



Revisiting the open-field test: what does it really tell us about animal personality?



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Animal personality has become a major topic in animal behaviour. Much recent progress has come from the use of the open-field test, which is routinely used to separate individuals into fast and slow explorers. However, there is no standard way to conduct the test and it is unclear whether the test really measures exploration. Here, we addressed these issues by combining an open-field test with a battery of independent assays intended to assess the convergent and discriminant validity of the behavioural traits suggested to measure exploration in the open-field test. Our study subjects were common mynas, *Acridotheres tristis*, introduced to Australia. The analyses confirmed that the open-field test allows individuals to be separated according to their propensity to explore, mainly through metrics related to spatial and object examination of the novel cage. However, other metrics classically used to describe exploratory behaviour, such as the latency to enter the novel space, reflected shyness rather than exploration. The open-field test can therefore be a powerful tool to investigate personality, but only if the biological meanings of the metrics derived from the test are properly validated with independent behavioural assays.

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Recent years have witnessed an explosion of interest in the study of animal personality. Experimental research has established that individuals within populations consistently vary in behavioural traits such as shyness, neophobia, exploration, aggressiveness and sociability (Dall & Griffith, 2014; Réale, Reader, Sol, McDougall, & Dingemanse, 2007; Sih, Bell, & Johnson, 2004). Much of this variation has been found to be heritable and often organized into functional syndromes, that is, in suites of correlated behaviours, largely influencing how animals deal with stressful situations such as exposure to novelty or enemies (Réale et al., 2010; Sih, Cote, Evans, Fogarty, & Pruitt, 2012; Wolf & Weissing, 2012). Once highly criticized for a lack of rigour and theoretical foundation, animal personality theory is now recognized as an important addition to the behavioural ecology literature.

Despite the enormous progress, the study of animal personalities still faces important challenges inherent in any young field (Carter, Feeney, Marshall, Cowlishaw, & Heinsohn, 2013). Perhaps the most obvious is how to define and measure personality traits. While the number of studies reporting personality experiments has increased exponentially in the last decade, considerably less attention has been paid to assessing whether the experiments really measure the behavioural traits they are intended to. As Carter et al. (2013, p. 466) wrote, this can lead to 'mislabelling traits and misinterpreting results, putting the development of animal personality theory at risk'.

One of the experimental paradigms that better illustrates the confusion about how personality traits are defined and measured is the open-field test (OFT, hereafter). Developed by Hall and Ballachey (1932), the test was initially intended to estimate locomotor activity and willingness to explore in rodents. The OFT involves measuring the behaviour of an animal after it is released into, or enters on its own accord, an open, novel arena. The simplicity of the settings of the test and the easy and rapid measurement of behaviours has made the OFT popular for measuring activity and exploration in a variety of animals beyond rodents

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(Carter et al., 2013; Walsh & Cummins, 1976; see Table A1 in the Appendix). A modified version of the OFT involves adding novel objects to the arena and quantifying the time the animal takes to visit all objects (Réale et al., 2010; Sih et al., 2004), as a measure of object exploration. The use of this OFT version has been central in establishing a continuum of variation in exploration propensity that ranges from fast to slow explorers (Verbeek, Drent, & Wiepkema, 1994). The fast–slow continuum has been very influential in creating links between personality, ecology and evolution (e.g. Réale et al., 2010).

The interpretation of the OFT is not as clear-cut as generally assumed, however (Bell, 2007; Carter et al., 2013; Walsh & Cummins, 1976). For example, in their review of the use of OFT, Walsh and Cummins (1976) highlighted that besides measuring exploration, the test can also be interpreted as measuring emotionality, fear, boldness and gregariousness. Likewise, Greggor, Thornton, and Clayton (2015) suggested that instead of measuring curiosity or exploration, this type of test may actually measure different kinds of neophobia. Carter et al. (2013) further noted that the OFT might measure several different traits (exploration/curiosity versus fear/anxiety) either simultaneously or depending on the specific experimental setting (e.g. whether the animal enters the open field freely or under force). Finally, in an OFT involving novel objects it is assumed that spatial and object explorations are correlated. However, this assumption remains to be tested. If it turns out that they are not correlated, then we will be committing the ‘jingle’ fallacy of using a single trait label to refer to two functionally different traits (Carter et al., 2013). Given the difficulties of interpreting the OFT and the lack of independent validation, some authors have called for caution when using the OFT to measure personality traits (e.g. Carter et al., 2013).

Our purpose here was to validate the extent to which the OFT measures spatial and object exploration by means of a multitrait and multitest approach (Campbell & Fiske, 1959; Carter et al., 2013). To this purpose, we conducted an OFT in which common mynas, *Acridotheres tristis*, were allowed to enter freely a cage decorated with novel objects. From this test we extracted all major behavioural traits suggested to measure exploration in previous studies (Table 1). Following the recent framework proposed by Carter et al. (2013), we then assessed the convergent validity of these behavioural traits as measures of exploration by comparing them with a less ambiguous measure of exploration drawn from a problem-solving test (Sol, Griffin, & Bartomeus, 2012; Sol, Griffin, Bartomeus, & Boyce, 2011). In this test, individuals had to lift a lid to obtain food hidden in a wooden well. The likelihood of solving

the motor task increased with the propensity of the individuals to touch the wooden well with their bill, indicating that, by pecking, individuals gained some useful information. Hence, the exploration measure was the number of pecks at the wooden well (see justification in the Methods; Sol, Griffin, et al., 2012). To demonstrate convergent validity (i.e. whether two tests actually measure the same trait), we expected that the behavioural variables extracted from the OFT would correlate with exploration measured during the problem-solving test. As we used two different assays to measure the traits, correlations should be little influenced by shared method variance (Campbell & Fiske, 1959). Note that demonstrating convergent validity is conceptually distinct from demonstrating the existence of a behavioural syndrome. In the former, two functionally similar behavioural measures (e.g. exploration around objects and in space) are correlated. In the latter, two ideally independently validated behavioural axes (e.g. shyness and activity) are correlated.

To further ensure that the studied behaviours measured the targeted trait, we also used a discriminant validity approach (Campbell & Fiske, 1959; Carter et al., 2013) in which we measured behavioural traits in additional experimental assays that should not strongly correlate with exploration. The traits examined were three components of personality (activity, neophobia and shyness) and a state-dependent factor (motivation; Sol, Griffin, et al., 2012; Sol et al., 2011). To demonstrate discriminant validity, none of these traits should strongly correlate with the behavioural traits suggested to measure exploration in the OFT.

METHODS

Ethical Note

All animal care, husbandry and experimental procedures were in accordance with the Australian code of practice for the care and use of animals for scientific purposes, and were approved by the University of Newcastle Animal Ethics Committee (protocol 1058).

Study Subjects

Our study subjects were common mynas from two populations introduced to Australia (Sol, Bartomeus, & Griffin, 2012; Sol et al., 2011). For invasive animals, the OFT is ecologically relevant because, being frequently exposed to novel challenges, the success of the invader will largely depend on how individuals react to novelty. For instance, the speed with which an individual explores,

Table 1
Behavioural variables recorded during the OFT

Behaviours recorded	Description
Likelihood of entering the open field (LE-OF)	
To cross or not to the open field	Dichotomous variable that had the value 1 for the individuals that crossed the tunnel into the open field and 0 for the individuals that did not cross
Time in the starting cage	Time (s) the individual spent in the starting cage after the screen blocking visual and physical access to the open field was lifted
Object examination (OE)	
Number of pecks to novel objects	Total number of pecks to the novel objects the individual performed during the entire period inside the open field
Spatial examination (SE)	
Examination of the open field	Dichotomous variable with 1 for the individuals that visited all the parts of the open field (the four corners of the cage and the perch) and 0 for the individuals that did not visit all parts
Time to examine the open field	Time (s) required by an individual to visit all four corners of the open field and fly onto the perch once it had entered the open field
Time spent on the ground (TS-G)	
Total length of time on the ground of the open field	Time (s) the individual spent on the ground of the open field
Control variables	
Activity in the starting cage	Number of movements per min the individual performed among the different sections of the starting cage (floor, perch, ceiling and nestbox)
Number of times visiting the perch in the open field	Number of times the individual jumped on the perch of the open field
Total length of time on the perches of the open field	Time(s) the individual spent on the perches of the open field

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