routine incorporation of string devices in the home environments of chicks and adult laying hens increases the opportunity for them to engage in important behaviours such as exploration and foraging. It is also considered likely to reduce boredom and feather pecking and to thereby improve their welfare and productivity.

Conclusions

Collectively, the findings described above demonstrate that the opportunity to explore extraneous stimulation is important to chickens, that enriched environments are attractive to them, and that the provision of appropriate visual, auditory, olfactory and tactile enrichment can improve the birds' welfare and productivity. The nature of most poultry housing systems provides ample opportunities for improvement. This paper describes the search for effective strategies for enriching the chickens' environment and it identifies some eminently practicable ways of doing so. These include playing the radio, incorporating familiar odourants in otherwise novel situations in order to reassure the birds, and providing them with string devices to stimulate foraging and to divert potentially injurious pecking away from other birds. The evolution of many of the studies described herein drew heavily on principles and methodologies (see Introduction) that are central to our interdisciplinary field of comparative psychology. As a result of the studies described above, the integrated application of appropriate environmental enrichment strategies and appropriate breeding programmes is considered likely to minimize the elicitation, expression and harmful consequences of behavioural states and behaviour patterns as varied as fear, boredom, feather pecking, and cannibalism. This, in turn, will improve the birds' welfare, productivity, and profitability.

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