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Environmental enrichment affects the fear and exploratory responses to novelty of young Amazon parrots

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Abstract

The development of techniques to reduce fear responses of captive animals is important because fear is generally considered an undesirable emotional state that is related to increased risk of injury and decreased biological functioning. We tested the effects of environmental enrichments designed to increase the physical complexity of the cage and to provide opportunities for foraging behaviors on responses to novelty of young Orange-winged Amazon parrots (*Amazona amazonica*). Parrots ($n = 16$) were housed in either barren or enriched conditions for 1 year and responses to novel objects and human handlers were tested periodically. Parrots in the enriched condition had significantly shorter latencies to approach novel objects placed in their home cages than parrots from the control group (repeated measures GLM: $F_{1,13} = 8.00$; $P = 0.014$). In addition, parrots from the enriched condition had shorter bouts of interaction ($F_{1,14} = 27.93$; $P < 0.0005$) and spent significantly less time interacting with novel objects overall ($F_{1,14} = 27.93$; $P < 0.0005$). Taken together, these results suggest that enrichment reduced both the fear response to novel objects and the motivation to explore and interact with those objects. When tested with a familiar handler, the control parrots had significantly higher response scores (i.e. they were less aggressive and more interactive) than the parrots from the enriched group (t -test; $P < 0.005$). This suggests that parrots housed in barren conditions may be more motivated to interact with familiar humans as a source of environmental stimulation. All parrots showed higher response scores to familiar than unfamiliar handlers, but in the control group there was a significant drop in score from the familiar to the unfamiliar handler (t -test; $P < 0.0005$) while in the enriched group the scores with familiar and unfamiliar handlers were similar. Thus, environmental enrichment reduced fear responses to both novel objects and unfamiliar human handlers. Factor analysis revealed that the responses to the novel object and novel human tests were independent, which implies that they did not measure the same underlying factor. Similarly, the

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factor analysis showed that enrichment independently decreased motivation to interact with novel objects and humans. Our results indicate that the enrichment protocol we employed can successfully modify both fear responses and motivation for environmental interaction in parrots and sheds light on the multi-factorial nature of both of these behavioral systems.

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1. Introduction

Biologically relevant environmental enrichment can significantly improve the welfare of captive animals by facilitating adaptive behavior (Newberry, 1995). Although animals may display a variety of maladaptive behaviors in captivity, excessive fear reactions such as escape attempts, panic, and aggression are among the most serious, and can result in wasted energy, injury, or decreased production (Jones and Waddington, 1992).

Novelty is often a potent stimulus for excessive fear reactions. Environmental enrichment that increases exposure to novelty during development has been successfully employed in both mammalian and avian species to modulate fear responses, as evidenced by increased activity in novel environments (Fernandez-Teruel et al., 1997; Escorihuela et al., 1994; Renner, 1987) and decreased fear responses to novel objects (Jones, 1982; Jones and Waddington, 1992). There is also evidence that enrichment of the physical environment can reduce fearfulness of humans (e.g. Jones and Waddington, 1992; Nicol, 1992; Pearce et al., 1989).

Captive parrots in zoos, laboratories and private homes are often exposed to unpredictable, yet benign, environmental changes such as additions to zoo exhibits, introduction of new toys or food items, and changing animal care staff. The ability to perceive this type of environmental change as benign and to modulate fear responses accordingly is important, as fear is generally considered an undesirable emotional state that is related to reduced welfare (Jones, 1997). Although environmental enrichment is a potentially promising strategy for reducing the fear responses of captive and companion parrots, little is known about the elements necessary for effective environmental enrichment for avian species in general, and particularly parrots (e.g. Birchall, 1990; Shepherdson, 1992; King, 1993). However, for any species enrichment is unlikely to be effective unless it reliably attracts and sustains appreciable interest (Jones et al., 2000), and has functional utility (Newberry, 1995). In this sense, environmental modifications that facilitate use of behavioral skills are likely to be more effective in improving welfare than a random assortment of objects (Mench, 1998). Design of enrichments of this sort requires knowledge of the biology and ecology of the species in question.

Two of the most severely constrained classes of behavior in captive parrots are foraging and locomotion. In the wild, parrots spend approximately 4–6 h per day foraging (Snyder et al., 1987). Birds regularly travel several miles between feeding sites, and once they arrive engage in a rich suite of local search, food selection, and food manipulation behaviors (Snyder et al., 1987). In contrast, many captive feeding methods for parrots allow minimal environmental interaction and greatly reduce the amount of work and energetic cost

involved in feeding activities. Thus, captive Orange-winged Amazon parrots (*Amazona amazonica*) spend only 30–72 min a day in feeding behaviors when fed a pelleted diet (Oviatt and Millam, 1997).

Wild parrots also exploit a complex physical environment and, in addition to flight, show a number of physical and behavioral adaptations to this habitat. For instance, they utilize their grappling beak and grasping feet to negotiate treetops and unstable fruit bearing branches, are adept climbers of vertical surfaces, and are equally graceful traversing the underside of branches (Sparks and Soper, 1990). In captivity, parrots are rarely able to fly, and are usually severely constrained in the other locomotor behaviors they can perform due to the design of their cage environment.

Thus, we designed and selected enrichment devices that provided the parrots with the opportunity to utilize food acquisition skills such as searching, selecting, processing and chewing in combination with locomotor skills such as maintaining balance, manipulating objects and climbing. By providing a variety of these enrichments on a rotating schedule, we sought to introduce novelty into the captive environment in the form of enrichments with high functional value to the parrots. We investigated the effects of this enrichment protocol on responses to two types of environmental novelty: novel objects introduced into the home cage and unfamiliar human handlers. Our hypothesis was that parrots that experienced the enrichment protocol would be less fearful of both these types of novel situations, as evidenced by shorter latencies to approach novel objects and decreased fearful and aggressive responses to unfamiliar humans, relative to birds without this experience.

2. Methods

2.1. Subjects, caging and management

Subjects were 16 (7M, 9F) Orange-winged Amazon parrots hatched in the animal colony at the University of California, Davis, from wild-caught pairs imported from Guyana in 1987. All subjects were parent-raised until weaning (18 weeks) in $1\text{ m} \times 1\text{ m} \times 2\text{ m}$ suspended welded wire cages. At 18 weeks of age, the parrots were moved to individual cages in another room. Individual housing was necessary in order to avoid confounding foraging and physical enrichment with social enrichment. All cages measured $0.75\text{ m} \times 0.75\text{ m} \times 1\text{ m}$ and were suspended 1 m above the ground. Each cage contained one wooden perch at a height of 1.75 m above the ground, a metal “L” shaped feeder, and a nipple drinker. Water and pellets (Roudybush low-fat maintenance pellets, Roudybush Inc., Sacramento, CA) were available ad libitum. Other food items (fruits, vegetables, seed and nuts) were presented daily in limited quantities. Parrots in both treatment groups received the same amounts of these additional food items; only the manner of presentation differed, since enriched birds received the items in their foraging enrichment devices (see subsequent sections).

We created treatment groups by dividing the parrots into two groups of eight, balanced for sex and parentage. Each group was then randomly assigned to either the control or the enriched condition. The control group had four males and four females and the enriched

group had three males and five females. The control and the enriched cages were spaced in the room so as to control for position effects. Visual barriers were installed between cages so that each parrot only had visual contact with the parrot in the adjacent cage; adjacent cages were assigned to the same treatment. Vocal contact was possible between all birds in the room. After 2 days of habituation to the new surroundings the enrichment protocol was implemented in the enriched cages.

To ensure that they would be suitable for adoption into private homes at the completion of the study, all parrots were handled four times per week throughout the study by one of two different handlers. The handling sessions lasted 60 min and began with the handler removing the parrot from its home cage and transferring it to a handling room. With the parrot sitting on a perch, the handler began basic taming and training exercises. Teaching the parrots to perch on a finger or stick and increasing tolerance to touch were the main goals of these sessions. These goals were accomplished by first allowing the parrots to habituate to both their surroundings and their handlers, and then by using verbal praise to encourage the parrots to accept being touched on the feet, breast, wings, back and head. As the parrots progressed, they were taught to offer a foot to “step-up” onto a perching substrate like a finger or stick. Peanuts and other treats were used as rewards during these exercises.

2.2. Enrichment protocol

Two categories of enrichments were used: physical and foraging. Examples of the enrichments used are given in Table 1. Physical enrichments were chosen to increase the physical complexity of the cage. They provided alternate perching sites, climbing or swinging opportunities, or movable objects that could be manipulated with the beak and/or feet. Foraging enrichments were chosen to provide an opportunity for the parrots to perform some amount of work in order to retrieve foods such as seeds, fruits, vegetables and nuts. These enrichments required that the parrots chew through barriers, manipulate

Table 1
Description of enrichment items used

Enrichment type	Enrichment item	Description
Foraging	T-shirt bags	Sack of cotton cloth hung on a rope from the top of the cage.
	Fruit cage	Cylindrical metal cage (height 15 cm, diameter 7 cm) hung with a chain from the top of the cage.
	Toy box	Plastic cube (25 cm ³) with holes and doors of various sizes and shapes hung from the top of the cage.
Physical	Treat basket	Enclosed woven basket hung from the top of the cage.
	“Boing”	A 2.5 cm diameter cotton rope wound around a spiral spring (0.75 m long) hung from the top of the cage.
	Diamonds	Two plastic diamonds (0.5 m long) connected end to end and hung from the top of the cage.
	Spring	Flexible plastic coil (0.75 m long) connected horizontally to opposite ends of the cage.
	Bridge	Swinging ladder (0.75 m long) made of wood and rope connected horizontally to opposite ends of the cage.

objects through holes, sort through inedible material, or open containers to obtain food items. Foraging enrichments were refilled daily between 09:00 and 10:00 h. Twenty-four different enrichments (12 foraging and 12 physical) were used over the course of the entire study and eight different enrichments (four foraging, four physical) were chosen for each of the three 16-week periods. All parrots in the enriched condition received one foraging and one physical enrichment in one of 16 possible combinations each week for 16 weeks. The order in which the combinations were presented was balanced using a Latin square design. We controlled for the time that the caretaker had contact with the parrots while enrichments were rearranged and refilled by spending an equal amount of time refilling feed cups in the control bird's cages.

2.3. Behavior testing

Each parrot was given two types of behavioral tests: response to novelty tests and response to handler tests. The handler response test was administered four times, and the response to novelty test twice, over the course of 1 week following each 16-week interval. The order in which these tests were performed was balanced among the 16 parrots using a Latin square design. Only one test was administered per day and testing occurred between 14:00 and 17:00 h.

2.3.1. Handler response testing

At the end of each 16-week period, we administered a 10-point handler response test, adapted from [Cramton \(1998\)](#) and [Aengus and Millam \(1999\)](#), to all parrots. Two familiar handlers as well as two unfamiliar handlers tested each parrot. The familiar handlers were the people who had been working with the parrots over the course of the 16-week period, while the unfamiliar handlers were people who were trained in parrot handling but who had never interacted directly with the test parrot.

The handler response test took about 10 min to complete, including a 5-min habituation period during which the handler simply sat next to the parrot but made no attempt to touch it. Following habituation, the handler completed the five components of the handler response test, which involved extending a finger toward the parrot, touching the parrot's back, touching the parrot's head, offering food, and observing flight distance when the parrot was placed next to the handler. Each component was assigned a score from 0 to 2 ([Table 2](#)).

Table 2
Scoring criteria for the handler response test

Test component	Score 0	Score 1	Score 2
Extended finger	Retreat/aggression	No response	Approach
Touch to back	Retreat/aggression	Accept with flinch or vocalization	Accept
Touch to head	Retreat/aggression	Accept with flinch or vocalization	Accept
Food offering	Retreat/aggression	No Response	Accept
Flight distance 15 s after being placed next to handler	>3 ft.	1–3 ft.	0–1 ft.

2.3.2. *Response to novel objects*

Novel object tests were also conducted at the end of each 16-week period. Twelve novel objects were used for these tests. These objects were chosen so as not to resemble the enrichments the parrots in the enriched group received, and included a stuffed toy chicken, a miniature artificial pine tree, a large plastic funnel, a string of seashells, a 6 in. bunch of hot pink feathers, a plastic action figure, a red silk flower, a child's sandal, a screwdriver, a bunch of measuring spoons, a rubber duck, and a small woven basket. Over the course of the study each parrot was tested with six of these objects. Any two parrots in visual contact with one another received different sets of the novel objects, and the order in which the objects were presented to all parrots was balanced using a Latin square. For each test, a novel object was placed in the parrot's home cage in a position that required the bird to approach the object in order to interact with it. The birds were observed via video camera, with the observer in the adjacent room watching on a monitor. Data were recorded using Hewlett-Packard HP 48 G+ graphing calculators programmed for data collection. Latency to interact with the object and duration of interaction were recorded over a 20-min test period. Interaction was defined as contact, excluding incidental contact, and included biting, climbing on, grabbing, swinging from, and chewing the object.

2.4. *Statistical methods*

The data for handler response score with familiar and strange handlers, latency to interact with novel objects, and overall duration and bout length of interaction with novel objects, were analyzed using repeated measures GLM. The assumptions of parametric methods (normality of error, homogeneity of variance and linearity) were confirmed from plots of coefficients versus fitted values and suitable transformations were applied where required. All analyses were performed using MiniTab (2000) software. Unless otherwise specified, the probability level accepted for significance was $P < 0.05$.

For response to handler score, repeated measures were made on each individual at three points in time. The interaction of time, treatment and handler was examined to see whether the effect of treatment in the response to handlers changed over time. Thus, each bird acted as its own control both within and between months. No transformation of the response to handler score was required. Post hoc *t*-tests were conducted to distinguish between means using an adjusted critical alpha of 0.0125.

For the response to novelty tests, repeated measures were made on each individual at three points in time. One parrot from the control group failed to approach the novel object during one trial and was thus dropped from the analysis to maintain a fully balanced model. Time and treatment were crossed and individual was nested within treatment. The interaction of treatment and time was examined in both cases to see whether the response to novelty changed over time. Latency data were log transformed and duration and bout length data were angular transformed to ensure homogeneity of variance.

In order to avoid pseudo-replication and to standardize with respect to individual, treatment, sex and time, partial correlation coefficients were calculated for each pair of variables (latency, duration, bout length, familiar handler response score, unfamiliar handler response score, change in handler score), partialling for individual, time, treatment and sex using GLM. Suitable transformations were applied as necessary. Principal component factor

analysis was performed on the resulting correlation matrix. Varimax rotation was applied. Four factors were extracted by discarding all factors with an Eigenvalue less than 1 and including factors with communality values above 0.75 for each variable.

3. Results

3.1. Response to novel objects

The response to novel objects is shown in Fig. 1. Across all months, both latency (repeated measures GLM: $F_{1,13} = 8.00$; $P = 0.014$) to interact and duration (repeated measures GLM: $F_{1,14} = 27.93$; $P < 0.0005$) of interaction were significantly shorter in the enriched group than in the control group. Parrots in the control condition had significantly longer bouts of interaction with novel objects (repeated measures GLM: $F_{1,14} = 19.85$; $P < 0.0005$), although the number of bouts did not differ between treatments. There were no significant effects of month, nor were there significant interactions between month and treatment.

3.2. Response to handlers

Individuals differed significantly in their response to handler scores ($F_{1,14} = 11.11$; $P < 0.0005$), and there was also a significant individual \times time interaction ($F_{2,28} = 5.14$; $P < 0.0005$). Thus, repeated measures analysis was the appropriate analysis; each parrot was used as its own control and the response scores with familiar and unfamiliar handlers were compared across groups.

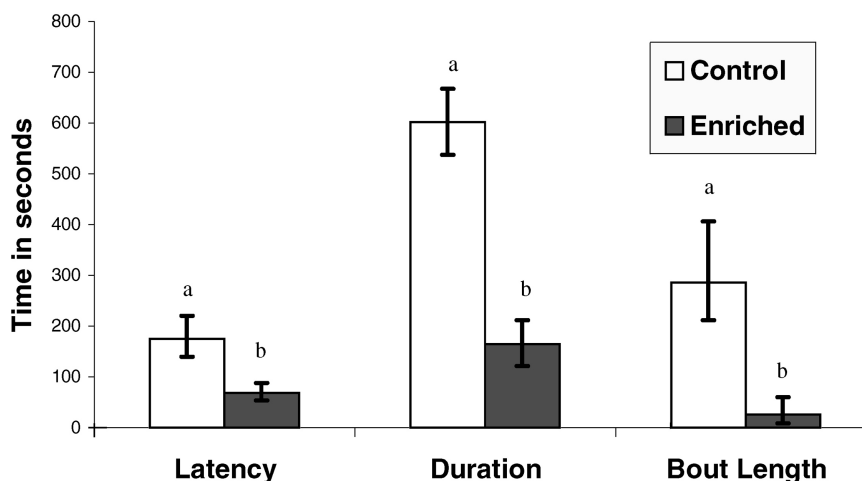


Fig. 1. Back transformed least squares means (\pm standard error) for latency to approach novel objects, duration of interaction and length of bouts of interaction with novel objects across all months in control and enriched groups. Within a measurement, means with different superscripts are significantly different.

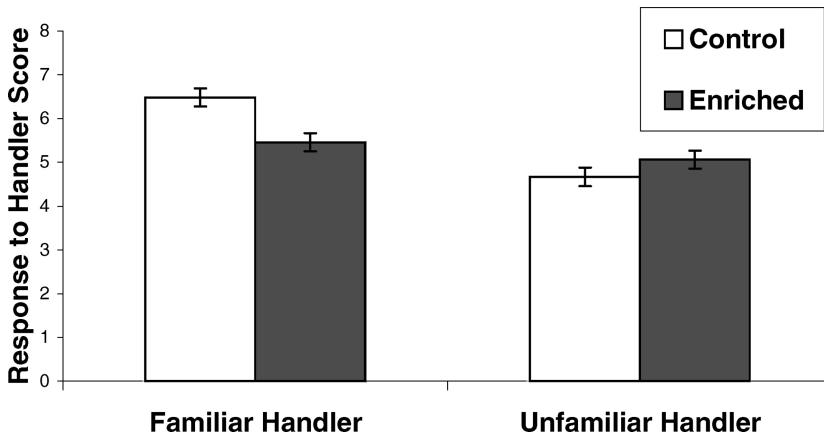


Fig. 2. Responses to familiar and unfamiliar handlers by parrots in the control and enriched conditions. Across all months, parrots from the control condition had significantly higher response scores with familiar handlers than parrots from the enriched condition. Parrots from the enriched condition had significantly greater stability of handler scores from familiar to unfamiliar handlers than did parrots from the control group.

Response to handler scores are shown in Fig. 2. Across all months, treatment had an effect on response scores with familiar and unfamiliar handlers as indicated by a significant treatment \times handler interaction ($F_{1,14} = 11.67$; $P = 0.004$). Post hoc tests revealed that the significance of the interaction was due to control birds showing significantly different responses to familiar and unfamiliar handlers (paired t -test: $t_{12} = 8.09$; $P < 0.0001$), while responses of the enriched parrots to familiar and unfamiliar handlers did not differ significantly (paired t -test: $t_{12} = 1.81$; $P = 0.09$, power = 0.999). Response to a familiar handler differed significantly between control and enriched birds, (paired t -test: $t_{12} = 4.18$, $P < 0.001$) while response to an unfamiliar handler did not (paired t -test: $t_{12} = 0.375$, $P = 0.71$, power = 0.256).

3.3. Correlation of measures

Response score with a familiar handler and response score with an unfamiliar handler were significantly correlated ($r = 0.377$; $P < 0.001$). There was a significant negative correlation between response score with an unfamiliar handler and change in response score from familiar to unfamiliar handler ($r = -0.372$; $P < 0.001$). There was a significant positive correlation between overall duration and bout length of interaction with novel objects ($r = 0.542$; $P < 0.001$). There were no other significant correlations between the measures.

3.4. Factor analysis

Factor loadings for each of the six variables are listed in Table 3. Relevant variables associated with each factor are in bold type. The four factors accounted for 26, 22, 21 and 17% of the total variance, respectively.

Table 3
Results of the factor analysis on the partial correlation matrix

Variable	Factor 1	Factor 2	Factor 3	Factor 4
Latency	0.998	0.006	−0.001	−0.028
Duration	0.051	0.861	−0.188	0.068
Bout length	−0.060	0.888	0.171	0.038
Familiar response score	0.013	−0.048	0.906	0.116
Unfamiliar response score	−0.035	0.082	0.664	− 0.619
Stability in response score	0.022	0.124	0.094	0.932

4. Discussion

The results of this study demonstrate that rearing young Orange-winged Amazon parrots with access to foraging and physical enrichments significantly modifies responses to novel objects and human handlers. The enrichments we provided were used frequently and consistently over the course of the study (see Meehan et al., 2002a) and the effects on response to novelty were established soon after enrichment was presented and were stable over continued periods of enrichment. Our results also shed light on the multifactorial nature of the response shown by the parrots to novelty.

Responses to novel stimuli can be affected by a complex of motivational systems, including both fear and exploration (e.g. Montgomery, 1955; Archer, 1979; Russell, 1979). Because fear and exploration are so interrelated it is difficult to determine either the relative importance of each motivational system on responses to novelty or the relative effect of enrichment on the different motivational systems. For example, enrichment can result in increased latencies to approach novel objects, which has been explained as a decreased state of motivation for exploration relative to animals raised in a barren environment (e.g. Pearce and Patterson, 1993), or decreased latencies to approach novel objects, which has been explained as a decrease in fearfulness due to enrichment (e.g. Jones and Waddington, 1992). Animals from enriched environments generally have shorter durations of interaction, which has been explained as a decreased motivation for exploration (e.g. Stolba and Wood-Gush, 1980; Wood-Gush et al., 1990; Pearce and Patterson, 1993 but, see Renner, 1987) and as a result of habituation to novelty (Zimmerman et al., 2001). To allow a more precise interpretation of the parrot's responses, we not only measured the effects of enrichment on latency to approach and duration of interaction with novel objects, but also assessed the relationship between latency and duration to determine if they were behavioral expressions of the same or different underlying motivational systems.

Parrots from the enriched condition had significantly shorter latencies to interact with novel objects placed in their home cages than did parrots from the control condition. Our data suggest that the accelerated approach toward novel objects in the enriched group reflects decreased fearfulness of the object rather than an increased tendency to engage in the direct investigation component characteristic of exploratory behavior (Birke and Archer, 1983), since the parrots in the enriched condition also had shorter overall duration of interaction and shorter bout lengths of interaction with the objects.

The two groups of parrots also showed qualitative differences in their interactions with the novel objects. Parrots in the enriched condition generally approached the object, sometimes several times during the test session, interacted with it briefly using their beaks and feet and then began to engage in other behaviors, such as preening or feeding, away from the object. Conversely, the interactions of the control birds were much more intense and prolonged, and included rapid movements, climbing and swinging on the objects and almost frenzied chewing. These interactions were usually continuous once initiated and the control parrots often had to be removed from the object when the testing session was over. Overall, the quality of the control group's behavior was characteristic of rebound behavior, or a compensatory increase in interaction with the novel objects due to a buildup of internal motivation to explore and interact with environmental elements, which is associated with behavioral deprivation (Mal et al., 1991; Houpt et al., 2001; Dellmeier et al., 1990; Bowers et al., 1993; Vestergaard, 1982; Hogan et al., 1991; Norgaard-Nielsen, 1997). Although additional evidence is required before the strength of the motivation to explore and interact with objects can be determined, the results of this study suggest that direct investigation of, and interaction with, the environment may be a behavioral need for young parrots.

When tested with humans, parrots from the control group had higher response to handler scores when tested with a familiar handler than did parrots from the enriched group. Response scores with the familiar handler were a measure of motivation to interact with humans, and the higher response scores of the control parrots may thus be explained by a build-up of motivation for interaction with humans resulting from living in a barren environment. Similarly, pigs reared in a barren environment show increased interaction with a familiar handler (Pearce et al., 1989; Schouten, 1986), and this level of social interaction has been explained as a substitution for environmental stimulation (Schouten, 1986).

While there was no significant treatment effect on the response to handler scores with unfamiliar handlers, the unfamiliar response score did load onto the same factor as the familiar handler response score. This may indicate that there is an underlying motivation to interact with humans (familiar and unfamiliar) that can be modified by exposure to inanimate environmental enrichment. Additionally, even though enrichment had the same directional effect on duration of interaction with novel objects and response to handler scores, the fact that the responses to the two tests did not load onto the same factor indicates that the enrichment protocol did not affect motivation for environmental interaction generally, but had separate effects on motivation to interact with these specific categories of stimuli.

Since there are individual differences in the tractability of animals, we used the change in response to handler score rather than simply the response to an unfamiliar human as our measurement of fear of novel humans. The enriched parrots showed a significantly greater stability between response scores (i.e. no significant drop in response to handler score between familiar and unfamiliar handlers) than the control parrots, which is indicative of a better ability to assess the unfamiliar handler as benign and transfer skills from the handling sessions with a familiar person to this novel situation. We consider this ability to be of great importance in many captive contexts because parrots are likely to encounter novel humans, such as visitors or veterinarians, regularly. Since handling of young Amazons can exert a strong influence on response to humans (Aengus and Millam,

1999), we were careful to insure that all parrots in both conditions received the same quality and quantity of handling experience. Therefore, differences in responses to unfamiliar handlers cannot be explained by differential handling experience and must be a result of living in an enriched environment.

The factors that emerged from our analysis suggest that enrichment affects four different components underlying the behavioral responses to the tests we conducted: (1) fear of novel objects—the latency factor; (2) motivation to interact with novel objects—the duration and bout length factor; (3) motivation to interact with humans—the familiar and unfamiliar handler response scores factor and (4) fear of novel humans—the unfamiliar handler and change in response score factor.

The fact that latency to approach novel objects, response to unfamiliar handlers and change in handler scores did not load onto the same factor suggests that the enrichment protocol we employed modulated fear reactions to those specific categories of stimuli, rather than acting on a global trait of fearfulness. This result adds to the debate regarding the nature of fear. By describing fearfulness as a “personality or temperament trait defining the general susceptibility of an individual to react to a variety of potentially threatening situations”, Boissy (1995, p. 166) demonstrates the view that fear is a unitary phenomenon that is subject to genetic and developmental factors. However, others suggest that a unitary representation of fear is too simplistic (Archer, 1973; Murphy, 1978) and assert that a complex of factors specific to the stimuli presented govern fear responses (Archer, 1979). The idea that fearfulness is a unitary trait is attractive to those interested in using environmental enrichment or alternative rearing techniques to reduce responses to frightening stimuli because this would allow for modification of general adaptability rather than stimulus or category-specific responses (Jones, 1997).

Evidence for the effects of enrichment on a unitary trait of fearfulness comes from studies where two criteria are met: (1) enrichment reduces fear responses and (2) strong intra-individual correlations are found between responsiveness to a variety of fear-evoking stimuli. Principal components analysis of correlation matrices of multiple behavioral measures is usually used to examine the strength and pattern of these individual correlations (e.g. Jones et al., 1991; Jones and Waddington, 1992). When calculating these correlations, however, it is important that potential intervening variables be controlled for so that correlations between responses to different stimuli can be conclusively determined to be a trait of the individual (i.e. fearfulness) rather than associated with other sources of variation. Factors that can have an effect on responses to novelty and that thus need to be partialled for in such an analysis include sex (e.g. Joseph and Gallagher, 1980), genetic background (e.g. Hemsworth et al., 1990; Romeyer and Bouissou, 1992), and environmental influences such as exposure to humans (e.g. Jones, 1994; Vallee et al., 1997), and environmental enrichment (e.g. Jones and Waddington, 1992; Hemsworth et al., 1996; Zimmerman et al., 2001).

The partial correlation method that we used is a statistically precise way of calculating the relationship between two variables when the influence of additional intervening variables is removed (Howitt and Cramer, 1997). In our study, we generated partial correlation matrices that controlled for the effects of treatment, sex and time. The factors that resulted from our analysis indicate that enrichment has the same directional effect on fear responses to novel objects and novel humans. However, the fact that measures on these

two tests do not correlate within individuals indicates that two distinct fear reactions, rather than an underlying singular trait, are affected by enrichment. The different approaches to correlational analysis may explain why our results are not in agreement with the findings of Jones et al. (1991) and Jones and Waddington (1992), studies in which partial correlation analysis was not employed. It is also possible that the relatively small sample size and limited number of measurements taken in our study reduced the probability of finding significant intra-individual correlations. Thus, while the results of our study suggest that fear reactions are category specific, they must be interpreted conservatively.

5. Conclusions

This study demonstrates that exposure to a varied enrichment protocol can effectively reduce fear responses to both novel inanimate stimuli and novel human handlers by young Orange-winged Amazon parrots. The factors arrived at in our analysis indicate that enrichment affects fear of novel objects and novel humans in the same direction, but independently. This demonstrated that inanimate enrichment reduces fear responses to both inanimate and animate stimuli, but does not support the idea that it does so by modifying general fearfulness. Enrichment also reduces motivation for environmental interaction with both objects and humans, and again these effects are in the same direction but are independent of one another. This suggests that motivation for exploration and environmental interaction may not be a unitary trait. Finally, this study provides evidence that motivation for exploration and fear are independent factors that interact in the expression of novelty-induced behavior. The enrichment protocol used in our study is practical for use in laboratories, zoos and private homes where parrots are housed and is recommended not only for its effectiveness in modulating fear responses, but also in reducing abnormal behaviors such as stereotypy and feather plucking (Meehan et al., 2002a,b).

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