Behavioural consistency – an evolutionary approach

What can animal personality research add to the story?
Behaviour as phenotype

• Most plastic trait

• Still, stable differences between:
  – species (or higher taxa)
  – populations (within species)
  – individuals (within populations)

• Seems like (...) it evolves
Behaviour as phenotype

• Most plastic trait

• Still, stable differences between:
  – species (or higher taxa)
  – populations (within species)
  – individuals (within populations)

• Seems like (...) it evolves
Behavioural consistency in one behaviour

- Traditional view
  - optimum $\times$ plasticity (no constraint)
Behavioural consistency in one behaviour

- Empirical data
Behavioural consistency in one behaviour

• Traditional view
  – Between-individual variation reflects either measurement error or random noise

• New view
  – Between-individual behavioural variation is significant
  – Change of paradigm
  – Numerous examples (from insects to apes)!
What does this mean?

• Behaviour of individuals of a certain population in one context* and situation*:

- Behavioural gradient

• Individuals do differ
• Individual behavioural repertoire < population level behavioural repertoire
What does this mean?

Consistent behavioural differences among individuals resembles human personality

→ ANIMAL PERSONALITY

‘Individual consistency in a given behaviour’

• Individuals do differ
• Individual behavioural repertoire < population level behavioural repertoire
Behavioural consistency across different behaviours

• Traditional view
  – Functionally different behaviours vary independent from each other
Behavioural consistency across different behaviours

- Empirical data
What does this mean?

- Different behaviours of the individuals in a population are not independent
What does this mean?

This also resembles a pattern well-known in human psychology:

→ BEHAVIOURAL SYNDROME

‘Individual consistency across functionally divergent behaviours’
Grey zone

Activity today and tomorrow \(\leftrightarrow\) activity - aggression

? Male-male aggression for females during reproductive season \(\leftrightarrow\) male-male aggression for food during wintering

CONTEXT vs. SITUATION
Integrating animal temperament within ecology and evolution

Denis Réale¹*, Simon M. Reader²,³, Daniel Sol³,⁴, Peter T. McDougall³ and Niels J. Dingemanse⁵

• ‘BIG FIVE’
  – Activity
  – Exploration(-avoidance)
  – Risk-taking (shyness-boldness)
  – Aggressiveness
  – Sociability
Original Article

A meta-analysis of correlated behaviors with implications for behavioral syndromes: relationships between particular behavioral traits

László Zsolt Garamszegi\textsuperscript{a}, Gábor Markó\textsuperscript{b,c} and Gábor Herczeg\textsuperscript{b,d}

• Pairwise comparisons $\rightarrow$ commonly used behavioral variables in syndrome research do not necessarily reflect equally different and independent biological domains

• No \textit{a priori} rule – look out for the context/function!
How does behavioural consistency emerge?
(intuitively maladaptive)
• HIPOTESIS 1 (constraint)
  – Hormonal
  – Pleiotrophy
  – Genetic linkage
  – Temperament
  → These are quite straightforward to interpret

• HIPOTESIS 2 (adaptive)
  – Behavioural consistency is adaptive
  → Problematic to interpret (needs some thinking...)

Adaptive explanations

• Life-history trade-offs: current vs. future reproductive success
  trade-off between current and future reproduction often results in polymorphic populations in which some individuals put more emphasis on future fitness than others → systematic differences in risk-taking behaviour

• Growth and mortality
  consistent individual differences in growth rates → consistent individual differences in behaviours that contribute growth-mortality trade-offs → behaviours that increase BOTH growth and mortality rates (e.g. foraging under predation risk) will be positively correlated with one another accross individuals; selection for high growth rates increase mean levels of potentially risky behaviours accross populations; faster-growing individuals take more risks

• Hawk-dove game theory strategies
  animal personalities = adaptive behavioural responses to differences in state
Life-history trade-offs

Life-history trade-offs favour the evolution of animal personalities

Max Wolf¹, G. Sander van Doorn¹†, Olof Leimar² & Franz J. Weissing¹

Growth-mortality trade-offs

Growth-mortality tradeoffs and ‘personality traits’ in animals

Hawk-dove game (state-dependent differences)

Recent models for adaptive personality differences: a review

Niels J. Dingemanse¹,*,† and Max Wolf²,†
We have theories, but do we have proofs?
Animal personality

• Quite straightforward
  – Individual variation = personality (behavioural type is in focus!)
  – Heritability widely proven
  – Links to fitness too
- Heritability widely proven...

<table>
<thead>
<tr>
<th>Method</th>
<th>Personality trait</th>
<th>Study species</th>
<th>$h^2$</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bayesian model</td>
<td>Aggression</td>
<td><em>Gasterosteus</em></td>
<td>0.01/ 0.14</td>
<td>(Bell, 2005)</td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>aculeatus</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bayesian model</td>
<td>Boldness</td>
<td><em>Gasterosteus</em></td>
<td>0.04/ 0.00</td>
<td>(Bell, 2005)</td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>aculeatus</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Parent-offspring</td>
<td>Exploration</td>
<td><em>Parus major</em></td>
<td>0.22*</td>
<td>(Dingemanse et al., 2002)</td>
</tr>
<tr>
<td>Full-sib</td>
<td>Exploration</td>
<td><em>Parus major</em></td>
<td>0.37*</td>
<td>(Dingemanse et al., 2002)</td>
</tr>
<tr>
<td>Selection experiment</td>
<td>EEB</td>
<td><em>Parus major</em></td>
<td>0.55*</td>
<td>(Drent et al., 2003)</td>
</tr>
<tr>
<td>Parent-offspring</td>
<td>Exploration</td>
<td><em>Parus major</em></td>
<td>0.25*</td>
<td>(Drent et al., 2003)</td>
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<tr>
<td>Full-sib</td>
<td>Risk-taking</td>
<td><em>Parus major</em></td>
<td>0.32*</td>
<td>(van Oers et al., 2004b)</td>
</tr>
<tr>
<td>Selection experiment</td>
<td>Risk-taking</td>
<td><em>Parus major</em></td>
<td>0.19*</td>
<td>(van Oers et al., 2004b)</td>
</tr>
<tr>
<td>Mother-offspring</td>
<td>Boldness</td>
<td><em>Ovis canadensis</em></td>
<td>0.21</td>
<td>(Réale et al., 2000)</td>
</tr>
<tr>
<td>Animal model</td>
<td>Boldness</td>
<td><em>Canis domesticus</em></td>
<td>0.27*</td>
<td>(Strandberg et al., 2005)</td>
</tr>
<tr>
<td>Animal model</td>
<td>Dominance</td>
<td><em>Pan troglodytes</em></td>
<td>0.63*</td>
<td>(Weiss et al., 2000)</td>
</tr>
<tr>
<td>Animal model</td>
<td>Openness</td>
<td><em>Pan troglodytes</em></td>
<td>-0.11</td>
<td>(Weiss et al., 2000)</td>
</tr>
<tr>
<td>Animal model</td>
<td>Dominance</td>
<td><em>Pan troglodytes</em></td>
<td>0.66*</td>
<td>(Weiss et al., 2002)</td>
</tr>
<tr>
<td>Animal model</td>
<td>Well-being</td>
<td><em>Pan troglodytes</em></td>
<td>0.40*</td>
<td>(Weiss et al., 2002)</td>
</tr>
</tbody>
</table>
- Links to fitness too...

Summary of data from each study used in the meta-analyses: boldness and reproductive success (a); boldness and survival (b); exploration and reproductive success (c); exploration and survival (d); aggression and reproductive success (e); aggression and survival (f)

<table>
<thead>
<tr>
<th>Species</th>
<th>Condition/sex</th>
<th>Method</th>
<th>N</th>
<th>r</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bighorn sheep (<em>Ovis canadensis</em>)</td>
<td>Wild/female</td>
<td>Trappability and response to human handlers</td>
<td>38</td>
<td>0.33</td>
<td>Réale et al. (2000)</td>
</tr>
<tr>
<td>Guanaco (<em>Lama guanicoe</em>)</td>
<td>Wild/female</td>
<td>Response toward humans</td>
<td>160</td>
<td>−0.10</td>
<td>Sarno and Franklin (1999)</td>
</tr>
<tr>
<td>Mink (<em>Mustela vison</em>)</td>
<td>Captive/female</td>
<td>Novel object (stick test)</td>
<td>200</td>
<td>0.11</td>
<td>Korhonen et al. (2002)</td>
</tr>
<tr>
<td>Sable (<em>Martes zibellina</em>)</td>
<td>Captive/female</td>
<td>Novel object (stick test)</td>
<td>122</td>
<td>0.03</td>
<td>Korhonen et al. (2001)</td>
</tr>
<tr>
<td>Black rhinoceros (<em>Diceros bicornis</em>)</td>
<td>Captive/mixed</td>
<td>Rating of traits</td>
<td>24</td>
<td>0.09</td>
<td>Carlstead et al. (1999)</td>
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<tr>
<td></td>
<td>Female</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cheetah (<em>Acinonyx jubatus</em>)</td>
<td>Captive/mixed</td>
<td>Rating of traits</td>
<td>44</td>
<td>0.61</td>
<td>Wielebnowski (1999)</td>
</tr>
<tr>
<td>Domestic pig (<em>Sus scrofa</em>)</td>
<td>Domestic/female</td>
<td>Response toward human</td>
<td>194</td>
<td>0.14</td>
<td>Hemsworth et al. (1999)</td>
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<tr>
<td>Merino sheep (<em>Ovis aries</em>)</td>
<td>Domestic/female</td>
<td>Response to confinement</td>
<td>39</td>
<td>−0.01</td>
<td>Murphy et al. (1994)</td>
</tr>
<tr>
<td>Bighorn sheep (<em>Ovis canadensis</em>)</td>
<td>Wild/juvenile mixed</td>
<td>Novel object</td>
<td>16</td>
<td>−0.62</td>
<td>Bremner-Harrison et al. (2004)</td>
</tr>
<tr>
<td>Pumpkinseed sunfish (<em>Lepomis gibbosus</em>)</td>
<td>Wild/juvenile mixed</td>
<td>Trappability</td>
<td>65</td>
<td>−0.29</td>
<td>Wilson et al. (1993)</td>
</tr>
<tr>
<td>Guppy (<em>Poecilia reticulata</em>)</td>
<td>Wild/</td>
<td>Response to predator</td>
<td>60</td>
<td>−0.32</td>
<td>Dugatkin (1992)</td>
</tr>
<tr>
<td>Guppy (<em>Poecilia reticulata</em>)</td>
<td>Domestic/juvenile female</td>
<td>Response to predator</td>
<td>24</td>
<td>0.61</td>
<td>Godin and Davis (1995)</td>
</tr>
</tbody>
</table>

Smith & Blumstein 2008 *Behavioral Ecology*
The case study of great tits (*Parus major*)
Repeatability and heritability of exploratory behaviour in great tits from the wild

NIELS J. DINGEMANSE*, CHRISTIAAN BOTH*, PIET J. DRENT*, KEES VAN OERS* & ARIE J. VAN NOORDWIJK*
Measuring exploration
Table 2. Repeatability estimates ($r$) of exploratory behaviour in two populations of wild-caught great tits for study area and sex

<table>
<thead>
<tr>
<th>Study area/Sex</th>
<th>N</th>
<th>Mean score</th>
<th>$V_p$</th>
<th>$r \pm SE$</th>
<th>$df$</th>
<th>$F$</th>
<th>$P$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Westerheide Male</td>
<td>111</td>
<td>17.74</td>
<td>55.21</td>
<td>0.48±0.07</td>
<td>110,111</td>
<td>2.84</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Westerheide Female</td>
<td>74</td>
<td>17.50</td>
<td>56.27</td>
<td>0.27±0.11</td>
<td>73,74</td>
<td>1.72</td>
<td>0.010</td>
</tr>
<tr>
<td>Oosterhout Male</td>
<td>22</td>
<td>20.37</td>
<td>69.83</td>
<td>0.46±0.17</td>
<td>22,23</td>
<td>2.73</td>
<td>0.012</td>
</tr>
<tr>
<td>Oosterhout Female</td>
<td>11</td>
<td>24.01</td>
<td>107.58</td>
<td>0.66±0.17</td>
<td>10,11</td>
<td>4.95</td>
<td>0.007</td>
</tr>
</tbody>
</table>

Table 3. Heritability estimates of exploratory behaviour of wild-caught great tits in the Westerheide study area

<table>
<thead>
<tr>
<th>Method</th>
<th>$N$</th>
<th>$N_{off}$</th>
<th>Mean score</th>
<th>$V_p$</th>
<th>$h^2 \pm SE$</th>
<th>$df$</th>
<th>$F$</th>
<th>$P$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Midparent–offspring</td>
<td>42</td>
<td>1.67</td>
<td>20.06</td>
<td>86.76</td>
<td>0.22±0.14</td>
<td>1.40</td>
<td>2.52</td>
<td>0.120</td>
</tr>
<tr>
<td>Father–offspring</td>
<td>59</td>
<td>1.78</td>
<td>20.96</td>
<td>72.52</td>
<td>0.31±0.19</td>
<td>1.57</td>
<td>2.53</td>
<td>0.117</td>
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<tr>
<td>Mother–offspring</td>
<td>63</td>
<td>1.65</td>
<td>18.96</td>
<td>95.41</td>
<td>0.34±0.16</td>
<td>1.61</td>
<td>4.30</td>
<td>0.042</td>
</tr>
<tr>
<td>Sibling analysis</td>
<td>50</td>
<td>2.64</td>
<td>15.13</td>
<td>90.72</td>
<td>0.61±0.20</td>
<td>49,82</td>
<td>2.16</td>
<td>0.001</td>
</tr>
<tr>
<td>Sibling analysis*</td>
<td>33</td>
<td>2.75</td>
<td>13.84</td>
<td>67.18</td>
<td>0.37±0.24</td>
<td>32,58</td>
<td>1.62</td>
<td>0.055</td>
</tr>
</tbody>
</table>
Natal dispersal and personalities in great tits (Parus major)

Niels J. Dingemanse¹*, Christiaan Both¹,², Arie J. van Noordwijk¹, Anne L. Rutten²,³ and Piet J. Drent¹
Fitness consequences of avian personalities in a fluctuating environment

Niels J. Dingemanse¹*,†, Christiaan Both¹,²†, Piet J. Drent¹ and Joost M. Tinbergen²
- Annual adult survival depends on personality.
- Selection on females & males: opposite! & fluctuate between years.
- Changing selection coincided with change in environmental factors (competition for space, food).
- annual adult survival depends on personality
- selection on females & males: opposite! & fluctuate between years
- changing selection coincided with change in environmental factors (competition for space, food)

Fitness depends on sex and environment → variability is maintained
The case study of great tits

Exploration is repeatable and heritable

Exploration assessed in lab predicts natal dispersal

Exploration affects both survival and reproductive success, in a sex- and year-dependent way
Behavioural syndrome

• Impossible to test
  – syndrome is a group-level presence/absence phenomenon, thus adaptive evolution cannot be directly tested

• Possibility
  – population comparisons
  – variation: constraint hypothesis rejected
  – systematic variation: adaptive hypothesis supported (but not proven!)
The case study of three-spined sticklebacks (*Gasterosteus aculeatus*)
Behavourial differences between individuals and two populations of stickleback (Gasterosteus aculeatus)

A.M. BELL

Center for Population Biology, University of California, Davis, CA, USA

Predictions of „constraint” vs. „adaptive” hypotheses

- constraint: behaviours should be positively correlated accross populations
- adaptive: not necessarily the same correlations among populations
Supports the adaptive hypothesis

- results: correlation only in one population but not in another
Behavioural syndromes differ predictably between 12 populations of three-spined stickleback

NIELS J. DINGEMANSE*, JONATHAN WRIGHT*†, ANAHITA J. N. KAZEM*†, DAWN K. THOMAS*, RACHAEL HICKLING*‡ and NICK DAWNAY*

- results: behavioural syndromes without (a) and with (b) predators

Supports the adaptive hypothesis
Evolution is not proven yet!

genetic adaptation vs. phenotypic plasticity/
Exposure to predation generates personality in threespined sticklebacks (*Gasterosteus aculeatus*)

- behaviours were not correlated BEFORE exposure to real predation
- behaviours correlated AFTER exposure to real predation → selection...

Filled circles: predated individuals
Exposure to predation generates personality in threespined sticklebacks (*Gasterosteus aculeatus*)

- behaviours were not correlated BEFORE exposure to real predation
- behaviours correlated AFTER exposure to real predation → selection...

Selection against aggressive and risk-taking individuals, but separately

The emergence of the syndrome is a plastic response to predation
The case study of three-spined sticklebacks

The presence/absence patterns of behavioural syndromes support the adaptive hypothesis.

Selection act on behavioural types, but the emergence of syndromes is a plastic response.
# Behavioral syndromes as evolutionary constraints

Ned A. Dochtermann\(^a\) and Niels J. Dingemanse\(^b,c\)

<table>
<thead>
<tr>
<th>Class</th>
<th>Species</th>
<th>Studies</th>
<th>Number of behaviors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actinopterygii</td>
<td><em>Gasterosteus aculeatus</em></td>
<td>4</td>
<td>2–3</td>
</tr>
<tr>
<td>Aves</td>
<td><em>Parus major</em></td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Aves</td>
<td><em>Tachycinetas bicolor</em></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Branchiopoda</td>
<td><em>Daphnia spp.</em></td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Insecta</td>
<td><em>Drosophila melanogaster</em></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Insecta</td>
<td><em>Gryllus firmus</em></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Insecta</td>
<td><em>Nicrophorus vespilloides</em></td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Mammalia</td>
<td><em>Canis familiaris</em></td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Mammalia</td>
<td><em>Mus musculus</em></td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>Mammalia</td>
<td><em>Ovis canadensis</em></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Reptilia</td>
<td><em>Thamnophis ordinoides</em></td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>
Genetic correlations between different behaviours are common, and act as evolutionary constraints. But does not explain what is observed in nature.
Some expansion

- Behaviour + behaviour $\rightarrow$ behavioural syndrome
- Behaviour + life-history = pace-of-life-syndrome (POLS)
- Behaviour + physiology = stress coping style
Review

Personality and the emergence of the pace-of-life syndrome concept at the population level

Denis Réale¹,* , Dany Garant², Murray M. Humphries³, Patrick Bergeron², Vincent Careau² and Pierre-Olivier Montiglio¹
Integrating behaviour with life history: boldness of the field cricket, *Gryllus integer*, during ontogeny

Petri T. Niemela\(^*\)\(^{1,2}\), Anssi Vainikka\(^{1,2}\), Ann V. Hedrick\(^3\) and Raine Kortet\(^2\)

### (immune function)

<table>
<thead>
<tr>
<th>Trait</th>
<th>Encapsulation</th>
<th>Growth rate</th>
<th>Maturation time</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(\rho)</td>
<td>(P)</td>
<td>(\rho)</td>
</tr>
<tr>
<td>Boldness1</td>
<td>-0.311</td>
<td>0.036*</td>
<td>0.095</td>
</tr>
<tr>
<td>Boldness2</td>
<td>0.042</td>
<td>0.781</td>
<td>0.054</td>
</tr>
<tr>
<td>Boldness3</td>
<td>-0.064</td>
<td>0.675</td>
<td>0.048</td>
</tr>
<tr>
<td>Boldness4</td>
<td>-0.067</td>
<td>0.657</td>
<td>-0.150</td>
</tr>
<tr>
<td>Encapsulation</td>
<td>×</td>
<td>×</td>
<td>×</td>
</tr>
<tr>
<td>Growth rate</td>
<td>-0.296</td>
<td>0.046*</td>
<td>×</td>
</tr>
<tr>
<td>MT</td>
<td>0.394</td>
<td>0.007*</td>
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Integrating behaviour with life history: boldness of the field cricket, *Gryllus integer*, during ontogeny

Petri T. Niemela\(^*\), Anssi Vainikka\(^{1,2}\), Ann V. Hedrick\(^3\) and Raine Kortet\(^2\)

(a) Empirical support for POLS

(fast strategy: 'grow fast – die young'

i.e. mature fast, don’t invest in your immune system)

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<td>×</td>
<td>×</td>
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<td>0.007(*)</td>
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</tr>
</tbody>
</table>

\(\ast\) indicates significance at the 0.05 level.
Coping styles in animals: current status in behavior and stress-physiology

J.M. Koolhaas\textsuperscript{a,\,*}, S.M. Korte\textsuperscript{b}, S.F. De Boer\textsuperscript{a}, B.J. Van Der Veg\textsuperscript{a}, C.G. Van Reenen\textsuperscript{b}, H. Hopster\textsuperscript{b}, I.C. De Jong\textsuperscript{a,\,b}, M.A.W. Ruis\textsuperscript{b}, H.J. Blokhuis\textsuperscript{b}

Review

Evolutionary background for stress-coping styles: Relationships between physiological, behavioral, and cognitive traits in non-mammalian vertebrates

\textit{Øyvind Øverli\textsuperscript{a,\,b,\,*}}, Christina Sørensen\textsuperscript{c}, Kim G.T. Pulman\textsuperscript{d}, Tom G. Pottinger\textsuperscript{e}, Wayne Korzan\textsuperscript{f}, Cliff H. Summers\textsuperscript{b}, Göran E. Nilsson\textsuperscript{c}
### Behavioral characteristics

<table>
<thead>
<tr>
<th></th>
<th>Proactive</th>
<th>Reactive</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attack latency</td>
<td>Low</td>
<td>High</td>
<td>[14]</td>
</tr>
<tr>
<td>Active avoidance</td>
<td>High</td>
<td>Low</td>
<td>[70,83]</td>
</tr>
<tr>
<td>Defensive burying</td>
<td>High</td>
<td>Low</td>
<td>[84], this paper</td>
</tr>
<tr>
<td>Nest-building</td>
<td>High</td>
<td>Low</td>
<td>[85]</td>
</tr>
<tr>
<td>Routine formation</td>
<td>High</td>
<td>Low</td>
<td>[16]</td>
</tr>
<tr>
<td>Cue dependency</td>
<td>Low</td>
<td>High</td>
<td>[17,84]</td>
</tr>
<tr>
<td>Conditioned immobility</td>
<td>Low</td>
<td>High</td>
<td>[17]</td>
</tr>
<tr>
<td>Flexibility</td>
<td>Low</td>
<td>High</td>
<td>[77]</td>
</tr>
</tbody>
</table>

### Physiological and neuroendocrine characteristics

<table>
<thead>
<tr>
<th></th>
<th>Proactive</th>
<th>Reactive</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>HPA axis activity</td>
<td>Low</td>
<td>Normal</td>
<td>[33,38,56,70,86]</td>
</tr>
<tr>
<td>HPA axis reactivity</td>
<td>Low</td>
<td>High</td>
<td>[20,28,56,87]</td>
</tr>
<tr>
<td>Sympathetic reactivity</td>
<td>High</td>
<td>Low</td>
<td>[38,77,88]</td>
</tr>
<tr>
<td>Parasympathetic reactivity</td>
<td>Low</td>
<td>High</td>
<td>[37,39]</td>
</tr>
<tr>
<td>Testosterone activity</td>
<td>High</td>
<td>Low</td>
<td>[34,35]</td>
</tr>
</tbody>
</table>
Original Article

Boldness behavior and stress physiology in a novel urban environment suggest rapid correlated evolutionary adaptation

Jonathan W. Atwell, Gonçalo C. Cardoso, Danielle J. Whittaker, Samuel Campbell-Nelson, Kyle W. Robertson, and Ellen D. Ketterson

Junco hyemalis, Dark-eyed junco
Field studies

**Flight initiation distance (m)**

- Foraging Birds:
  - Mt Laguna: 10
  - San Diego: 30

- Incubating Females:
  - Mt Laguna: 17
  - San Diego: 24

Common garden study

**Exploratory behavior score (PC1)**

- Females:
  - Mt Laguna: 13
  - San Diego: 15

- Males:
  - Mt Laguna: 16
  - San Diego: 10

(a) Field study (females only)

- Plasma corticosterone (ng/ml)

(b) Common garden study

- Mt Laguna ♀ (10)
- San Diego ♀ (11)
- Mt Laguna ♂ (9)
- San Diego ♂ (10)

Time postcapture (min)

- Mt Laguna ♀ (27)
- San Diego ♀ (31)
Supports the existence of stress copying styles and the co( parallel?) evolution of physiology and behaviour.
So where are we now?

• Animal personalities and behavioural syndromes are of common occurrence in nature.

• Adaptive evolution is proven in personalities and suggested in syndromes.
  – BUT behavioural type vs. presence/absence of consistency is tested!

• Do we understand the evolution of behavioural consistency after all?

• What next?
Main problem
animal personality

Repeated measures of behaviour

Testing repeatability

No

Negative result

Yes

Analysing behavioural type
Main problem
behavioural syndromes

- Measuring several behaviours
- Testing correlation
  - Negative result (no)
  - Analysing behavioural type (yes)
Main problems

• In practice, we study the evolution of behaviour, ‘personality’ and ‘syndrome’ are only buzzwords.
• We know nothing about the emergence of behavioural consistency!
• ...neither about its individual variation.
• In the absence of significant repeatability or correlation “there is nothing to look at”?
Main problems

Solution: quantifying behavioural consistency on the individual level

- In practice, we study the evolution of behaviour, ‘personality’ and ‘syndrome’ are only buzzwords
- We know nothing about the emergence of behavioural consistency
- ...neither about its individual variation
- In the absence of significant repeatability or correlation “there is nothing to look at”?
Individual deviation from behavioural correlations: a simple approach to study the evolution of behavioural syndromes

Gábor Herczeg • László Zsolt Garamszegi

Unpredictable animals: individual differences in intraindividual variability (IIV)

Judy A. Stamps a,*, Mark Briffa b,1, Peter A. Biro c,2
Animal personality

Repeted measures of an individual
Behaviour

Repeated measures of individuals

Behavioural type

Behavioural consistency

Behaviour

Repeated measures of individuals
Behavioural consistency

Repeated measures of individuals

A > B

A < B
Behavioral syndrome

Behavioral syndrome (correlation)

Behavioural type (configuration)

Syndrome deviation

Personality trait 1 ranks

Personality trait 2 ranks
Future

• Parallel study of behavioural type AND behavioural consistency (+behavioural plasticity)
  – Individual variation
  – Heritability
  – Fitness
  – Correlations → strategies

• Current evolutionary methods

• Rejecting binary thinking (presence/absence) and focusing strictly on individual behavioural variation
If you are interested in studying more about phenotypic plasticity and its evolutionary significance, ask this fisherman ➔

Gábor Herczeg
Behavioural Ecology group
Dept. of Systematic Zoology and Ecology

Interests:
- Evolution of behavioural consistency
- Adaptive divergence by predation & competition
- Visual & chemical signals in sexual selection

gaborherczeg@caesar.elte.hu