Behavioral persistence in captive bears: implications for reintroduction

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Abstract: We investigated the relationship between stereotypic behavior and abnormal behavioral persistence, a trait that could have potentially negative implications for reintroduction efforts, for 18 Asiatic black bears (*Ursus thibetanus*) and 11 Malayan sun bears (*Helarctos malayanus*) individually housed in a government confiscation facility in Thailand. Reintroduction or augmentation programs using captive-reared animals are typically less successful than those involving wild-reared conspecifics. One reason for this may lie in deficiencies in the behavior of captive animals. Attributes of stereotypy performance were quantified by observing bears from blinds. Mean stereotypy frequencies ranged between 0 and 51% (mean = 18%, SE = ±3), of all observations, and stereotypy frequency increased with age. To assess behavioral persistence, 12 bears were trained in a spatial discrimination task; once a performance criterion had been met, further responses were unrewarded and the ability to cease responding was assessed. The number of trials for which bears continued responding without reward was positively related to stereotypy frequency. This finding suggests that captivity can exert subtle but potentially detrimental influences on behavioral control that could possibly be manifest even in non-stereotypic animals. In the wild, where behavior must be adaptive and flexible to meet fluctuating conditions, such behavioral deficiencies could help account for reduced survivorship of reintroduced subjects.

Key words: Asiatic black bear, behavioral persistence, captive-bred, *Helarctos malayanus*, Malayan sun bear, reintroduction, stereotypy, *Ursus thibetanus*

Given the current forecast for continued habitat destruction and increasing species extinction rates (Wilson 1988), many animal populations seem destined to decline, and the need for reintroduction as a conservation strategy is becoming increasingly necessary. However, the science of animal reintroduction is still in its infancy, and failure rates are typically high (Griffith et al. 1989, Fischer and Lindenmayer 2000). Four of the world's 8 bear species are currently recognized as facing a high risk of extinction in the wild, in the medium-term future (Hilton-Taylor 2000). The survival of a fifth species, the Malayan sun bear, currently listed as data deficient, is almost certainly equally at risk, given the scale of habitat destruction throughout its range coupled with its persecution as a pest and capture for the pet and medicine trades (Meijaard 1999). For species with sufficient remaining habitat, it is likely that future conservation efforts will involve animal reintroduction, either to re-colonize areas after debilitating factors have been removed, or to augment numerically or genetically fragile populations.

To date, release programs for bears have typically involved wild animals that have been kept in captivity for only short periods of time, if at all (e.g. Jonkel et al. 1980, Alt and Beecham 1984, Servheen et al. 1995, Arquilliere 1998, Eastridge and Clark 2001). However, for some bear populations it may not always be possible to take wild animals for translocation without compromising the fitness of the source population, and in these situations, captive-bred individuals (which we define as animals either born and raised in captivity, or born in the wild but raised in captivity from infancy), may be the only alternative.

In addition to being more expensive and time-consuming, reintroduction programs using captive-bred animals are almost universally less successful than those involving wild conspecifics (Griffith et al. 1989, Frantzen et al. 2001, Clark et al. 2002). For example,

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Ginsberg (1994) reported that during the first year of release, the mortality of captive-bred canids was double that of translocated wild animals. The poor survivorship of captive-bred animals is often attributed to behavioral deficiencies (e.g. Kleiman et al. 1986), although habituation to humans may also play a role (e.g. Buchalczyk 1980, Alt and Beecham 1984). The importance of preserving species-typical behaviors, exposing potential release candidates to complex environments, and providing training for particular skills is now well acknowledged (e.g. Kleiman et al. 1986, Beck et al. 1991, Griffin et al. 2000, Wallace 2000). However, reintroduction programs typically place less emphasis on the more general and often subtle ways in which captivity can affect the behavior of animals, for example in terms of time allocation, activity levels, and behavioral flexibility (e.g. Dittrich 1984, Wemelsfelder et al. 2000, Swaisgood et al. 2001).

A particularly conspicuous way in which animals maintained in captivity often differ from their wild counterparts is in the performance of stereotypies: seemingly purposeless repeated behaviors that are invariant in form (in that movements are the same on each repetition) (Ödberg 1978, Mason 1991a). The etiology of these behavior patterns is not fully understood, but rearing, husbandry, and genetic factors have all been implicated (Mason 1993b). Individual factors such as behavioral temperament are also known to play a role in stereotypy development, because closely related animals, reared and housed under identical conditions, can vary in stereotypy frequency (Mason 1991b, Dallaire 1993, Mason 1993a). There are also marked species differences in the form and prevalence of stereotypy that appear to be related to a species' natural behavioral ecology (Morris 1964, Mason and Mendl 1997, Clubb and Mason 2001, Clubb 2002) and may reflect the degree to which the captive environment restricts that species' behavior. For example, across 23 species of carnivore, Clubb and Mason (2001) found a positive correlation between a species' home range size in the wild and the frequency of pacing in captivity. Bears are particularly susceptible to the development of stereotypy, a propensity possibly related to their complex feeding behaviors and large home ranges in the wild, neither of which can be fully reproduced in captivity. Thus, even when maintained in large naturalistic enclosures, bears often display stereotypy (e.g. Ormrod 1992).

Stereotypy is a highly conspicuous behavior and it is doubtful that animals exhibiting these aberrant behavior patterns would be considered for release. However, its performance is sometimes associated with other less discernible changes in behavior such as decreased behavioral flexibility and reduced attention to the environment (e.g. Ödberg 1978, Cronin et al. 1984). These influences could be highly detrimental to reintroduction efforts and importantly, because rearing conditions can cause such changes even without producing stereotypy (e.g. Jones et al. 1991), animals that do not stereotype cannot be assumed to be unaffected.

Evidence has recently been presented of a correlation between stereotypy and changes in the general organization or control of behavior. Using bank voles (*Clethrionomys glareolus*), Garner and Mason (2002) found a correlation between stereotypy frequency and an individual's ability to suppress a learned response when this response ceased to be rewarding (a measure of behavioral persistence). The most stereotypic animals were also more generally active and switched between different behaviors faster. Garner and Mason (2002) argue that together, these correlations suggest that captivity can alter the organization of behavior by acting on the basal ganglia, the parts of the brain responsible for selecting and ordering behavior patterns. Evidence was found for the same relationship to exist in songbirds (Garner et al. In Press). Abnormal behavioral persistence *per se* would undoubtedly be a debilitating trait for potential reintroduction subjects, given that animals in the wild must demonstrate flexible behavior to meet irregular and unpredictable situations. The further implication that time spent in captivity can disrupt behavioral organization at a fundamental level raises concern for other facets of reintroduction programs, such as the training of complex species-typical survival skills.

The aims of this study were two-fold: (1) to describe the forms, frequency, and prevalence of stereotypic behavior in captive Asiatic black bears and Malayan sun bears; and (2) to test the hypothesis that, consistent with the findings of Garner and Mason (2002), animals with higher levels of stereotypy are behaviorally more persistent.

Methods
Animals and housing
The subjects of this study were 29 bears: 18 Asiatic black bears (7 males, 11 females) and 11 Malayan sun bears (5 males, 6 females) individually housed in a government facility in Thailand. All animals were between 1.5 and 11 years of age, having been captured in the wild shortly after birth and later confiscated by the Thai Royal Forest Department. The holding facility was not open to the public.

Cages measured $5 \times 4 \times 3$ m $(L \times W \times H)$, were concrete floored, and had 3 walls of bars and 1 of cement, leading to a covered den area of $2 \times 4 \times 3$ m. Apparatus for climbing and tires and logs for enrichment were provided in each cage, but no further environmental enrichments were offered. Water was available *ad libitum* from 2 water nozzles located in the main cage section and food was provided between 1500 and 1600 each day.

Behavioral assessment

Behavior was assessed by scan-sampling (i.e. observing the behavior of each bear in a pre-determined order, Martin and Bateson [1993:85]) from observation blinds between the cages. A scan of all bears took approximately 13 minutes to complete, and approximately 30 scans were completed on each observation day. All scans were evenly distributed between the hours of 0700 and 1800. Preliminary observations showed that bears quickly habituated to an observer moving between blinds, and in pilot studies, a significant correlation was found between behavior measured by the scanning method and measurements taken from video recordings during periods of no disturbance, confirming that the observer's presence did not alter the bears' behavior.

Behavior was assessed from a total of 2,149 scans made over 6 observation periods (minimum observation period of 10 days) between June 2000 and May 2002. Not all bears were assessed in each observation period; 18 bears were studied solely or mainly from June 2000 to February 2001, and the remaining 11 bears from October 2001 to May 2002. Seven mutually exclusive categories of posture and locomotion were distinguished along with 15 categories of normal behavior (Vickery 2003) and 25 stereotypic behaviors or elements (detailed in Table 1). Stereotypic behaviors were defined as actions that were repetitive, invariant, and without obvious function, and were repeated ≥ 3 times in succession.

Measurement of behavioral persistence

To assess behavioral persistence, 12 bears (6 Asiatic black bears, 6 sun bears) were chosen at random and taught a simple learning task (spatial discrimination between 2 identical apparatus, left and right, that were clamped to the bars of their home cage). Each bear was rewarded for pressing on its randomly allocated correct lever. Rewards were sections of fresh fruit or dog biscuit (C.P. Dog Food, Pokphand Animal Feed, Bangkok, Thailand) presented through a metal chute. Throughout all trials the experimenter (SSV) was positioned behind a large black screen to minimize unintentional body cues that might influence performance (Hediger 1981).

Trials were conducted over 6 weeks between mid-December 2000 and early February 2001. All bears received 1 session of 20 trials per day until a performance criterion of 90% (18 of 20 trials correct) over 3 consecutive sessions was met. The probability of a bear attaining this criterion by chance is <0.0002 (binomial distribution for $n = 20$; $P = 0.5$).

Once the performance criterion had been met, sessions continued as previously but no rewards were given for responses to either apparatus. A criterion of 65% or fewer responses made to the previously 'correct' apparatus (13 out of 20 trials or less) over 3 consecutive sessions, was set to denote a return to choosing between the two apparatus at random i.e. giving up or extinction (gradual waning of a conditioned response when the usual reinforcer is omitted, e.g. Mackintosh 1974) of the learned response. This was our measure of the bears' ability to suppress and modulate the previously rewarded but now unsuccessful response.

Measures and statistical analysis

Stereotypy frequency was calculated as a proportion of all observations (the number of observations of stereotypy divided by the total number of observations). To assess the relationship between stereotypy frequency and responding during extinction trials, we used the level of stereotypy measured immediately prior to task presentation. For all other analyses, individual means were calculated across all observation periods to control for possible seasonal effects (e.g. Carlstead and Seidensticker 1991, Kolter and Zander 1997, Ames 2000). Forms of stereotypy were categorized as being either (1) locomotory (involving locomotory movements, e.g. pacing); (2) oral (involving movements of the tongue or jaw area, e.g. sham chewing); or (3) other (movements falling outside of the previous categories, e.g. head swaying).

The frequencies of the 3 types of stereotypy were analyzed using non-parametric Kruskal-Wallis tests because the assumptions of parametric testing (homogeneity of variance, normality, and linearity) were violated and could not be met through transformation. All other analyses were carried out using General Linear Models (GLM, Minitab 12, Ryan and Joiner 2001). Differences in stereotypy frequency due to a bear's species and sex were assessed using a model analogous to a 2-way ANOVA, and the regression relationship between time spent in captivity and stereotypy frequency was tested using a model of the form:

Table 1. Prevalence (number of bears of each species exhibiting behavior) and description of the stereotypic behaviors observed in 29 captive bears (18 Asiatic black bears and 11 Malayan sun bears) in Thailand, June 2000 to May 2002.

Category	Description	Black bear	Sun bear
Locomotory			
Standard pace	Locomotion along a full cage length, body aligned with the cage bars or wall, head held centrally	5	10
Standard weave	Locomotion with body perpendicular to cage bars or wall, front feet occupy two or more positions, rear feet may be lifted and repositioned or only shuffled.	4	2
Extended pace	As 'Standard pace' but pace exceeds one cage length	0	5
Loop	Circular or elliptical route of locomotion	3	0
Head throw	Throwing head back and over shoulder.	3	0
Short weave	As 'Standard weave', but front feet occupy one definite position and may hover over a second.	0	1
Weave with steps back and forth	Standard or short weaving movements interspersed with back and forth movements, body traces a T-shape.	1	0
Steps	1 or 2 steps combined with 'Head sway'.	1	0
Turning movements and elements used in conjunction with pace			
Head dip	Muzzle angled down and moves toward cage floor at turn	1	9
Water bath usage	Water bath stepped onto or sat on at turn of pace	2	8
Body rear	Head and upper body reared at turn of pace, front feet lifted from ground	1	7
Head rear	Muzzle angled up at turn, feet on ground.	0	1
Head scoop	Head reared and dipped in a single movement at turn, may be shaken at the bottom of dip	0	1
Body flop	Head and upper body reared at turn and fall in a collapse-like movement	0	1
Oral stereotypies			
Tongue flick	Flicking tongue in and out of mouth	1	2
Tongue curl	Tongue curled up and around muzzle	0	1
Jaw clamping	Teeth clamped together repetitively.	0	1
Sham chewing	Jaws moved as though food is being chewed but the mouth is empty	0	1
Self-licking	Repeated licking of a body area, distinguished from excessive grooming by the invariance and repetition of movements	0	1
Retching food	Food taken into the mouth, chewed, and retched onto paw or surface, differs from regurgitation and re-ingestion in that food never reaches the stomach.	0	1
Other stereotypies			
Head sway	Body positioned in 'Short weave' but primary movement is a pendulum-like swaying of head with eyes directed at cage floor, front feet touch the ground at one definite position	5	0
Head lean	Head smoothly leaned far back over shoulders, without throwing action	1	0
Head circle	Head rotated in a circular fashion.	1	0
Hopping	Body positioned as in 'Short weave' but weight transferred between the front feet in a hopping motion	0	1
Claw grating	Claws of front feet rasped together producing a grating noise.	0	1

Stereotypy frequency

= time in captivity

+ species | sex covariate: time in captivity

We hypothesized that bears displaying higher levels of stereotypy would take longer to extinguish responding; this was tested using a similar model in which stereotypy frequency was log (natural) transformed to meet the assumptions of parametric testing. Other factors included in the model were: (1) number of trials to reach the performance criterion (included as a covariate because the number of trials for which an animal is rewarded affects the speed of extinction [e.g. Thompson et al. 1963]); (2) time in captivity (included as a covariate because a relationship between time in captivity and stereotypy frequency was expected); (3) species; and (4) sex. The form of the model was:

Stereotypy frequency

= responses taken to extinguish + trials to learn

+ time in captivity

+ species | sex covariates: responses taken to

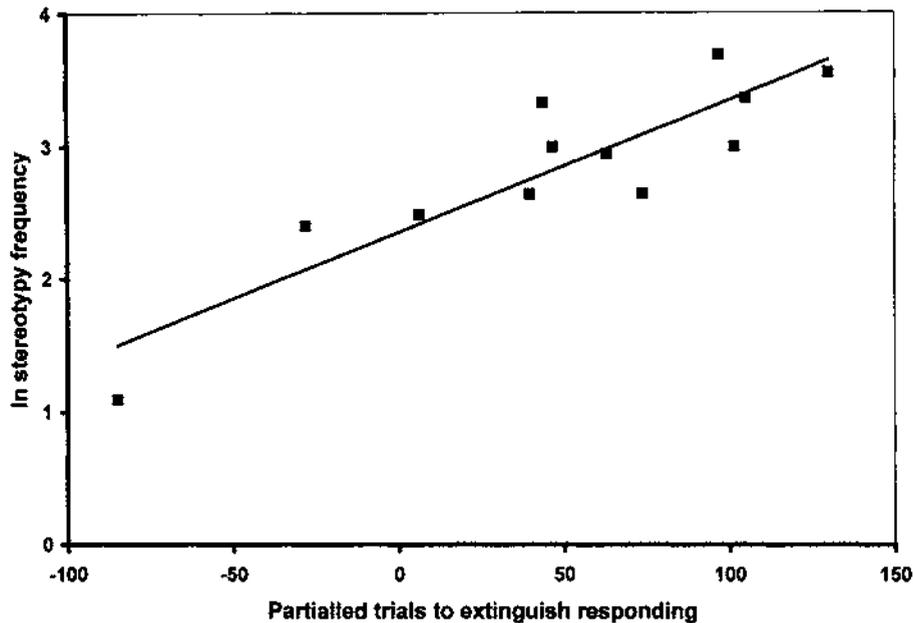extinguish + trials to learn + time in captivity

Fig. 1. The relationship between stereotypy frequency (natural log transformed) in 12 captive bears (6 Asiatic black bears, 6 sun bears) and the number of unrewarded responses made during extinction sessions in Thailand, 2000 and 2001. Trials to extinguish responding are statistically controlled for: (1) the number of trials required to learn the initial discrimination; (2) time spent in captivity; (3) species; and (4) sex. The least stereotypic animal (bottom far left data point), although different from the other bears, is not statistically an outlier.

Results

Stereotypic behavior

A wide range of locomotory, oral, and other stereotypies were observed. Pacing was the most prevalent stereotypy, but other forms such as weaving, head swaying, hopping, tongue flicking, and sham chewing were also displayed (Table 1). Across all bears, locomotory stereotypies were significantly more frequent than either oral or other stereotypies (Kruskal-Wallis $H = 35.28$, 2 df, $P < 0.001$). Frequencies of locomotory stereotypy did not differ between the species, but sun bears performed higher frequencies of oral stereotypies than black bears ($H = 4.79$, 1 df, $P = 0.029$) and black bears performed greater frequencies of stereotypies categorized as 'other' ($H = 6.52$, 1 df, $P = 0.011$). Of the 29 bears assessed, only 2 (<7%) exhibited no stereotypic behavior. Individual mean frequencies of stereotypy ranged between 0 and 51% of all observations ($n = 29$; mean $= 18\%$, SE $= 3$) and were unaffected by species or sex. Time spent in captivity was found to be significantly associated with an individual's level of stereotypy, with older bears showing increased frequencies ($F = 7.59$; 1, 23 df; $R^2 = 52\%$; $P = 0.011$).

Relationship between response persistence and stereotypy frequency

Bears made between 1 and 36 errors (mean $= 13$ errors, SE $= 3.07$) before reaching the performance criterion. No relationship was found between an individual's learning rate and stereotypy frequency. The number of responses made by individuals during extinction trials was highly variable, ranging between 11 and 115 (mean $= 47$ responses, SE $= 8.6$). As predicted, a significant positive relationship was found between an individual's stereotypy frequency and the number of responses made during extinction ($F = 4.41$; 1, 5 df; $R^2 = 79\%$; 1-tailed $P = 0.045$; Fig. 1). In contrast, responding in extinction was unrelated to time spent in captivity or a bear's species or sex.

Discussion

Few detailed studies of stereotypy in Asiatic black or Malayan sun bears are available for comparison, but the forms and frequencies of stereotypy observed here were comparable to those reported in zoo-housed bears of other species (e.g. Wechsler 1991, Ames 1994, Kolter and Zander 1997, Langenhorst 1998). Locomo-

tory stereotypies were more common and performed at higher frequencies than non-locomotory forms, a finding consistent with that of Clubb and Mason (2001), who reported carnivores to be especially prone to pacing stereotypies. Interestingly, although frequencies of total stereotypy did not differ between Asiatic black bears and sun bears, significant differences were found in the frequency with which the 2 species exhibited oral and other (non-locomotory, non-oral) stereotypies. Because rearing, husbandry, and housing conditions were virtually identical and bears of the 2 species did not differ in how long they had spent in captivity, these findings may reflect biological differences between the species. Previous studies have reported the development of different forms of stereotypy in closely related animal groups (e.g. Würbel et al. 1996), and these might stem from differences in a species' natural behavioral ecology (e.g. Mason and Mendl 1997).

The finding that older animals, having spent more time in captivity, display higher frequencies of stereotypy has been previously reported in bank voles, American mink (Mustela vison), and domestic pigs (Cooper and Ödberg 1991, Terlouw et al. 1991, Mason 1993a).

As predicted, our results also show that an individual's frequency of stereotypy correlated with behavioral persistence. This is consistent with Garner and Mason (2002) and supports the hypothesis that time spent in captivity detrimentally affects behavioral organization. One reason that stereotypic bears are more persistent could be that dysfunction of the basal ganglia underlies this behavioral deficit, as was suggested by Garner and Mason (2002). Disorders of this brain structure have previously been implicated in the performance of stereotypies induced by stimulant drugs (e.g., Lyon and Robbins 1975) and those associated with human psychiatric disorders such as autism (e.g. Turner 1997) and schizophrenia (e.g. Ridley 1994). Furthermore, captive stereotypic animals have been shown to have altered basal ganglia functioning (e.g., studies assessing susceptibility to stimulant drugs, Terlouw et al. 1992). However, there are other possible explanations for the relationship between stereotypy and persistence. The first is that highly stereotypic individuals persist in the task because they are hungrier; after all, stereotypy frequency was found to peak prior to feeding time, and the task was food-related. However, stereotypy frequency was not correlated with learning rate, as would be expected if highly stereotypic animals were more food motivated (because motivation and learning are highly correlated in operant studies e.g. Tarpy 1982:300), and

in a later study (Vickery 2003) no measure of food motivation predicted the number of responses that a bear made in extinction. The second alternative explanation is that animals naturally differ in their tendencies to form routines (e.g. Benus et al. 1987, Mason 1991b) and our correlation is simply a product of these individual differences. If this were the case, we might expect bears that persist in the task to have the most habit-like, unvarying stereotypies but not to differ in their general activity levels or the rate at which they switch between behaviors. Work is on-going to investigate this; however, in the meantime we believe that an effect of captivity on behavioral organization is the most likely explanation. Interestingly, a bear's persistence in responding was unrelated to time spent in captivity, suggesting that these represent 2 separate influences on stereotypy frequency.

Overall, if our hypothesis is correct, abnormal behavioral persistence induced by captivity could help explain why captive-bred bears often fare poorly after reintroduction. Particularly during the early stages of release, behavioral flexibility could be critical to survival as animals adapt their current behavioral strategies to meet the demands of the wild environment. Deficits in behavioral organization may impair an animal's ability to select the most appropriate action for a given situation and to modify its immediate behavior as environmental conditions change. Stereotyping bears are thus likely to be particularly poor candidates for release. However, the relationship between stereotypy and behavioral persistence is unlikely to be a simple one, and it cannot be assumed that only animals visibly displaying stereotypies will be affected, because individuals differ greatly in their susceptibility to stereotypy for reasons yet unexplained. Furthermore, deficits in behavioral organization can occur before the onset of stereotypy (see Cools 1980, Ridley et al. 1981 for stimulant-induced effects, and Jones et al. 1991 for rearing effects), so even non-stereotypic bears may show 'pre-stereotypy' low-level changes in persistence.

Management implications

The possibility that captivity impairs behavioral organization suggests that further research is needed to elucidate the best ways to prevent such detrimental behavioral changes. Reintroduction programs are faced with balancing the benefits of time spent in captivity (for rehabilitation or pre-release training) with the potential damage that captivity can exert in terms of behavioral deterioration. Maintaining bears in large, naturalistic

enclosures, in which they can perform a full range of natural behaviors and exert control over their environment, is likely to offer some protection against behavioral deficits. Furthermore, environmental enrichment has had some success in reducing the development of stereotypies, particularly when introduced early in life (e.g. Ödberg 1987, Callard et al. 2000), a time when animals seem most susceptible to the detrimental effects of a restricted environment (e.g. Sutanto et al. 1996). However, fully meeting the needs of bears in managed enclosures is a considerable challenge, and Stiver et al. (1997) reported that American black bears (Ursus americanus) reared in large naturalistic enclosures still showed poor post-release survival. These authors concluded that it was inappropriate to release pen-reared bears into the wild given the limitations of present management methods. In view of problems experienced when releasing first generation captive-bred animals, a better alternative might be to introduce captive-bred bears to controlled areas of wild or semi-wild habitat (e.g. islands) and use their offspring for translocation projects. These cubs, having themselves been exposed to natural conditions during their critical development period, should have chances of survival comparable to the offspring of wild animals. Similar methods have been employed in reintroduction programs involving other species (Beck et al. 1991, Moore and Smith 1991) and have shown encouraging results.

Although it may be some time before the reintroduction of captive-bred bears is a necessary conservation measure, research is needed now to develop rearing and management strategies which least compromise an animal's behavioral organization and enhance its chances of survival in the wild. Research efforts could concentrate on the more common bear species such as the American black bear, of which large numbers are brought into captivity each year as orphaned cubs. In this way strategies could be developed for later use on the more vulnerable species, with which we cannot afford to make mistakes.

Acknowledgments

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