Behavioural Processes xxx (2016) xxx–xxx

Contents lists available at ScienceDirect

Behavioural Processes

journal homepage: www.elsevier.com/locate/behavproc

Individual personality differences in goats predict their performance in visual learning and non-associative cognitive tasks

Christian Nawroth[a,*,1], Pamela M. Prentice[b,1], Alan G. McElligott[a,*]

[a] Queen Mary University of London, Biological and Experimental Psychology, School of Biological and Chemical Sciences, London, UK
[b] University of Edinburgh, Royal (Dick) School of Veterinary Studies, Edinburgh, UK

ARTICLE INFO

Article history:
Received 29 January 2016
Received in revised form 30 July 2016
Accepted 1 August 2016
Available online xxx

Keywords:
Cognition
Exploration
Feature cues
Learning type
Sociability
Transposition

ABSTRACT

Variation in common personality traits, such as boldness or exploration, is often associated with risk–reward trade–offs and behavioural flexibility. To date, only a few studies have examined the effects of consistent behavioural traits on both learning and cognition. We investigated whether certain personality traits ('exploration' and 'sociability') of individuals were related to cognitive performance, learning flexibility and learning style in a social ungulate species, the goat (*Capra hircus*). We also investigated whether a preference for feature cues rather than impaired learning abilities can explain performance variation in a visual discrimination task. We found that personality scores were consistent across time and context. Less explorative goats performed better in a non-associative cognitive task, in which subjects had to follow the trajectory of a hidden object (i.e. testing their ability for object permanence). We also found that less sociable subjects performed better compared to more sociable goats in a visual discrimination task. Good visual learning performance was associated with a preference for feature cues, indicating personality-dependent learning strategies in goats. Our results suggest that personality traits predict the outcome in visual discrimination and non-associative cognitive tasks in goats and that impaired performance in a visual discrimination tasks does not necessarily imply impaired learning capacities, but rather can be explained by a varying preference for feature cues.

Contents

* Corresponding authors.
E-mail addresses: nawroth.christian@gmail.com (C. Nawroth), a.g.mcelligott@qmul.ac.uk (A.G. McElligott).
[1] Both authors contributed equally to this work.

http://dx.doi.org/10.1016/j.beproc.2016.08.001
0376-6357/

1. Introduction

Personalities refer to consistent individual differences in behaviour across time and context (Réale et al., 2007), and have been demonstrated across many taxa (Briard et al., 2015; David et al., 2011; Morton et al., 2015; Pike et al., 2008; Rodríguez-Prieto et al., 2011). Consistent behavioural responses are traditionally arranged along five key personality axes that include exploration/avoidance, bold/shy, aggression, sociability and activity (Gosling, 2001; Réale et al., 2007). Accumulating evidence suggests that the variation of personality traits observed within populations is heritable and has fitness advantages (Dingemanse et al., 2002; Sih et al., 2004). Personality traits are therefore likely to be under evolutionary selection.

According to selection theory, the maintenance of variation in personality traits within a population results from individual trade-offs between current and future fitness returns (Dall et al., 2004; Wolf et al., 2007). Individuals directing energy towards immediate fitness goals will display risky behaviours, such as boldness toward predators or fast explorers of novel situations (Sih et al., 2004). In contrast, individuals concentrating energy towards future fitness goals will display risk-averse behaviours, displaying shy and non-aggressive behaviours towards other individuals and be slow to explore novel environments.

Consistency in risk prone or risk aversive behaviours within a population (otherwise known as coping strategies) are made up of suites of correlated personality traits (Drent et al., 2003; Verbeek et al., 1996). Correlations between boldness, aggression and exploration have been seen in many taxa and reflect alternatives in life history strategies (Dingemanse et al., 2004; Marchetti and Drent, 2000; Wolf et al., 2007). If correlations between personality traits are components of broader life-history strategies, then it might be expected that individual variation in other behavioural and physiological traits could also be related and exist within populations. It has been suggested that personality trait differences (e.g. bold, fast explorers or shy, slow explorers) may be linked to variation in behavioural flexibility and learning performance via differences in attention to environmental cues and the degree to which internal and external cues guide behaviour (Carere and Locurto, 2011). For example, in great tits (*Parsus major),* slow explorers respond to external stimuli by readily adjusting their behaviour to changes in their environment, compared to fast explorers that have active routines and do not perform well in fluctuating environments (Verbeek et al., 1996). It could therefore be expected that slow explorers would excel in acquiring information in situations when changes in environmental cues are relevant, such as locations or stimuli associated with food (Guillette et al., 2011). Such differences in internal and external cues for guiding behaviour can then be the link by which personality affects behavioural responsiveness, learning ability and successful adjustment to environmental changes.

The relationship between personality traits and learning ability is also supported by several studies on reversal learning. In reversal learning, animals first learn to discriminate between two stimuli, where one of the stimuli is rewarded. In the reversal phase, the rewarded stimulus is changed; the previously unrewarded stimulus now becomes rewarded, requiring a shift of attention. Fast explorers (or bold and proactive animals) are better at learning an initial discrimination task (Benus et al., 1987; Guillette et al., 2009) but slow explorers (or shy, reactive animals) are better at adapting to changes in an already learned task (Bolhuis et al., 2004; Guillette et al., 2011). However, some studies in birds do not show this relationship between explorative behaviour and behavioural flexibility (Bebus et al., 2016; Cole et al., 2011), while others even show the opposite effect (Bousquet et al., 2015).

Sociability (a key axis of animal personality) is defined by Réale et al. (2007) as an individual's reaction to the presence or absence of conspecifics. Like explorative behaviour, it is also connected to other behavioural traits, particularly in the social domain. For example, juvenile dogs (*Canis familiaris*) that are highly sociable are more likely to adopt an interactive conflict resolution strategy, while those that are less sociable tend to react passively (Riemer et al., 2013). Shy female kangaroos (*Macropus giganteus)* have fewer preferred associates within populations, and also have significantly larger mean foraging group sizes compared to bolder individuals, indicating a link between boldness and sociability of subjects (Best et al., 2015). Therefore, although exploration and sociability can be interconnected (e.g. Best et al., 2015), little is known how sociability is related to behavioural flexibility and learning performance.

Only a few studies (predominantly on primates) have investigated how consistent behavioural traits, such as boldness or sociability, predict performance in non-associative cognitive tasks. For example, common marmosets (*Callithrix jacchus*) that express higher emotional reactivity show a lower participation rate in a cognitive task in which they had to use human-given cues to find food (Schubiger et al., 2015). However, the level of emotional reactivity did not predict performance in the task. Other research rated capuchin monkeys (*Cebus apella*) on five personality dimensions and analyzed their participation rate and performance in a specific cognitive task (Morton et al., 2013). In this task, a small opaque cup was placed in front of one compartment and a larger opaque cup in front of another compartment. The correct response was to sit in the compartment that had the larger cup in front of it. Individuals that scored high on openness were more likely to participate in the task, whereas less assertive subjects performed better in the task. This negative effect of assertiveness may be best understood as individuals having motivational priorities other than food.

For ungulates, most studies investigating behavioural types and correlates to other behavioural traits focused on coping types (being either proactive or reactive). Pig (*Sus scrofa*) coping types

are associated with aggression (Melotti et al., 2011) and also affect exploration patterns but not performance in a maze task (Jansen et al., 2009). In goats, Lyons (1989) found that they express consistent individual differences in temperament, in terms of reaction to humans (timidity), which reliably predict differences in pituitary adrenal responsiveness. Additionally, social strategies in conflict resolution is associated with personality traits in goats (Miranda-de la Lama et al., 2011). Recently, it was shown that personality traits such as exploration/avoidance behaviour and sociability towards other goats are stable over a time interval of about one year. In addition, heart rate responses of the goats were predicted by their sociability outcomes, but not their exploration/avoidance behaviour (Briefer et al., 2015).

We examined whether personality traits predict performance in learning and non-associative cognitive tasks in goats. We

Please cite this article in press as: Nawroth, C., et al., Individual personality differences in goats predict their performance in visual learning and non-associative cognitive tasks. Behav. Process. (2016), http://dx.doi.org/10.1016/j.beproc.2016.08.001