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Do you see the same cat that I see? Relationships between Qualitative Behaviour Assessment and indicators traditionally used to assess temperament in domestic cats

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Abstract

*This study into the behaviour of domestic cats (*Felis catus*) aimed to assess the relationship between behavioural expressions obtained via the Qualitative Behaviour Assessment (QBA) and quantitative outcomes of temperament tests. Four behavioural tests were used: Unfamiliar person (UP); Novel object (NO); Conspecific reaction (CR); and Food offering (FO) tests. Tests were filmed and assessed using an ethogram that included 25 discrete behavioural categories, generating quantitative information (coding method) on the existing temperament dimensions. Videos were also assessed by another observer using the QBA method, based on a list of 20 adjectives rated in visual analogue scales (rating method). Data were analysed using Principal Component Analysis. Spearman's rank correlation coefficients were used to relate the principal components (PC) of QBA to the temperament dimensions obtained with the coding method. The QBA allowed us to identify three PC, explaining 76.63% of the total variance. PC1 ranged from 'calm/relaxed/friendly' to 'tense/fearful/alert', reflecting the valence of cats' behavioural and emotional expressions towards the stimuli tested. PC2 ranged from 'indifferent' to 'agitated/active', indicating the level of emotional arousal, and PC3 ranged from 'aggressive' to 'suspicious' and could be interpreted as an axis of 'aggressiveness — caution' in response to the stimuli. The first PC obtained for each test by using the coding method was significantly correlated with the PC1 of QBA, suggesting that the variations in cats' behavioural and emotional expressions identified by QBA were correlated with the main quantitative outcomes of temperament tests traditionally applied for domestic cats. QBA could be a promising tool for identifying and differentiating cat temperament profiles. Further research is required to assess the potential use of QBA as a feasible and practical method for use in shelters.*

Keywords: *animal welfare, conspecific reaction test, food offering test, novel object test, personality, unfamiliar person test*

Introduction

Temperament may be defined as inter-individual behavioural differences consistent over time and different contexts (also known as animal personality) (Réale *et al* 2007; Briffa & Weiss 2010; Stamps & Groothuis 2010; Hudson *et al* 2015). Animals' behavioural responses in different contexts show several dimensions which, together, enable perception of their individuality (Mendl & Harcourt 2000). Temperament is expressed when animals find themselves in novel situations (Réale *et al* 2007). Thus, quantification of reactions to novel stimuli enables recognition of distinctive temperament profiles (Feaver *et al* 1986; Siegford *et al* 2003). Considerable variation in terms and methodologies used to identify dimensions of temperament in companion animals makes comparative analysis of existing papers extremely challenging (Gartner & Weiss 2013). Highfill and collaborators (2010) classified two methodologies for the assessment of animal temperament: i) 'rating methods', characterised by the use of observers' perceptions to describe animals' emotional states using descriptive adjectives quantified via visual analogue or Likert scales; and ii) 'coding methods', whereby animal behaviour in either natural or experimental settings (such as standardised tests) is recorded using discrete behavioural categories in an ethogram (Highfill *et al* 2010).

The use of qualitative approaches to assess behaviour have become more prevalent following Wemelsfelder and collaborators (2001), who pioneered the concept of integrative assessment of the 'whole animal' as opposed to merely considering isolated behavioural elements. According to those authors, qualitative observation of animals enables subtle behavioural fluctuations beyond the powers of quantitative methodology to be assessed (Wemelsfelder *et al* 2001). Thus, the Qualitative Behaviour Assessment (QBA) was created, a type of rating method allowing assessment of animals' body language and interactions with the environment at a specific moment, enabling inferences to be made as to their emotional states and expressivity (Wemelsfelder 2007). The QBA has become a valid welfare measure, an indicator of animals' negative and positive emotional states (Wemelsfelder & Lawrence 2001; Walker *et al* 2010; Fleming *et al* 2013).

Animals with different temperaments express distinctive behavioural, emotional, and physiological responses to a challenging situation that can be used to characterise their styles of responses (Koolhaas *et al* 2010). Animals' individuality influences the way in which emotions are expressed behaviourally (Koolhaas *et al* 2010). Thus, if QBA enables identification of stable inter-individual differences in animals' behavioural and emotional expressions when exposed to challenging situations, it could be used as a tool for assessing temperament. To do so, a potential approach would be to use QBA to assess inter-individual differences of animals exposed to different stimuli (or tests) and then to compare them to the results from quantitative methodologies typically used in the assessment of temperament. In addition to different contexts, inter-individual differences found with QBA should also remain consistent over time. This concept has already been explored in other studies testing the use of QBA for temperament assessment (Sant'Anna & Paranhos da Costa 2013; Góis *et al* 2016), but none were conducted with domestic cats (*Felis catus*).

As regards domestic cats in shelters, welfare issues arising as a result of stress are rife (McCobb *et al* 2005). Adult cats tend to spend longer in shelters and run the risk of developing behavioural and physiological problems due to handling, accommodation, and socialisation, that lead, ultimately, to their euthanasia (Gourkow & Fraser 2006). This scenario is linked inextricably to instances of return and abandonment that arise for a host of different reasons, including owners' lack of understanding regarding the behaviour of their pet(s) (Shore 2005). Temperament also influences the adoptive process of cats (Gourkow & Fraser 2006) with adopters citing traits such as friendliness and playfulness as reasons for cats being selected for adoption. So, profile identification becomes vital in setting up handling strategies that focus on cats' individuality and the improvement of such strategies has the potential to increase the number of adoptions through enhancing cats' welfare (Gourkow & Fraser 2006). Identifying cats' behavioural inter-individual differences would also increase adoption success through helping develop more realistic expectations regarding cats' behaviour (Shore 2005; Weiss *et al* 2015).

Pet studies into temperament tend to involve dogs (*Canis lupus familiaris*) (Gartner 2015) with studies of QBA limited to merely four (Walker *et al* 2010, 2016; Arena *et al* 2017, 2019). Despite QBA having been focused predominantly on studies of farm animals (Stockman *et al* 2012; Góis *et al* 2016), it has the potential to be highly effective in assessing pet behaviour, since the close bond humans harbour with companion animals enables the perception and recording of their body language. QBA also has applications in practical situations in which time and resources are scarce (Sant'Anna & Paranhos da Costa 2013; Góis *et al* 2016). This study aimed to assess the relationship between behavioural expressions obtained using the Qualitative Behaviour Assessment (QBA) and quantitative outcomes of temperament tests traditionally applied to domestic cats.

Materials and methods

This study was approved by the Animal Ethics Committee, Federal University of Juiz de Fora/MG, Brazil (Protocol n 051/2018). Forty-two adult, mixed-breed, short hair cats from a private shelter were utilised (22 females and 20 males), all of them neutered and showing no clinical signs of disease. Cats were kept in stable groups (co-habiting for more than three years) taking into account familiarity level and origin.

Animals were housed in eight pens measuring 55 m^2, on average. Each pen housed two to nine cats and the space availability per cat ranged from 3.35 to 43.5 m^2, with access to a courtyard fenced with wire mesh. Pens' indoor environment had shelves of differing heights, a plastic bed covered with newspaper, sandboxes, and feeding areas. Dry cat food and water were offered *ad libitum*. The free-range area was partially covered, providing natural ventilation, visual contact between adjacent pens, and a variety of enrichment items (elevated areas, wooden shelves and boxes, tyres, and large concrete pipes). These items were distributed throughout pens in numbers relative to the size of each pen.

For the assessment of cats' temperament, four behavioural tests were applied, followed by behavioural recording via a method of coding (quantitative analyses using an ethogram). Subsequent to this, test videos were analysed by a rating approach, ie the QBA.

Coding method

Four standardised tests were carried out to assess animals' temperament (Table 1): i) Unfamiliar person (UP) test (adapted from McDowell *et al* 2016), to evaluate animals' responses to an unknown human on a seven-phase scale of raising levels of stimulus (ranging from 3 to 5 min); ii) Novel object (NO) test (adapted from Durr & Smith 1997), to assess responses to novelty. For this 2-min test, cats were exposed to a toy train that emitted light and sound and a balance sought between perception of the object as very frightening, neutral or uninteresting; iii) Conspecific reaction (CR) was a 3-min test deployed to gauge the response to an unknown cat. A stuffed cat was used in order to avoid subtle variations in the conspecific's behaviours, which may potentially have influenced the reactions of the cat being tested. Fake models can be used for tests assessing behaviour towards conspecifics in companion animals (Leaver & Reimchen 2008; Barnard *et al* 2012; Shabelansky *et al* 2015); and iv) the Food offering (FO) test was carried out to assess cats' anticipatory responses to positive stimuli, ie excitability and anxiety responses when offered wet food by a human during a 3-min test. Any cat showing behaviours indicative of panic, ie jumping over the

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Table 1 Description of procedures performed in each temperament test in respective phases.

Test/Phase	Description
Unfamiliar person test	
Phase 1	An unknown person entered the pen, went to the opposite end relative to the cat's position in the pen, turned to face the cat and stood still for 1 min
Phase 2	During 1 min the animal was called by the unknown person
Phase 3	Flight distance test: a person started moving from the opposite end relative to the cat's position in the pen, approaching the cat in a straight line whilst moving calmly within its visual field. If the cat moved, the person stopped and the distance to the cat when it moved was noted. If the cat did not move, the person reached for the cat and tried to touch it. The procedure was repeated three times, with the average distance (cm) used in the analyses. Leather gloves were used for security reasons
Phase 4	The animals were stroked on the head and on the back, in this order repeatedly for 1 min
Phase 5	The tester attempted to lift and hold the animal against their chest. This was attempted three times
Phase 6	Whilst being held, the animals were stroked on the head and on the back, in this order repeatedly for 1 min. After that, the cat was placed on the ground
Phase 7	The tester held the tail of the animal firmly, holding it for 3 s
Novel object test	
Phase 1	An unknown stimulus (a toy with sound and light) was positioned in the centre of the room for 1 min
Phase 2	The toy was turned on for 1 min more
Conspecific reaction test	
Phase 1	A stuffed cat was positioned in the centre of the pen for 3 min
Food offering test	
Phase 1	A person stood in the centre of the pen holding a pot containing wet cat food, for 3 min
Phase 2	The food was offered to each animal individually.

The Unfamiliar person test was adapted from McDowell *et al* (2016) and the Novel object test was adapted from Durr and Smith (1997). The procedure was interrupted in any of these phases if the animal showed behaviours indicative of panic.

walls and/or attempting to escape climbing the wire mesh, brought testing to an immediate halt. Five cats (11.90%) displayed an extreme reaction to the UP and, of these, three (7.17%) also reacted with extreme fear to the NO test. Here, tests were suspended and the cat in question released back into its pen. The detailed procedures of all tests are described in Table 1.

UP and NO tests were carried out sequentially over four consecutive days, while the CR was performed one week later, and the FO test 27 days after the first two tests. All the tests took place in cats' home pens. UP and NO tests occurred with cats held individually in one of the divisions within their home pen (indoor or in the courtyard area) with, on average, 12 m^2 available (range: 4–27 m^2). Although testing areas varied in terms of size, all were sufficient to enable the cat to explore and maintain distance from the stimuli. CR and FO tests, on the other hand, took place with cats within in their pen groups, allowing them to access their entire pen.

Cats' behaviour was recorded using a Canon VixiHf R800 video camera (Canon Inc, USA) and a Go Pro Hero 5 (GoPro Inc, USA) attached to the tester's head. The resultant footage was used to record each animal's behaviour via continuous and focal sampling methods (Martin & Bateson 1993) with the ethogram adapted from Feaver *et al* (1986). Categories characterised as events were quantified by frequency and categories of states as duration (Table 2).

Qualitative Behaviour Assessment (QBA)

Footage of each cat's four temperament tests were edited and combined into one video segment. The process involved: (i) detaching each test with its respective times as set out in Table 3; (ii) merging footage of each cat performing all four tests (n = 42 video clips; on average 12 min in length), whilst ensuring test order was randomised for all 42 clips; (iii) excluding the voice of the tester to avoid inadvertently influencing perceptions during QBA; and (iv) inclusion of arrows indicating which cat (in a group) is the subject of the test. Each video lasted approximately 12 min, giving a total of 503.35 min. Merging the four short clips into one longer video segment is a break from traditional QBA methodology since the majority of previous studies made use of shorter video clips (1 or 2 min) with a single test or scenario (Walker *et al* 2010; Arena *et al*

Table 2 Ethogram used for coding records of the behavioural tests (adapted from Feaver *et al* 1986).

Behavioural categories	Description
Locomotion	Walk, run, or jump (s)
Standing	Remains upright in the same place, with legs stretched and the four feet touching the ground (s)
Lying	The ventral area of the body touching the ground (s)
Sitting	Back legs and posterior on the ground and the front legs stretched with feet touching the ground (s)
Tail up	Tail end positioned above the level of the animal when standing or tail raised off the ground when sitting or lying (s)
Tail down	Tail positioned parallel to or below the level of the animal when standing, and close to the ground, but far from its body, when sitting or lying (s)
Tail tucked	Tail positioned between the hind legs towards the belly when standing; and close to the ground, but near or under the body, when sitting or lying (s)
Near secure area	The cat is positioned near the exits or hideout (s)
Grooming	Licks or bites itself, scratches or rubs its paw above the head (s)
Looking	Head turned and eyes directed towards the test object (s)
Sniffing	Cat has nose close to object with movements of nose (s)
Down ear posture	Both ears positioned horizontally or facing backward (s)
Drinking	Cat consumes water (yes/no)
Tolerance Phase 4 (p6) Phase 6 (p4)	Time (s) during which the animal allowed physical touch in UP test at phase 4 and phase 6
Latency NO Phase 1 (p1) Phase 2 (p2)	Time (s) from the first exposure to stimulus and the first occurrence of the behaviour of touching the object at phase 1 and phase 2. Animals that got away were penalised with 10 s
Latency CR Latency FO Phase (p1)	Time (s) until animal was less than 1 m away from the stuffed cat or the person
Test duration	Duration (s) of test NO
Closer	Time (s) in which the cat stayed within 1 m from the test object in tests CR and FO
Out of sight	Time (s) during which the animal was not visible
Approach	Move to shorten the distance from the test object (frequency)
Vocalisation	Cat emits sounds from its mouth, mainly mewing (frequency)
Rub	Rub the head, the body or the tail on objects or the observer (frequency)
Flight distance	Distance (cm) that a cat allows a non-familiar person to approach before expressing the first withdrawal or attack response (hiss or kick) or defensive behaviours (down ear posture, muscle tension, freezing/immobile)
Did not allow to be caught	Measurements (scores) of behavioural reaction at the moment of attempts to hold the cat in the arms (or on the lap) of the test person 1 Accepted to be held in arms (lap) at the first attempt 2 Accepted to be held in arms (lap) at the second attempt 3 Accepted to be held in arms (lap) at the third attempt 4 Did not accept to be held in arms (lap)

NO: Novel object test;
FO: Food offering test;
CR: Conspecific reaction test.

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2019). Our adaptation was designed to enable investigation of whether QBA would allow behavioural information to be gathered that correlated with the coding methods. Thus, a single video clip was required, containing the same cat's reactions to the stimuli quantified in all four behavioural tests with the coding method. Merely selecting parts of the behavioural tests could have created bias and prevented gathering of each animal's 'whole picture.'

The QBA observer (ACS) had prior experience of applying the QBA method and, despite having over ten years' contact with cats (primarily as a pet owner), was unfamiliar with the study cats. The observer viewed the entire video clip once prior to scoring the cats' body language, rating how it reacted in terms of behaviour and emotional expression in response to the four tests. The observer neither took part in the behavioural test procedures, nor watched the video clips for the coding process.

Cats' behavioural expressions were assessed with the use of 20 adjectives ('active', 'affectionate', 'aggressive', 'agitated', 'attentive', 'alert', 'calm', 'confident', 'curious', 'fearful', 'friendly', 'indifferent', 'nervous', 'relaxed', 'sociable', 'stressed', 'suspicious', 'tense', 'vocal' and 'greedy') which were chosen based on previous work (Wemelsfelder *et al* 2001; Góis *et al* 2016; Ha & Ha 2017; Litchfield *et al* 2017) and with the aim of maintaining a balance between positive and negative expressions of behaviour (Sant'Anna & Paranhos da Costa 2013). The adjectives were quantified using a continuous 126-mm visual analogue scale, with markings to the left indicating a reduced expression of the characteristic in question and, to the right, a greater expression. The distance (mm) from the left extremity to the observer's mark, was deemed the score for each adjective.

Data analysis

Principal Components Analyses (PCA) were applied to the QBA data by creating a matrix of animals (42 rows) and adjectives (20 columns). The PCA is a method that combines all the variables in a data matrix to identify specific associations and, based on the results, generates indexes that are the principal components describing the variations found in the dataset (Manly 2008). A matrix of correlation was used and principal components with eigenvalues above 1 were retained as the main dimensions of cats' temperament. Variables with loadings ≥ 0.6 were considered as the higher contributors to the temperament dimensions. Analysis of variance was used to test for any confounding effects of pen group and sex on the QBA data and since no significant effects were found ($P > 0.05$), these factors were omitted from further analyses.

For the coding method, four PCA were performed on the ethogram data (one for each behavioural test). Behavioural categories that occurred in less than 20% of the animals were removed from coding analyses (Kasbaoui *et al* 2016). Four matrices of animals (rows) per behaviour (columns) were used — one for each behavioural test — and the scores each animal attained within these axes (or dimensions) were defined as their temperaments.

Table 3 Variable loadings of the Principal Components Analysis applied to the Qualitative Behaviour Assessment (QBA) of cats (n = 42).

Adjectives	PC1-QBA	PC2-QBA	PC3-QBA
Calm	**0.97**	0.03	–0.00
Relaxed	**0.95**	0.07	0.10
Friendly	**0.85**	–0.20	0.26
Greedy	**0.82**	–0.27	0.07
Confident	**0.79**	–0.00	0.51
Affectionate	**0.77**	–0.24	0.33
Curious	**0.68**	–0.39	0.09
Active	**0.65**	**–0.61**	–0.21
Fearful	**–0.93**	–0.19	–0.05
Tense	**–0.93**	–0.11	0.09
Alert	**–0.89**	–0.30	0.11
Stressed	**–0.81**	–0.16	0.30
Nervous	**–0.77**	–0.23	0.45
Attentive	**–0.66**	–0.52	0.26
Suspicious	**–0.57**	–0.32	**–0.60**
Indifferent	0.47	**0.64**	–0.12
Aggressive	–0.46	0.08	**0.71**
Sociable	0.59	–0.28	0.14
Vocal	0.44	–0.48	–0.16
Agitated	0.18	–0.72	–0.23
Variance (%)	54.59	12.69	9.35

Loadings in bold represent the adjectives with the highest contributions to the principal components (values ≥ 0.60).

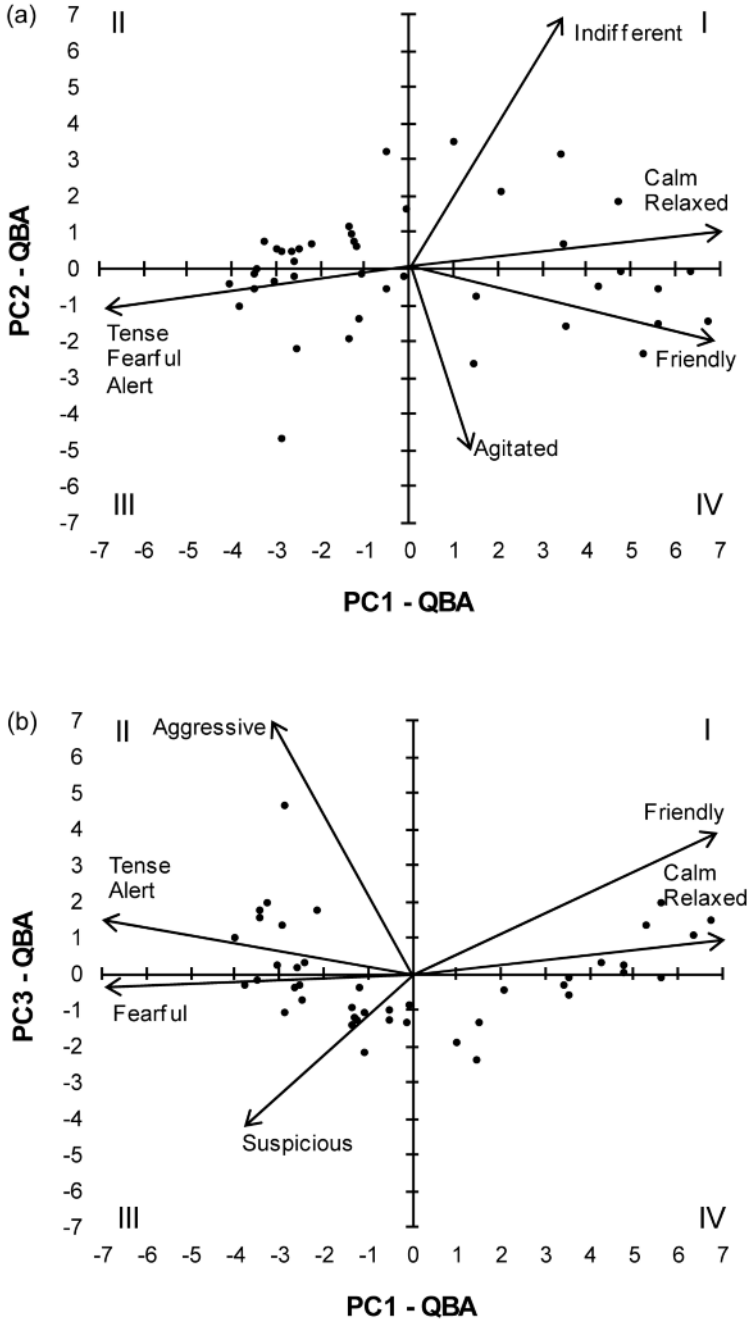
In order to assess the relationships between the coding data generated by each behavioural test and the QBA, Spearman's rank correlation coefficients were used and $P < 0.05$ deemed the level of significance.

Results

Qualitative Behaviour Assessment (QBA)

In the PCA applied to the 20 adjectives, three components were retained, explaining 76.63% of the total variance (Table 3). Component 1 (PC1-QBA) ranged from 'calm/relaxed/friendly/confident/greedy/affectionate/curious/active' to 'tense/fearful/alert/stressed/nervous/attentive', reflecting an axis of valence of cats' behavioural and emotional expressions. Component 2 (PC2-QBA) ranged from 'indifferent' to 'agitated/active', reflecting the level of arousal. Component 3 (PC3-QBA) ranged from 'aggressive' to 'suspicious' and can be interpreted as an axis of aggressiveness — caution in response to the stimulus. The plots of animals in the three principal components are shown in Figure 1.

Figure 1



Plot of cats in the components extracted using the Qualitative Behaviour Assessment (n = 42) showing (a) plot of first and second principal components (PC1 vs PC2) and (b) plot of first and third principal components (PC1 vs PC3). Numbers from I to IV represent each quadrant.

Characterisation of cats' temperament based on the coding methods

The PCA applied to the Unfamiliar person test showed three principal components with eigenvalues above 1 which, between them, explained 68.25% of the total variance in the data. Component 1 (PC1-UP) ranged from 'stay still/lay down/tail tucked/did not allow to be caught' to 'standing/approach/locomotion/rub/tolerance-p6/tail-up/tolerance-p4.' Component 2 (PC2-UP) had only higher negative loadings for 'seated/tail down.' Similarly, PC3-UP showed a single variable with loading ≥ 0.6, the flight distance (Table 4).

In the Novel object test, three components were retained, explaining 68.13% of the total variance. Component 1 (PC1-NO) ranged from 'standing/approach/locomotion/tail down/sniff' to 'lay down/latency-p1/tail tucked.' Component 2 (PC2-NO) ranged from 'latency-p2' to 'test duration/stay still/look.' Component 3 (PC3-NO) had only positive loadings ≥ 0.6 for 'grooming/seated' (Table 4).

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Table 4 Variable loadings of the Principal Components Analysis of four behavioural tests recorded using the coding method (n = 42).

Tests	Unfamiliar person (UP)			Novel object (NO)			Conspecific reaction (CR)		Food offering (FO)		
Variables	PC1	PC2	PC3	PC1	PC2	PC3	PC1	PC2	PC1	PC2	PC3
Standing	**–0.94**	–0.02	–0.12	**0.78**	–0.16	–0.39	**0.90**	–0.16	**0.90**	–0.25	–0.14
Approach	**–0.92**	0.08	–0.06	**0.78**	–0.26	–0.14	**0.83**	–0.05	**0.81**	–0.22	–0.23
Locomotion	**–0.90**	0.21	–0.21	**0.76**	–0.10	–0.40	**0.87**	–0.22	**0.86**	–0.18	–0.26
Lay down	**0.84**	0.45	0.23	**–0.73**	–0.46	–0.27	**–0.74**	**–0.63**	**–0.83**	–0.36	–0.25
Tail tucked	**0.80**	0.35	0.13	**–0.64**	–0.48	–0.16	**–0.67**	**–0.60**	**–0.85**	–0.37	–0.13
Stay still	**0.90**	–0.21	0.21	–0.17	**–0.96**	0.13	–0.21	**–0.90**	–0.46	**–0.82**	0.15
Tail down	–0.37	**–0.78**	–0.09	**0.73**	–0.20	0.24	**0.89**	–0.17	0.52	–0.15	**0.62**
Near secure area	0.50	0.06	–0.28	–0.23	–0.44	–0.09	**–0.82**	–0.40	**–0.69**	–0.35	–0.02
Look	0.00	0.48	–0.16	–0.31	**–0.64**	–0.04	0.48	**–0.65**	–0.32	**–0.66**	0.01
Down ear posture	0.46	0.27	0.08	–0.32	–0.17	–0.18	–0.05	–0.24	–0.35	–0.31	–0.25
Sniff	–0.44	0.29	–0.32	**0.60**	–0.22	–0.42	**0.80**	–0.23	–	–	–
Seated	–0.13	**–0.80**	–0.26	0.54	–0.27	**0.66**	–	–	0.22	–0.22	**0.78**
Latency p1	–	–	–	**–0.71**	0.41	0.23	**–0.91**	0.22	**–0.84**	0.30	0.10
Grooming	–	–	–	0.31	–0.19	**0.79**	–	–	0.33	–0.17	0.58
Closer	–	–	–	–	–	–	0.92	–0.22	**0.73**	–0.29	0.03
Out of sight	–	–	–	–	–	–	0.03	**0.96**	0.06	**0.94**	–0.15
Tail up	**–0.70**	0.43	–0.02	–	–	–	–	–	**0.80**	–0.29	–0.37
Rub	**–0.85**	0.34	0.03	–	–	–	–	–	0.55	–0.16	–0.37
Vocalisation	–0.48	0.24	–0.51	–	–	–	–	–	0.40	–0.25	0.15
Tolerance p6	**–0.72**	–0.12	0.41	–	–	–	–	–	–	–	–
Tolerance p4	**–0.66**	0.10	0.54	–	–	–	–	–	–	–	–
Allowed to be caught	**0.79**	0.03	–0.38	–	–	–	–	–	–	–	–
Flight distance	0.32	0.06	**–0.74**	–	–	–	–	–	–	–	–
Test duration	–	–		0.02	**–0.97**	0.02	–	–	–	–	–
Latency p2	–	–		0.04	**0.92**	–0.12	–	–	–	–	–
Variance (%)	45.40	12.94	9.91	29.99	26.54	11.59	52.24	24.26	40.62	17.10	10.85

Loadings in bold represent the adjectives with the highest contributions to the principal components (values ≥ 0.60).

In the Conspecific reaction test, two PC were retained, explaining 76.51% of the total variance in the dataset. Component 1 (PC1-CR) ranged from 'closer/standing/tail down/locomotion/approach /sniff' to 'latency/near secure area/lay down/tail tucked.' Component 2 (PC2-CR) ranged from 'out of sight' to 'stay still/look/lay down/tail tucked' (Table 4).

In the Food offering test, three components were retained and, together, explained 68.57% of the total variance. Component 1 (PC1-FO) ranged from 'standing/locomotion/approach/tail up/closer' to 'tail tucked/latency/lay down/near secure area.' Component 2 (PC2-FO) had higher positive loadings for 'stay still/look/out of sight' and no variables with negative loadings. Similarly, component 3 (PC3-FO) had only higher positive loadings ≥ 0.6 for 'seated/tail down' (Table 4).

The correlations among the principal components of the four tests were then calculated. The first components of all the tests were significantly correlated with one another ($r > 0.40$; $P < 0.05$; Table 5), revealing a tendency for cats with lower scores in PC1-UP to show higher scores in PC1-NO, as well as in PC1-CO and PC1-FO.

Correlation between coding and rating (QBA) methods

Spearman's rank correlation coefficient was used to evaluate the associations between the principal components obtained in QBA and those obtained in the coding method applied to the four tests. The PC1-QBA was negatively correlated with PC1-UP and positively with PC3-UP, PC1-NO, PC1-CR, and PC1-FO (Table 6). The PC2-QBA was positively correlated with PC1-UP and negatively with PC1-NO, PC1-CR, and PC1-FO (Table 6).

Table 5 Spearman's rank correlation coefficients between the principal components (PC) obtained in the four behavioural tests by using the coding method.

Principal component test	PC1 - Unfamiliar person	PC1 - Novel object	PC1 - Conspecific reaction	PC1 - Food offering
PC1 - Unfamiliar person	–	–0.644***	–0.424**	–0.493***
PC1 - Novel object	–0.644***	–	0.457**	0.572***
PC1 - Conspecific reaction	–0.424**	0.457**	–	0.532***
PC1 - Food offering	–0.493***	0.572***	0.532***	–

*** $P < 0.001$; ** $P < 0.01$.

Table 6 Significant Spearman's rank correlation coefficients found between QBA principal components (PC) and the dimensions obtained by using the coding method applied to the four behavioural tests.

Principal component test	PC1 - Unfamiliar person	PC3 - Unfamiliar person	PC1 - Novel object	PC1 - Conspecific reaction	PC1 - Food offering
PC1 - QBA	–0.681***	0.307*	0.533***	0.470**	0.695***
PC2 - QBA	0.308*	0.263	–0.319*	–0.309*	–0.399**

*** $P < 0.001$; ** $P < 0.01$; * $P < 0.05$.

Discussion

The present study aimed to explore the potential of QBA in revealing inter-individual differences in cats' behavioural and emotional expressions when undergoing behavioural tests, and to assess the relationship between QBA and traditional coding methods used to assess temperament in domestic cats. The QBA revealed three principal components, the first ranged from 'calm/relaxed/friendly' to 'tense/fearful/alert', expressing the variation in cats' emotional valence. The second ranged from 'indifferent' to 'agitated/active', expressing variability in cats' emotional arousal. The third factor ranged from 'aggressive' to 'suspicious', showing variability in cats' negative reactions to the stimuli tested. The PC1-QBA was highly correlated with PC1 from Unknown person and Food offering tests and moderately correlated with PC1 of Novel object and Conspecific reaction tests as recorded by coding method. PC2-QBA showed low correlations with PC1 of all tests, and PC3-QBA was not related to the coding method outcomes.

The first QBA component was defined in terms ranging from a positive (calm/relaxed/friendly) to negative (tense/fearful/alert) emotional valence. It expressed the variability of how positively or negatively animals responded to the testing stimuli. In the second component, cats ranged from an adjective indicating low arousal (indifferent) to others expressing high emotional arousal (agitated/active). The bi-dimensional structure formed by valence vs arousal has been described as a rational model to express emotions in animals (Mendl *et al* 2010). It is a pattern widely reported in several studies that used QBA in different species, where PC1 expressed valence, characterised by adjectives, such as 'calm', 'relaxed', 'content', 'confident', 'comfortable', 'docile', 'happy', 'friendly' vs 'fearful', 'tense', 'nervous', 'scared', 'restless', 'frustrated', 'uncomfortable.' In turn, PC2 is described as the level of emotional arousal, ranging from 'passive', 'indifferent', 'bored', 'apathetic' vs 'attentive', 'lively', 'agitated', 'playful', 'sociable' and 'curious' (Rousing & Wemelsfelder 2006; Napolitano *et al* 2008; Minero *et al* 2009, 2016; Grosso *et al* 2016; Diaz-Lundahl *et al* 2019). Considering the pattern of axes found and that the proportion of variance explained by each axis agreed with earlier studies using QBA (Rousing & Wemelsfelder 2006; Napolitano *et al* 2008; Minero *et al* 2009, 2016; Grosso *et al* 2016; Diaz-Lundahl *et al* 2019), we may infer that merging shortened video clips into larger segments has little effect on the fundamental essence of the QBA method. However, further studies are needed to fully elucidate the advantages and limitations of such methodology.

Regarding interpretation of QBA outcomes within the temperament profile, the QBA results showed a general correspondence with Koolhaas *et al*'s (2010) framework of animals expressing individuality in response to challenging situations. Briefly, they state that the styles of responses to a stressful situation (referred to as coping styles) should also be expressed in a bi-dimensional model whereby one of the axes reflects the quality of response to a stressor and the other the quantity (ie intensity) of response. Perhaps we can say that PC1 and PC2 enabled identification of cats' distinctiveness as to how they respond to the stimulus (ranging from 'calm' to 'tense') and the intensity of behavioural responses (from 'indifferent' to 'active'), which could reflect aspects of their temperaments when exposed to four differing contexts. Additionally, a crucial factor not addressed here, determining the potential effectiveness of QBA as a tool to assess temperament, would be consistency over time.

It is possible to draw parallels between QBA outcomes and those from studies using rating methods to assess cats'

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temperament (Ha & Ha 2017; Litchfield *et al* 2017; Evans *et al* 2019). Firstly, it is crucial to point out that despite the majority of studies into cat temperament applying rating methods based on adjectives rated on Likert scales, the raters were cat owners or shelter caretakers relying upon their familiarity with the animals (not behavioural recordings) to formulate assessments (Gartner *et al* 2014; Arahori *et al* 2016, 2017; Menchetti *et al* 2018; Salonen *et al* 2019). Comparing the temperament dimensions described in these studies with our QBA axes, it is possible to find a degree of similarity. For example, the dimensions 'agreeableness' and 'extraversion' from Gosling and Bonnenburg (1998), Litchfield *et al* (2017) and Evans *et al* (2019) reflect cat emotional stability and valence of emotional responses towards another cat or a human, ranging from the most positive (agreeableness) to the most negative (avoidable) ones, as did our PC1-QBA. Other studies described dimensions with comparable behavioural and emotional patterns to those found in PC1-QBA, such as 'friendliness' (Delgado *et al* 2012; Arahori *et al* 2016, 2017), 'playfulness' and 'amicability' (Bennett *et al* 2017). The PC2 can be comparable to the dimension 'active' in the study of Ha and Ha (2017) and PC3-QBA could be comparable with 'human non-social' (Ha & Ha 2017), 'roughness' (Arahori *et al* 2016, 2017), 'human aggressive' (Ha & Ha 2017), 'aggressiveness' (Finka *et al* 2019) and 'aggression' (Salonen *et al* 2019). It is worth noting that in these temperament studies, the dimensions (or axes) might express a continuum between two divergent extremes. However, in the interests of simplicity, the behavioural dimension could be given a single name that might better characterise one of the extremes, eg the dimension of friendliness ranged from the most to the least friendly cat.

In the Unfamiliar person test, the first component varied from cats that remained still, laid down, with tail tucked, and resisted being caught to those that remained standing, approached and rubbed against the human, moved, remained with tail up and tolerated being caught during the test. Thus, PC1-UP could be interpreted as characterising styles of responses from the most negative (higher scores in PC1) to more positive responses towards the observer (lower scores in PC1). It is reasonable to infer that animals with higher scores perceived the unknown person as an aversive and frightening stimulus, whereas those showing lower PC1-UP scores, perceived the tester as positive. PC1-UP showed a high negative correlation with the PC1-QBA. In other words, cats with negative responses toward the unfamiliar human (higher scores in PC1-UP) were rated as more tense, fearful, alert, stressed, nervous and attentive in the QBA (lower scores in PC1-QBA). At the other extreme, those cats displaying positive behaviours toward an unknown human (receiving lower scores in PC1-UP) were rated as calm, relaxed, friendly, confident, greedy, and affectionate. This result indicates that PC1-QBA could capture the behavioural responses to the observer in agreement with the coding for UP.

The PC2-UP was not correlated with PC1-QBA, and PC3-UP showed a weak correlation. The PC2-UP highlighted cats that remained seated and with tail down. In turn, the PC3-UP had a single variable with higher loading, ranking cats from the shorter to the longer flight distance. The low positive correlation between PC3-UP and PC1-QBA indicates a tendency for cats with greater flight distances to be rated as more fearful, tense, alert, stressed, nervous, attentive, and suspicious.

In the Novel object test, the first component varied from cats that remained standing, approached the object, spent more time in locomotion, with their tail down and sniffed the object, to those that spent more time lying down, with their tail tucked and took longer to touch the object in phase 1. Animals with higher PC1-NO scores were more positively engaged with the novel object, displaying exploratory behaviours (approach, locomotion, and sniff). Boissy *et al* (2007) noted exploration to be affected by fear, with investigative processes only occuring when there was no fear and no further needs requiring to be addressed — a scenario perhaps reflective of positive welfare. The PC1-NO was positively correlated with PC1-QBA, showing that cats rated as calm, relaxed, friendly, confident, greedy, and affectionate in QBA were also those exploring the object the most during the test. Cats rated as more tense, fearful, alert, stressed, nervous and attentive in the QBA typically did not interact and remained lying down with their tail tucked at the time of the test: traits reflecting an axis from 'neophilic' to 'neophobic' profiles. These results indicate that even although the QBA was carried out using extended video footage of all four tests, its findings may also reflect some of the reactions expressed in the Novel object test.

Neither the PC2-NO nor the PC3-NO were correlated with the QBA. The PC2-NO highlighted cats that showed an increased latency to touch the novel object in phase 2 compared to those that had a longer test duration, remained still, and kept their tail tucked during the test. Following on from this, the PC3 picked out individuals that remained seated and groomed themselves during the tests from those that did not. Neither component was particularly informative as regards the behavioural style of cats' responses to the objects. Perhaps PC2 is a consequence of test interruption for animals with panic responses, giving a lower test duration for some cats.

The Conspecific reaction test had two principal components, the first picked out those cats that spent more time standing, that locomoted, with the tail down, approached, sniffed, and stayed closer to the stuffed cat relative to those showing increased latency to approach values, and that spent more time lying down, with the tail tucked, close to the secure area. It displayed a continuum of responses ranging between positive and negative towards the stuffed cat. In the second dimension, the extremes ranged from cats staying out of sight to those that spent more time lying down, with the tail tucked, still, and looked at the model. Only the PC1-CR showed a moderately positive correlation with the PC1-QBA and a low negative correlation with the PC2-QBA. Thus, animals with more positive approach behaviours in the CR test were also classified as more calm, relaxed, friendly and confident in the PC1-QBA, and more active in the PC2-QBA.

Regarding the Conspecific reaction test, a limitation must be described. Notably, the risk that cats perceived the stuffed cat as merely an inanimate object, not another cat. However, it was possible to discern a difference in cats' responses to the conspecific compared to the test object which perhaps suggests that the stuffed animal was not perceived as an inanimate object in the same way that the toy train was. It was also possible to find a relationship between tail position and responses to stimulus being tested. Tail down was related to engagement responses towards the conspecific, while tail up was linked with positive reactions to unfamiliar persons and tail tucked with negative responses in the same test. It has previously been described that tail down reflects states of mental relaxation, whereas tail up is associated with affiliative components of positive relationships with either humans or other familiar animals (Bradshaw & Cameron-Beaumont 2000). Previous studies have tested the use of fake models in companion animals (Leaver & Reimchen 2008; Barnard *et al* 2012; Shabelansky *et al* 2015). In a study of domestic dogs, both a fake and a real dog were used to assess the behavioural reaction to an unknown conspecific (Shabelansky *et al* 2015). The authors reported that the model was able to elicit friendly behaviours (such as tail wag, play growl, and jump up on dog), but was less effective at triggering the authentic aggressive or fearful behaviours one would expect had it been a real dog (Shabelansky *et al* 2015). We speculate that an important factor in these cases is test duration, which should be short, since the more time that elapses, the greater the likelihood of the tested animal realising the conspecific is actually inanimate. Further research is needed to clarify the effectiveness of stuffed animals in behavioural tests with cats.

In the Food offering test, animals showing higher PC1-FO scores spent more time standing, locomoting, closer to the person, with the tail up, while animals with low scores remained laid down, with the tail tucked, close to a secure area, and showed increased latency to approach the person. The PC1-FO was positively correlated with the PC1-QBA, and also showed a low negative correlation with the PC2-QBA. Thus, animals that showed more anticipatory behaviours (higher scores in PC1-FO) were those characterised as being more calm, relaxed, friendly, confident in PC1-QBA, and tended to be more active in PC2-QBA. Anticipatory behaviours are expressed through changes in behavioural patterns, directed towards an object or situation perceived as positive, before obtaining it (Boissy *et al* 2007). Cats that interacted with the tester are possibly more capable of anticipating a stimulus perceived as pleasant. This ability to anticipate something pleasant has a positive valence, indicating positive emotional states (Boissy *et al* 2007). In PC2-FO, cats stayed still and looked at the person or stayed out of sight. This component separated out those animals not remaining visible throughout the entire test. In PC3-FO, cats remained seated with the tail down. Neither were correlated with the QBA.

To summarise, PC1-QBA was correlated with the first components of quantitative data. For all tests, the PC1 was the most informative axis, showing higher loadings for discrete behavioural categories indicative of how positively or negatively animals were engaged with the stimuli tested. It suggests that QBA facilitated synthesis of cats' body language on a single scale, gathering information from cats' reactions to the four stimuli tested. These results corroborate those of Walker *et al* (2016), who showed correlations between QBA components and quantitative behavioural categories in shelter dogs. In the present study, the greater correlations between QBA and quantitative outcomes were found in the Unknown person and Food offering tests. A result appearing to suggest that the observer was better able at distinguishing cat behavioural responses in situations involving human-animal relationships.

Some of the poor correlations between the QBA and the coding method were seen because the QBA enabled the gathering of behavioural expressions excluded from quantitative analyses due to the low occurrence of such discrete behavioural categories in the data. For example, aggressive behaviours occurred in less than 20% of the sampled cats and, thus, the variables were not included in the PCA. Behaviours expressing aggression towards humans not included in the quantitative analyses were nibbles, hisses, and kicks. They probably lead to the observer perceiving the cat to be 'aggressive' in the QBA. Thus, we may infer that rare or infrequent responses, in terms of characterising temperament variation in a sample, are not lost by using QBA.

Thus, QBA could be a promising tool for revealing inter-individual differences in behavioural and emotional expressions of cats and warrants further investigation as a potential indicator of temperament. By using the proper adaptations to this purpose, QBA enabled identification of useful profiles to help characterise the temperament of shelter cats. Four cat profiles were identifiable using the QBA, 'calm/active' (Figure 1[a]; quadrant IV), 'calm/quiet' (Figure 1[a]; quadrant I), 'fearful/flighty' (Figure 1[a]; quadrant III) and 'fearful/aggressive' (Figure 1[b]; quadrant II). PC3-QBA was defined as the dimension of aggression and illustrates the way in which animals react to potentially stressful situations, a crucial factor to consider since animals are likely to come into close contact with humans and one picked up during coding.

Despite its integrative and flexible approach, the QBA does have limitations related to feasibility that should be acknowledged. To judge how the QBA results are related in practice, interpretation by an expert ethologist is indicated (Fleming *et al* 2016). This method also does not eliminate the need for an experimentation phase (ie standardised behavioural tests), considering that animals require analysis in a number of situations and to be exposed to different stimuli in order to express their individual behavioural differences. It might imply some difficulties in terms of application during the routine management of shelters. A possible solution might entail QBA being applied by an individual familiar to the animals. Since it is carried out in

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accordance with people's perceptions, it is necessary to develop studies involving inter- and intra-observer reliability for QBA, even though it has been regarded as reliable in other contexts (Wemelsfelder & Lawrence 2001). It is worth analysing the extent to which QBA results are consistent over time and whether the profiles of the assessors influence the reliability of temperament assessment.

Animal welfare implications

Identifying shelter cats' temperament profiles can be an additional tool in helping to improve the management practices of such institutions. Assessment of temperament would favour both shelter management and the allocation of eligible cats to proper and appropriate owners. For instance, allocating cats to collective pens has to take their temperament into account. Providing enrichment items could also help to clarify the individuality of target cats, ie fearful animals benefit from the provision of elevated areas, such as shelves, hiding sites, and secure areas, while friendly cats could prosper from contact with humans and designated play activities (Rochlitz 2000).

Identifying specific temperaments better matched with owners' preferences and profiles could also improve human-animal relationships, raising the chances of successful adoptions. Fearful animals are less attractive to adopters, with the most desirable behavioural profiles being friendly, sociable, and relaxed (Gourkow & Fraser 2006). A significant risk to developing post-adoption attachment between owner and pet are unreal expectations harboured by owners. Thus, it is fundamental to inform and advise adopters of the temperament of their prospective pet (Weiss *et al* 2015).

In the present study, the QBA revealed inter-individual variation of cats' behavioural and emotional responses that might express different temperament profiles that are 'calm/active', 'calm/quiet', 'fearful/flighty', and 'fearful/aggressive.' In terms of implications, the 'calm/active' animals could be targeted at people with a willingness to interact, play, and stimulate positive activities for these animals. 'Calm/quiet' cats could be appropriate for families with children and older people, since they are less active and easier to care for, with lower risks of accidents. Animals displaying 'fearful/flighty' and 'fearful/aggressive' extremes may be in need of behavioural interventions during sheltering to help increase their tolerance to humans, thereby improving the cats' welfare as well as owners' safety. 'Fearful/aggressive' cats could also be adopted by people with a higher level of knowledge about cats' behaviour, who could understand their peculiarities and provide adequate care and environment. The appropriate allocation of cats to owners could be enhanced through the use of QBA as an assessment tool, reducing the number of returns and abandonments and helping to assist future owners in their search for companion animals.

Conclusion

The QBA revealed inter-individual differences in cats' behavioural and emotional expressions when exposed to behavioural tests traditionally used to assess temperament. Outcomes of QBA were correlated with some of the dimensions of temperament obtained by the coding method through discrete behavioural categories. The first principal component of QBA was highly correlated with the PC1 of the coding method applied to Unknown person and Food offering tests, and moderately correlated with the PC1 of Novel object test and Conspecific reaction. QBA could be a promising tool to identify and elucidate temperament profiles of cats and, thus, be a more practical methodology than quantitative coding in shelters. The QBA allows identification of temperament profiles, such as 'calm/active', 'calm/quiet', 'fearful/flighty', 'fearful/aggressive.' Based on the effectiveness of these profiles it would be possible to readily identify possible adoptions requiring behavioural interventions as training strategies. Further research is required to establish the consistency and reliability of utilising QBA for the assessment of cats' temperament.

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