

# 1 **Smarter through group living: A response to Smulders**

2 **Authors:** Benjamin J. Ashton<sup>1\*</sup>, Amanda R. Ridley<sup>1</sup>, Alex Thornton<sup>2</sup>

## 3 **Affiliations:**

4 <sup>1</sup>Centre for Evolutionary Biology, School of Biological Sciences, University of Western Australia, 35  
5 Stirling Highway, Crawley 6009, Australia.

6 <sup>2</sup>Centre for Ecology and Conservation, University of Exeter, Penryn Campus, Treliever Road, Penryn  
7 TR10 9FE, UK

8 \*Correspondence to: [benjamin.ashton@research.uwa.edu.au](mailto:benjamin.ashton@research.uwa.edu.au)

## 9 **Abstract**

10 In our recent paper(Ashton, Ridley, Edwards, & Thornton, 2018) we investigated the causes of  
11 individual variation in cognitive performance in the Australian magpie *Cracticus tibicen dorsalis*. We  
12 presented individuals with a cognitive test battery consisting of four tasks designed to quantify  
13 behavioural inhibition, associative learning, reversal learning, and spatial memory. We reported a  
14 strong, positive relationship between group size and individual performance in all four tasks of the  
15 cognitive test battery(Ashton, Ridley, et al., 2018). Furthermore, females that performed better in  
16 the cognitive test battery had greater reproductive success (a greater number of successful clutches  
17 per year, fledglings per year, and fledglings surviving to independence per year), compared to  
18 females that performed badly (Ashton, Ridley, et al., 2018). An opinion piece by Smulders (2018)  
19 raised the interesting notion that these patterns may be underlined by motivational factors. In this  
20 commentary we highlight why none of the available data is consistent with this explanation, but  
21 instead support the argument that the demands of group living influence cognitive development,  
22 with knock-on consequences for fitness.

## 23 **Key words**

24 Social intelligence hypothesis, cognitive ecology, Australian magpie

25 In the last few years the field of cognitive ecology has increasingly begun to recognise the  
26 importance of adopting an intraspecific approach, focusing on the causes and consequences of  
27 individual variation in cognitive performance(Ashton, Thornton, & Ridley, 2018; Boogert, Madden,  
28 Morand-Ferron, & Thornton, 2018; Morand-Ferron, Cole, & Quinn, 2015; Thornton & Lukas, 2012). A  
29 number of important recent advances have been made in the field, including the identification of  
30 links between cognitive performance and group size(Ashton, Ridley, et al., 2018; Langley, Horik,  
31 Whiteside, & Madden, 2018), effects of spatial memory on survival (Maille & Schradin, 2016) and  
32 evidence for a “general cognitive factor” underpinning performance across a range of tasks in birds  
33 (Shaw, Boogert, Clayton, & Burns, 2015). However, determining that observed differences in  
34 individual performance result from cognitive differences rather than other factors is extremely  
35 challenging (Boogert et al., 2018; Rowe & Healy, 2014; Thornton, Isden, & Madden, 2014), so the  
36 results of these studies need to be interpreted with great caution. This is particularly the case where  
37 studies are carried out on wild populations of animals, where results are often correlational because  
38 experimental manipulations may be logistically challenging, or (in some cases) impossible. In our  
39 work on Australian magpies, for instance, experimental manipulations of group size were neither  
40 logistically or ethically feasible, so a causal effect of group size on individual cognitive performance  
41 could not be determined unequivocally. Nevertheless, we took great pains to rule out alternative  
42 explanations for the observed relationship.

43 Smulders (2018) suggests individuals living in larger groups may face greater competition for food,  
44 and therefore have greater motivation to interact with experimental tasks, which may explain the  
45 positive relationship between group size and cognitive performance reported in our study (Ashton,  
46 Ridley, et al., 2018). First, we note that a positive association between group size and food  
47 competition is by no means a universal phenomenon; indeed several studies show that foraging  
48 intake can increase with increasing group size (Blundell, 2002; Courchamp, Rasmussen, &

49 Macdonald, 2002; Sorato, Gullett, Griffith, & Russell, 2012). More specifically, several lines of  
50 evidence suggest differences in motivation do not underpin the group size- cognition relationship in  
51 Australian magpies. We examined the potential effect of two factors likely to influence food  
52 motivation: body mass and foraging efficiency (defined as the mass of food (in grams), caught per  
53 foraging minute (Edwards, Mitchell, & Ridley, 2015)). Less efficient foragers (who might be predicted  
54 to be hungrier), and individuals in poor condition (potentially indicated by body mass), might be  
55 more motivated to engage with the tasks and therefore perform better. Neither of these factors  
56 predicted cognitive performance (Ashton, Ridley, et al., 2018). Furthermore, additional analyses  
57 show there was no relationship between foraging efficiency and group size (Spearman's correlation,  
58  $r_s = -0.097$ ,  $p = 0.458$ ,  $n = 61$  individuals across 14 groups ranging in size from 3 - 12), suggesting  
59 there is no difference in food competition between groups of different sizes. Although food  
60 motivation is expected to vary over time in response to prevailing conditions, we found that  
61 individual cognitive performance was highly consistent, with individuals showing strong repeatability  
62 when tested on different versions of each task (Ashton, Ridley, et al., 2018). We also examined the  
63 potential effects of factors that may be direct indicators of food motivation, namely the latency to  
64 interact with the task, and time spent interacting with the task ("task attention"). One would expect  
65 more food motivated birds to approach the task more quickly and spend more time engaged with  
66 the task; if our results were driven by food motivation, we would therefore predict latency to  
67 interact with the task and time spent interacting with the task to explain variation in cognitive  
68 performance. However, neither of these factors predicted cognitive performance (Ashton, Ridley, et  
69 al., 2018). For these reasons, differences in motivation are unlikely to drive the positive relationship  
70 between group size and cognitive performance.

71 Repeated testing of juveniles showed that the relationship between group size and cognitive  
72 performance emerged after 100 days post-fledging (Ashton, Ridley, et al., 2018), consistent with the  
73 idea that the size of the group an individual grows up in has an influence on its cognitive  
74 development (we note that at day 100 it was only possible to quantify performance in behavioural

75 inhibition and spatial memory because fledglings at this age were unable to pass the associative and  
76 reversal learning tasks, regardless of their group size (see methods, Ashton, Ridley, et al., 2018)).  
77 Smulders (2018) suggests motivation may also explain the emergence of the group size-cognition  
78 relationship in juveniles. However, much like the adults, neither body mass (Pearson's correlation,  $r$   
79 = 0.291,  $p = 0.2$ ,  $n = 21$  individuals tested from 11 groups ranging in size from 3-12) nor latency to  
80 interact with the task (Spearman's correlation,  $r = -0.144$ ,  $p = 0.532$ ,  $n = 21$  individuals tested from  
81 11 groups ranging in size from 3-12) correlated with group size in juveniles, suggesting there is no  
82 difference in motivation between groups (the correlations reported were for juveniles at 100 days  
83 post-fledging, but results were qualitatively the same for all ages). Furthermore, body mass and  
84 latency to interact with the tasks did not predict cognitive performance when the group size-  
85 cognition relationship had emerged at both 200 and 300 days post-fledging (Ashton, Ridley, et al.,  
86 2018).

87 We found strong positive correlations in individual performance across the four tasks in our test  
88 battery. On the basis of these findings, Smulders(2018) suggests we "jump to conclusions about  
89 general intelligence" in Australian magpies. While we point out the parallels between our results and  
90 the literature on "general intelligence", we deliberately avoid the term when discussing our findings  
91 and follow Shaw et al.(2015) in using the more neutral term "general cognitive performance". We  
92 are also careful to be open about the fact that the underlying causes of correlations between  
93 performance on different tasks are not understood (supplementary material: "It is, however, worth  
94 noting that the underlying causes of the correlations in performance among tasks are not known. It  
95 is, for instance, possible that some performance in all tasks may place similar demands on working  
96 memory (e.g. in colour discrimination individuals must not only learn, but remember which colour  
97 was rewarded)" Ashton, Ridley, et al., 2018). However, we wholeheartedly agree that expanding the  
98 cognitive test battery to include a greater variety of tests covering a wider range of cognitive  
99 domains will help elucidate the extent to which Australian magpie cognition is underpinned by  
100 domain-general processes (see also Whiten, 2018). The suggestion to test dispersed juveniles is

101 another excellent idea, although contrary to Smulders' argument, non-territorial flocks of juveniles  
102 occur only in the Eastern (non-cooperatively breeding) subspecies of Australian magpie, not in the  
103 Western subspecies we studied (Johnstone & Storr, 2004). Likewise, further investigation of the  
104 relationship between provisioning rate and female cognitive performance is an important future  
105 research objective that will help elucidate the causes and consequences of individual variation in  
106 cognition in Australian magpies. However, we reiterate there is no evidence to suggest females in  
107 larger groups are more food-motivated, indicating that if a relationship between female cognitive  
108 performance and female provisioning rate did emerge, it is likely to be underpinned by cognitive  
109 processes.

110 In summary, as Smulders suggests, the results of observational studies are often open to alternative  
111 explanations, but the evidence accumulated from our research provides compelling evidence that, in  
112 Australian magpies at least, living in large groups has positive cognitive consequences.

### 113 **References**

114 Ashton, B. J., Ridley, A. R., Edwards, E. K., & Thornton, A. (2018). Cognitive performance is linked to  
115 group size and affects fitness in Australian magpies. *Nature*, *554*, 364–367.

116 <http://doi.org/10.1038/nature25503>

117 Ashton, B. J., Thornton, A., & Ridley, A. R. (2018). An intraspecific appraisal of the social intelligence  
118 hypothesis. *Philosophical Transactions of the Royal Society B*, *373*. Retrieved from

119 <http://dx.doi.org/10.1098/rstb.2017.0288>

120 Blundell, G. M. (2002). Sociality in river otters: cooperative foraging or reproductive strategies?

121 *Behavioral Ecology*, *13*(1), 134–141. <http://doi.org/10.1093/beheco/13.1.134>

122 Boogert, N. J., Madden, J. R., Morand-Ferron, J., & Thornton, A. (2018). Measuring and

123 understanding individual differences in cognition. *Philosophical Transactions of the Royal*

124 *Society B*, *373*. Retrieved from <http://dx.doi.org/10.1098/rstb.2017.0280>

125 Courchamp, F., Rasmussen, G. S. a, & Macdonald, D. W. (2002). Small pack size imposes a trade-off  
126 between hunting and pup-guarding in the painted hunting dog *Lycaon pictus*. *Behavioral*  
127 *Ecology*, *13*(1), 20–27. Retrieved from  
128 <http://www.beheco.oupjournals.org/cgi/doi/10.1093/beheco/13.1.20>

129 Edwards, E. K., Mitchell, N. J., & Ridley, A. R. (2015). The impact of high temperatures on foraging  
130 behaviour and body condition in the Western Australian Magpie *Cracticus tibicen dorsalis*.  
131 *Ostrich*, *86*(1–2), 137–144. <http://doi.org/10.2989/00306525.2015.1034219>

132 Johnstone, R. E., & Storr, G. M. (2004). *Handbook of Western Australian Birds Volume II – Passerines*.  
133 Western Australian Museum.

134 Langley, E. J. G., Horik, J. O. Van, Whiteside, M. A., & Madden, J. R. (2018). Individuals in larger  
135 groups are more successful on spatial discrimination tasks. *Animal Behaviour*, *142*, 87–93.  
136 <http://doi.org/10.1016/j.anbehav.2018.05.020>

137 Maille, A., & Schradin, C. (2016). Survival is linked with reaction time and spatial memory in African  
138 striped mice. *Biology Letters*, *12*(8), 277–286. <http://doi.org/10.1098/rsbl.2016.0346>

139 Morand-Ferron, J., Cole, E. F., & Quinn, J. L. (2015). Studying the evolutionary ecology of cognition in  
140 the wild: a review of practical and conceptual challenges. *Biological Reviews*, *91*, 367–389.  
141 <http://doi.org/10.1111/brv.12174>

142 Rowe, C., & Healy, S. D. (2014). Measuring variation in cognition. *Behavioral Ecology*, *25*, 1287–1292.  
143 <http://doi.org/10.1093/beheco/aru090>

144 Shaw, R. C., Boogert, N. J., Clayton, N. S., & Burns, K. C. (2015). Wild psychometrics: evidence for  
145 ‘general’ cognitive performance in wild New Zealand robins, *Petroica longipes*. *Animal*  
146 *Behaviour*, *109*(February), 101–111. <http://doi.org/10.1016/j.anbehav.2015.08.001>

147 Smulders, T. V. (2018). Smarter through group living ? *Learning & Behavior*, 1–2.

- 148 Sorato, E., Gullett, P. R., Griffith, S. C., & Russell, A. F. (2012). Effects of predation risk on foraging  
149 behaviour and group size: Adaptations in a social cooperative species. *Animal Behaviour*, *84*(4),  
150 823–834. <http://doi.org/10.1016/j.anbehav.2012.07.003>
- 151 Thornton, A., Isden, J., & Madden, J. R. (2014). Toward wild psychometrics: linking individual  
152 cognitive differences to fitness. *Behavioral Ecology*, *25*(6), 1299–1301.  
153 <http://doi.org/10.1093/beheco/aru095>
- 154 Thornton, A., & Lukas, D. (2012). Individual variation in cognitive performance: developmental and  
155 evolutionary perspectives. *Philosophical Transactions of the Royal Society of London. Series B,*  
156 *Biological Sciences*, *367*(1603), 2773–83. <http://doi.org/10.1098/rstb.2012.0214>
- 157 Whiten, A. (2018). Brainpower boost for birds in large groups. *Nature*.  
158 <http://doi.org/10.1038/d41586-018-01487-3>

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