SCIENTIA PLENA VOL. 18, NUM. 2 2022
www.scientiaplena.org.br doi: 10.14808/sci.plena.2022.028001

Comparison of three analytical approaches to assess temperament dimensions in nonhuman animals

Comparação de três abordagens analíticas para acessar as dimensões do temperamento em animais não-humanos

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(Recebido em 04 de fevereiro de 2021; aceito em 28 de fevereiro de 2022)

A critical aspect in the research about behavioral individual differences is the researchers' decision of which statistical methods to use to reduce the dimensionality of observed behavioral data. Our aim was to compare the main behavioral dimensions obtained from three different data reduction techniques: the Feaver's Method, Factor Analysis, and Principal Component Analysis. Three behavioral tests were carried out with 13 individuals of *Amazona vinacea* and 12 of *Psittacara leucophthalmus* species: reaction to an unknown person test, the reaction to potential predator test and the novel object test. We extracted the main behavioral dimensions using the three methods. Then we applied the Pearson's correlation to test the relationships between the main dimensions found. The first Principal Component, the Factor 1, and the dimension 1 of Feaver's Method were composed of behavioral variables reflecting 'vigilance'. Variables in second Principal Component, Factor 2 and dimension 2 of Feaver's Method reflected 'fearfulness'. A strong correlation was found between the first Principal Component and dimension 1 of Feaver's Method (r = 0.90), but not with Factor 1 (P > 0.05). Moderate correlations were found between second dimension with three methods. We conclude that PCA and Feaver's Method generate similar results for the first principal dimension, but not for the second dimension, and Feaver's Method seems to be a better predictor of this aspect of parrots' behavioral individual differences for small samples sizes.
Keywords: Personality, Principal Component Analysis, Psittacidae.

Um aspecto crítico na pesquisa sobre diferenças individuais comportamentais é a decisão dos pesquisadores sobre quais métodos estatísticos utilizar para reduzir a dimensionalidade dos dados. Assim, o objetivo deste estudo foi comparar as principais dimensões comportamentais obtidas a partir de três técnicas de redução de dados: Método de Feaver, Análise de Fatores e Análise de Componentes Principais. Três testes comportamentais foram realizados com 13 indivíduos da espécie *Amazona vinacea* e 12 da espécie *Psittacara leucophthalmus*: teste de reação à pessoa desconhecida, teste de reação ao potencial predador e teste do novo objeto. Em seguida, extraímos as principais dimensões comportamentais aplicando os três métodos nas variáveis coletadas durante os testes, e aplicamos a correlação de Pearson para testar as relações entre as principais dimensões encontradas. O primeiro Componente Principal, o Fator 1 e a dimensão 1 do Método de Feaver foram compostos por variáveis comportamentais que refletem a 'vigilância'. As variáveis no segundo Componente Principal, Fator 2 e dimensão 2 do Método de Feaver refletiram 'medo'. Uma forte correlação foi encontrada entre o primeiro Componente Principal e a dimensão 1 do Método de Feaver (r = 0,90), mas não com o Fator 1 (P > 0,05). Correlações moderadas foram encontradas entre a segunda dimensão com três métodos. Concluímos que o PCA e o Método de Feaver geram resultados semelhantes para a primeira dimensão principal, mas não para a segunda dimensão, e o Método de Feaver parece ser um melhor preditor das diferenças individuais comportamentais em papagaios para pequenas amostras.
Palavras-chave: Personalidade, Análise de Componentes Principais, Psittacidae.

1. INTRODUCTION

The study of animal behavioral individual differences has been growing in the last decades, with many theoretical and empirical papers being published [1-3] for a range of purposes, such as animal conservation, animal welfare, and the understanding of behavioral and physiological plasticity in animals [4-6]. The terms animal temperament, personality, copying styles, behavioral syndromes, and predispositions are synonyms and can be found in the scientific literature to describe interindividual differences stable overtime and across different contexts [4, 7-9].

Individual differences have been characterized by a set of main dimensions, which in turn are composed by several correlated facets or traits [10]. Main dimensions of temperament reflect animals' alternative response patterns in reaction to a potential stressor or challenging situation [8]. To assess the animals' responses to a threatening stimulus, several behavioral tests can be used, such as novel object, open-field, emergence, and predation risk tests [11, 12]. In these tests, animals are confronted with potentially new or stressful situations and their behavioral responses are recorded using discrete behavioral categories, enabling to identify divergent behavioral styles of responses [13-17].

Given its multidimensional nature, one important analytical issue in the assessment of animals' individual differences is how to combine several descriptors or behavioral categories to compose one or few interpretable scales, here defined as behavioral dimensions. It requires the use of data reduction techniques. Frequently used approaches for reducing the dimensionality of datasets are Feaver's Method [18] and multivariate exploratory techniques, such as Factor Analysis (FA) and Principal Component Analysis (PCA) [19]. Feaver's Method is based on the correlation among behavioral categories or descriptors, using groups of correlated variables to formulate indexes, which are interpreted as the main behavioral dimensions [18]. PCA and FA are methods that combine all the variables in a data matrix to identify associations among them and, based on the results, generates indexes that are the principal components or factors describing the variation present in the datasets [20].

All three methods have some advantages but also limitations. PCA and FA have been widely used in animal behavior research, however, they have limitations because of the need for a large sample size (usually more than 40 individuals) and greater sample size compared to the number of variables [12, 18, 21, 22]. The application of Feaver's Method has been less common, being useful for studies with small sample sizes [18, 23-26]. However, the Feaver's Method requires a certain level of judgment by the researcher to compose the dimensions based on the matrix of correlations among variables, leading to subjectivity, what should be more concerning with a bigger the number of variables. Thus, the aim of the present study was to compare the main behavioral dimensions obtained from Feaver's method, Factor Analysis and Principal Component Analysis, evaluating which method should be more appropriate in the assessment of behavioral individual differences in non-human animals, using psittacine as model. Previous studies have compared the outcomes and characteristics of factors and components under a mathematical perspective [27-29], that is not the purpose of the present study. This article illustrates the usefulness of Principal Components, Factor Analysis and Feaver's Method for the analysis and interpretation of behavioral data, in a palatable manner for ethologists.

2. MATERIAL AND METHODS

This study was approved by Ethics Committee on Animal Use / CEUA – UFJF, protocol number 30/2017, by the State Forest Institute (Instituto Estadual de Florestas, IEF/Juiz de Fora), authorization 034/2017, and by the Brazilian Institute for the Environment and Renewable Natural Resources (Instituto Brasileiro do Meio Ambiente e dos Recursos Renováveis, IBAMA/Juiz de Fora), process number: 02555.1000180/2017-34.

All animals came from the Wild Animal Triage Centre (Centro de Triagem de Animais Silvestres, CETAS), and were under the supervision of IEF/IBAMA entities – Juiz de Fora, Brazil. Thirteen adult individuals (five males and eight females) of Vinaceous-breasted Amazon parrot (*Amazona vinacea*) and twelve adults (three males and nine females) of White-eyed parakeets (*Psittacara leucophthalmus*) were used (hereafter, parrots will be used for all individuals of both species). The parrots were assigned to CETAS, where they remained in captivity for at least one year (being in captivity because of illegal wildlife trade). Thus, age, history and precise time in captivity are unknown.

Behavioral evaluations were conducted in a private rural property in Bias Fortes municipality, state of Minas Gerais, southeast Brazil, being in the range of natural occurrence of the two species. After data collection, birds with adequate flight ability and health were reintroduced in the area. The management of the parrots during the study and the experimental facilities were fully described in Ramos et al. (2020) [30]. Three behavioral tests were applied to assess parrots' behavioral individual differences in response to several stimulus: a) the reaction to an unknown person test (RUPt) assessed the reactions of parrots to an unfamiliar person entering in their aviary; b) the reaction to potential predator test (RPt) to evaluate the parrots' behaviors towards a taxidermized model of a predator, an ocelot (*Leopardus pardalis*); and c) the novel object test (NOt) to test the reactions to a novel stimuli, an unknown colored stick with yellow and green stripes positioned on their feeder. For the full description of the behavioral tests' procedures, behavioral categories recorded in each test and the variables analyzed, see Ramos et al. (2020) [30].

Statistical analyses

Initially, the values of all variables (behaviors) were standardized and converted into z-scores, transforming the distribution to mean = 0 and standard deviation = 1. Then, PCA and FA were applied to the matrixes of animals (rows) per behavioral variables (columns). The following behaviors were used: locomotion$^{RUPt, RPt}$, inactive$^{RUPt, NOt, RPt}$, alert$^{RUPt, NOt, RPt}$, preening$^{RUPt, NOt, RPt}$, vocalization$^{RUPt, NOt, RPt}$, latency^{RUPt}, distant$^{RUPt, NOt}$, flight distance and touch novel object. The use of PCA and FA were considered based on the ratio of sample size to the number of variables close to 2:1 and on previous studies reporting stable principal components even for small sample sizes [21, 22]. For the PCA, matrix of correlations was used, since correlation is an appropriate matrix for variables measured using different scales, compared to covariance matrix. For the FA the extraction of components was performed by the Principal Axis Factor and the varimax rotation was applied. For simplicity, this article will present only the first and second principal components (PC1 and PC2, Factor1 and Factor2), which represent the greatest proportion of the data variation (higher eigenvalues), and therefore the scores received for each animal in these two axes were defined as the main dimensions of behavior. In both analyses, variables with loadings above 0.50 were discussed as main contributors to the respective dimensions.

Then we extracted the main dimensions of the birds' behaviors by Feaver's Method [18]. We applied the Pearson's Correlation to the standardized 13 variables of the three behavioral tests (the same as used in the PCA and FA) and then we grouped the significant correlations with absolute values ≥ 0.50 to compose the main behavioral dimensions found. Feaver et al. (1986) [18] recommended to use values of correlation ≥ 0.70. As we had a single value within this range, we adopted 0.50, that can be considered acceptable [31]. Thus, the resulting profiles were: (1) Vigilance and (2) Fearfulness and to obtain the behavioral scores for each bird in the two dimensions found, the z-scores were combined as follows:

1) Vigilance = (Alert^{RUPt} + Alert^{RPt} + Alert^{NOt} + Vocalization^{RPt} – (Inactive^{RUPt} + Preening^{RUPt} + Inactive^{RPt} + Inactive^{NOt} + Preening^{RPt})) / 9

2) Fearfulness = (Distance^{RUPt} – (Locomotion^{RPt} + Vocalization^{RPt})) / 3

The mean inter-item correlation was used as a measure of internal consistency for all the dimensions found, considering adequate values between 0.15 and 0.50 as recommended by Clark and Watson (1995) [31]. Thus, means of absolute values of Pearson's correlation coefficients for the behavioral categories composing the dimensions 'vigilance' and 'fearfulness' were calculated. Finally, we applied Pearson's Correlation to assess the association between the behavioral dimensions obtained with Feaver's Method, FA, and PCA.

3. RESULTS

3.1 Behavioral dimensions obtained with PCA

In the PCA applied to the variables of the three tests, PC1 and PC2 together explained 39.79% of the total variance in the data set. The PC1 corresponded to 27.70% of the total variance, with higher positive loadings for alert^{RUPt}, alert^{RPt}, alert^{NOt}, vocalization^{RUPt}, vocalization^{RPt}, vocalization^{NOt}, flight distance, and locomotion^{RPt} and had higher negative loadings for preening^{RPt}, preening^{RUPt}, and inactive^{RPt} (Table 1). These dimensions might reflect birds' individual variation in 'vigilance', since vigilant birds were mainly characterized by the alertness and vocalization behaviors in the three behavioral tests, while indifferent birds remained inactive and more time in preening when exposed to the predator and the unknown person. The PC2 explained 12.09% of the total variance, with higher positive loadings for inactive^{NOt} and locomotion^{RPt}, in addition to negative loadings for alert^{RPt} and alert^{NOt}. The PC2 and can be categorized as 'fearfulness' dimension, whereby birds with less fear remained inactive in the novel object test and moved more in the predator test, while the fearful ones were characterized by alert behaviors.

Table 1: Loadings of variables in the first two principal components (component 1 - 'vigilance' and component 2 - 'fearfulness'), eigenvalue and % of total variance, obtained from temperament tests with the vinaceous-breasted Amazon parrots (Amazona vinacea) and white-eyed parakeets (Psittacara leucophthalmus), N = 25. ^{RUPt}: reaction to an unknown person test; ^{NOt}: novel object test, ^{RPt}: reaction to predator test.

Method/ Behaviors	**Principal component analysis**		**Factor analysis**	
	PC 1	**PC 2**	**Factor 1**	**Factor 2**
Distance ^{RUPt}	-0.48	-0.38	-0.29	0.49
Locomotion ^{RUPt}	0.05	-0.10	0.00	0.02
Inactive ^{RUPt}	-0.46	0.14	-0.20	0.16
Alert ^{RUPt}	**0.76**	-0.02	0.38	-0.37
Preening ^{RUPt}	**-0.61**	0.03	-0.53	0.28
Vocalization ^{RUPt}	**0.72**	0.12	**0.52**	-0.46
Latency ^{RUPt}	0.16	0.26	-0.18	-0.21
Flight distance	**0.60**	-0.05	0.44	-0.22
Distance ^{NOt}	0.42	0.34	0.21	-0.38
Inactive ^{NOt}	-0.15	**0.78**	-0.44	-0.49
Alert ^{Not}	**0.59**	**-0.50**	**0.67**	0.14
Preening ^{NOt}	-0.47	-0.13	-0.39	0.27
Vocalization ^{NOt}	**0.55**	-0.11	**0.63**	-0.17
Touch novel object	-0.16	-0.23	0.14	0.16
Locomotion ^{RPt}	**0.51**	**0.69**	0.04	**-0.87**
Inactive ^{RPt}	**-0.60**	0.13	0.01	0.18
Alert ^{RPt}	**0.63**	**-0.53**	0.42	0.17
Preening ^{RPt}	**-0.70**	0.17	**-0.65**	0.22
Vocalization ^{RPt}	**0.59**	0.42	0.22	**-0.61**
Eigenvalue	5.26	2.30	4.79	1.88
Variance (%)	27.70	12.09	25.21	9.91

3.2 Behavioral dimensions obtained with FA

In the FA, the first two factors, together, explained 35.12% of the common variance in the data set. The Factor 1 corresponded to 25.21% of the common variance and showed higher positive loadings for the alert^{NOt}, vocalization^{NOt} and vocalization^{RUPt}, with negative loadings for preening^{RPt} (Table 1). The Factor 1 can be characterized as behavioral 'vigilance', ranging from birds that showed higher duration of alert and more vocalizations towards stimulus to those ones that remained in preening during the predator test. The Factor 2 explained 9.91% of the common variance in the dataset and had only variables with higher negative loadings (locomotion^{RPt} and vocalization^{RPt}), reflecting those animals that had higher level of locomotion and vocalizations during predator test (less fearful ones), also characterized as 'fearfulness' dimension.

3.3 Behavioral dimensions obtained with Feaver's Method

The calculation of Pearson's coefficient applied to the variables of the three behavioral tests resulted in thirteen significant correlations, which were grouped into two dimensions (Table 2). The first group also characterized as the 'vigilance' dimension; vigilant birds were alert in the three behavioral tests and vocalized more when exposed to the predator, while indifferent birds remained inactive in the three tests and preening when exposed to the predator and the unknown person. In the second dimension found, 'fearfulness', fearful birds when exposed to the unknown person vocalized less, moved less and became more distant than birds with less fear.

3.4 Association between the temperament dimensions found with the three methods

Similar inter-item correlation coefficients were found for the first dimensions obtained by using PCA (0.34), FA (0.39), and Feaver's Method (0.33). The second dimension of Feaver's Method and Factor 2 of FA showed higher inter-item coefficient of correlation (0.51 for both) than that obtained with PCA (0.31), showing higher internal consistency for the formers. There was a strong correlation between PC1 and Feaver's Dimension 1 ($r = 0.90$, $P \leq 0.01$) and a moderate correlation between PC2 and Feaver's dimension 2 ($r = 0.60$, $P \leq 0.01$). In its turn, Factor 1 was not correlated with PC1, neither with Feaver's dimension 1 ($P > 0.05$ for both). A significant correlation was found between Factor 2 with PC2 ($r = 0.58$, $P \leq 0.01$) and with Feaver's Dimension 2 ($r = 0.60$, $P \leq 0.01$).

Table 2: Pearson correlations between behaviors in three temperament testes of Vinaceous-breasted Amazon parrots (Amazona vinacea) and White-eyed parakeets (Psittacara leucophthalmus). (N = 25). Bold values for significant correlations ($P \leq 0.05$) and $r \geq 0.50$. ^{RUPt}: reaction to an unknown person test; ^{NOt}: novel object test. ^{RPt}: reaction to predator test.

Behaviors	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1. Distance ^{RUPt}	-	-0.04	0.13	-0.24	0.26	-0.40	0.08	-0.11	-0.25	0.00	-0.21	0.16	-0.36	0.09	**-0.52**	0.16	0.00	0.18	**-0.50**
2.Locomotion ^{RUPt}		-	-0.24	-0.17	-0.12	0.04	0.02	-0.19	0.21	-0.18	0.09	0.12	-0.08	0.03	0.15	-0.13	0.05	-0.04	-0.12
3. Inactive ^{RUPt}			-	**-0.66**	0.12	-0.38	-0.03	-0.04	0.03	0.19	-0.06	-0.01	-0.18	-0.18	-0.23	0.37	-0.33	0.26	-0.30
4. Alert ^{RUPt}				-	**-0.53**	0.46	0.14	0.31	0.15	-0.08	0.33	-0.22	0.29	-0.22	0.33	**-0.51**	**0.50**	-0.44	**0.51**
5. Preening ^{RUPt}					-	-0.32	-0.10	-0.19	-0.30	0.20	-0.39	0.41	-0.14	-0.15	-0.32	0.11	-0.28	**0.62**	-0.33
6. Vocalization ^{RUPt}						-	-0.02	**0.61**	0.25	-0.11	0.27	-0.27	0.44	0.02	0.48	-0.31	0.27	-0.43	0.45
7. Latency ^{RUPt}							-	0.16	0.28	0.23	0.00	-0.17	-0.25	-0.16	0.29	-0.33	0.15	-0.08	-0.11
8. Flight distance								-	0.32	-0.12	0.37	-0.23	0.47	-0.11	0.21	-0.34	0.37	-0.34	0.23
9. Distance ^{NOt}									-	0.05	0.25	-0.19	0.39	-0.37	0.31	-0.11	-0.01	-0.08	0.29
10. Inactive ^{NOt}										-	**-0.52**	-0.30	-0.22	-0.27	0.35	0.12	-0.32	0.08	0.18
11. Alert ^{NOt}											-	-0.47	0.46	-0.26	-0.07	-0.34	**0.54**	-0.40	0.00
12. Preening ^{NOt}												-	-0.22	-0.02	-0.24	0.02	-0.21	**0.53**	-0.12
13. Vocalization ^{NOt}													-	-0.13	0.10	-0.03	0.21	-0.40	0.28
14. Touch NO														-	-0.10	0.39	-0.13	-0.23	-0.06
15. Locomotion ^{RPt}															-	-0.28	-0.09	-0.30	**0.51**
16. Inactive ^{RPt}																-	**-0.78**	0.22	-0.35
17. Alert ^{RPt}																	-	**-0.60**	0.20
18. Preening ^{RPt}																		-	-0.29
19. Vocalization ^{RPt}																			-

4. DISCUSSION

The three analytical methods used allowed us to obtain a first dimension of 'vigilance' and a second dimension of 'fearfulness' in captive parrots. The first dimensions obtained with PCA and Feaver's Method were highly correlated and had adequate values of internal consistency. Most of the variables with higher loadings in PC1 were also used in Feaver's equation 1 of the present study, indicating that they ranked the parrots in similar ways. Thus, 'vigilant' parrots characterized based on PCA and Feaver's Method became more alert and vocalized more, carefully observing the stimuli presented during the three tests. Whereas 'indifferent' parrots spent more time preening feathers and being inactive, showing minimal interest for the stimuli in front of them. Vigilant individuals did not approach the objects/person/predator during the tests. For Factor Analysis, despite part of the variables with higher loadings in PC1 had both higher loadings in Factor1, the scores of animals generated by both methods did not classify the parrots in similar ways, since no significant correlations were found. The same as for Feaver's Method and Factor Analysis.

PCA and FA have been the most used methods of data reduction in animal personality research. In spite of being apparently similar multivariate techniques, PCA and FA have important differences, that have to be considered when defining which of them to use [27, 29, 32, 33]. PCA is a linear combination, that summarizes a set of observed variables to a smaller number of principal components, which account for the higher percentage of the total variances in the observed variables [20, 27, 29]. The PC are uncorrelated and orthogonal variables, and PC scores are actual scores [34]. By using a PCA in correlation matrixes, we obtained first a dimension similar to the simple combination (sum) of correlated variables (generated by Feaver's Method). Factor Analysis outcomes were more divergent from those obtained by PCA and Feaver's Method, which is expected, since FA is method more sophisticated than the PCA [33]. Factor analysis enables the identification of a predefined number of constructs underlying a set of observed variables [27, 29]. Thus, the factors generated are underlying constructs, that influence the responses of observed variables [34]. In its turn, Factors scores are not a combination of measured variables (as PC are), but the outcomes of hypothetical underlying constructs (the factors). While PCA account for the total variance in the dataset, in FA only the covariances or common variances are considered. Thus, as lower the levels of covariation / correlations among the observed variables, more dissimilar the results of PCA and FA would be [33].

Another important difference between PCA and FA is that the PC are always orthogonal and uncorrelated among each other, while Factors can be correlated constructs [32]. The assumption of independent components might conflict with the expected structure of the behavioral differences found. For example, by using PCA, parrots 'vigilance' dimension was not related to their 'fearfulness' dimension rank ($r = 0$ between PC1 and PC2). In its turn, the Factors 1 and 2 of FA showed a correlation of 0.67 ($P < 0.05$), suggesting that more vigilant parrots were, in parts, regarded as more fearful ones. This is an interesting property for the behavioral individual differences research, because by using FA, the dimensions found should be associated, i.e., they are not restricted to correlate. Similarly, Feaver's first and second dimensions were also correlated (0.42, $P < 0.05$).

The second dimension, 'fearfulness', obtained by Feaver's Method, FA and PCA were only moderately correlated. Different behavioral variables were gathered by the three methods in this component. By using PCA, unfearful parrots spent more time inactive in the novel object test and showed higher locomotion when exposed to predator model, whereas fearful parrots remained more alert in both tests. By using FA unfearful ones showed higher frequency of vocalization and locomotion towards the predator. When using Feaver's Method, parrots described as unfearful also showed higher vocalization and locomotion when exposed to predator model and remained at greater distances from the unknown person than the fearful parrots. The unique variable that contributed to the three analytical methods was locomotion when exposed to the predator model. The second dimensions obtained by the three methods, probably, did not classify the parrots' fearfulness in identical ways, which explains the moderate strength correlation found (0.60).

The three 'fearfulness' dimension found revealed appropriate responses for captive parrots. However, the dimension found with Feaver's Method could be more causally related to a fear response, considering that in wild birds more fearful individuals usually show greater flight distance (or flight initiation distance) from unknown humans [35]. Moreover, despite both dimensions displaying adequate internal consistency, the 'fearfulness' dimension described by Feaver's Method showed higher inter-item correlation than that obtained by PCA. Internal consistency refers to the extent to which the items that compose a dimension are intercorrelated, revealing higher specificity of the target construct, which may be desirable in narrow constructs such as fear [31].

An important point that has to be acknowledge is the limitation of sample size. According to Feaver et al. (1986) [18], the PCA and FA require a ratio of sample size to the number of variables of 1:1, preferably 1:2, and more than 40 individuals. In fact, previous studies using Feaver's Method had small sample sizes [24-26], this being the main justification for the use of this analysis. However, it is also possible to find studies in which PCA or FA was applied despite the small number (24 individuals [36], 34 individuals [8], 7 individuals [37], 27 individuals [21], 15 individuals [22]), leading us to suppose that even for small samples the multivariate techniques might yield interpretable and stable dimension patterns [21, 22]. The quality of PCA and FA outputs is dependent on other characteristics of the dataset, such as ratio of sample size to the number of variables, communality, and factors overdetermination, considering adequate overdetermined factors those with high loadings on at least three to four variables and exhibiting simple and interpretable structures [38]. Communality is a measure of common variance, i.e., the variance in observed variables accounted for by a common factor, being more important for the quality of FA [34]. A critical aspect in the research about behavioral individual differences, in the field of animal personality and its implications, is the researchers' decision of which statistical methods to use to reduce the dimensionality of observed behavioral data, enabling to combine multiple variables into one scale (or dimension).

5. CONCLUSION

We conclude that the three methods used to reduce data dimensionality might generate outcomes slightly to moderately different. PCA and Feaver's Method generated similar results for the first principal dimension found, 'vigilance', however the FA scores for vigilance differed from both. For the second dimension, the three methods were not in general agreement. Despite this, all of the methods of analyses have revealed interpretable 'fearfulness' dimensions. Feaver's Method showed higher internal consistency and a narrower classification of animals in this construct, which would, therefore, seems to be a better predictor of parrots' behavioral individual differences for small samples sizes. In summary, the definition of which method of dimensionality reduction to use should not be seem as a matter of choice, since it can bring implications to the interpretations of dimensions found. Despite the three methods might result in interpretable behavioral dimensions, they might rank the animals in different ways, given the dissimilarities in the components and factors scores.

6. ACKNOWLEDGEMENTS

Authors would like to thank Coordination for the Improvement of Higher Education Personnel (CAPES) for the financial support and scholarship provided for GAPR, to Dr. Robert Young (University of Salford Manchester) for revising the manuscript, and to the State Forest Institute (IEF/Juiz de Fora), Brazilian Institute for the Environment and Renewable Natural Resources (IBAMA/Juiz de Fora), and Reserva do Ibitipoca for their support to the study.

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