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1 **The effects of social conformity on Gouldian finch personality**

2

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12

13

14 **Abstract**

15 Consistent individual differences in behaviour observed within a population are termed  
16 'personality'. Studies of personality typically test subjects in isolation, ignoring the potential  
17 effects of the social environment, which might restrict the expression of individual behaviour  
18 via conformity, or enhance it by facilitation. The Gouldian finch (*Erythrura gouldiae*) exhibits  
19 polymorphism in head colour (red or black) which is related to different personalities: black  
20 headed birds are bolder and less aggressive than red-headed birds. As such, this species  
21 provides a unique opportunity to investigate the effects of the presence of a social partner on  
22 the expression of individual behaviour. Using two behavioural tests that reflect individual  
23 'boldness', exploration of a novel object and time taken to return to feeding following a  
24 predator threat, we show that Gouldian finches adjust their behaviour according to  
25 personality of their partners: where a bird's partner is bolder, it becomes bolder; where a  
26 bird's partner is shyer, it becomes shyer. This social conformity effect was reduced,  
27 however, for black-headed birds paired with red-headed partners in the novel object test, in  
28 keeping with previous research finding bolder individuals are less plastic in their responses.  
29 Since variation in personality can promote group cohesion and improve the functioning of  
30 social groups in a variety of contexts, we hypothesise that head-colour could act as a cue,  
31 facilitating preferential associations with those of similar or dissimilar personalities in large  
32 mobile flocks of Gouldian finches.

33

34 **Keywords**

35 boldness, colour polymorphism, *Erythrura gouldiae*, Gouldian finch, neophilia, personality,  
36 risk-taking, Social

37

38 **Highlights**

39 We tested Gouldian finch personality in an asocial and social setting

40 Our experiments show birds' behaviour changes according to their partners identity

41 Shy birds take more risk when paired with bolder flock-mates

42 Bold birds take less risk when paired with shyer flock-mates

43

## 44 INTRODUCTION

45

46 Differences in behaviour are often observed in individuals within a species that are otherwise  
47 similar to each other in terms of sex, age and size (Koolhaas et al., 1999; Reale, Reader,  
48 Sol, McDougall, & Dingemanse, 2007; Sih, Bell, Johnson, & Ziemba, 2004). Consistency in  
49 these behavioural traits both within and between individuals represents a behavioural  
50 syndrome (Sih et al., 2004), which can be heritable (Drent, van Oers, & van Noordwijk, 2003;  
51 van Oers, Drent, de Goede, & van Noordwijk, 2004), and may have complex underlying  
52 genetic and physiological foundations (Carere, Caramaschi, & Fawcett, 2010; van Oers, de  
53 Jong, van Noordwijk, Kempenaers, & Drent, 2005). Understanding how these “personality”  
54 types emerge, their causes, and their consequences, has become a major challenge in  
55 behavioural and evolutionary biology (Wolf, van Doorn, Leimar, & Weissing, 2007).

56

57 Studies of personality are usually performed with individuals in isolation (Webster & Ward,  
58 2011). However, most species are at some point in their lives social; whether this is with a  
59 sexual partner, as part of loose aggregations with variable membership, or as part of a  
60 stable social group (Krause & Ruxton, 2002). Such social interaction may have little or no  
61 effect on individual personality so that whilst individuals may interact, their behavioural  
62 responses remain unchanged, and so the average behaviour of a social group should reflect  
63 these. For example, in threespine sticklebacks, *Gasterosteus aculeatus*, behavioural  
64 responses when tested alone reliably predict their behaviour in a social group, and  
65 individuals maintain their behavioural types despite the experience of repeated social  
66 interactions (Laskowski & Bell, 2014). However, the presence of conspecifics might restrict  
67 individual behavioural responses via conformity or enhance differences in behaviour by  
68 facilitation.

69

70 Social conformity is often examined from a social learning perspective, and recent  
71 experimental tests with wild vervet monkeys (*Chlorocebus pygerythrus*) has shown that

72 individuals will abandon personal foraging preferences in favour of group norms new to them  
73 (van de Waal, Borgeaud, & Whiten, 2013). But social conformity may also act on personality.  
74 Recent empirical work with guppies (*Poecilia reticulata*) found that group activity scores  
75 correlated with that of the least active member of a group, rather than the average of all  
76 group members activity (Brown & Irving, 2014), and tests with mosquitofish (*Gambusia*  
77 *holbrooki*) have shown that individuals conforming to the speed of the group they are in  
78 (Herbert-Read et al., 2013). Similarly, Schuett & Dall (2009) studied pairs of zebra finches  
79 (*Taeniopygia guttata*) and found that the more exploratory the partner a bird was paired with,  
80 the more exploratory this focal individual became. Overall, this “Conformity Hypothesis”  
81 assumes that individuals will tend to synchronise their behaviour in time and space (David-  
82 Barrett & Dunbar, 2012; King & Cowlshaw, 2009), altering their behaviour in line with their  
83 group-mates, and potentially suffering consensus costs (Biro, Sumpter, Meade, & Guilford,  
84 2006; King, Douglas, Huchard, Isaac, & Cowlshaw, 2008).

85

86 Rather opposite effects are expected in the case of facilitation processes (Dindo, Whiten, &  
87 De Waal, 2009; Harlow & Yudin, 1933; Hemelrijk & Wantia, 2005) where the presence of  
88 another individual can further enhance individual differences, to reduce direct competition  
89 and/or facilitate social coordination (Conradt & Roper, 2009; Sumpter, Krause, James,  
90 Couzin, & Ward, 2008). This facilitation effect can reinforce individual differences in  
91 personality (Burns, Herbert-Read, Morrell, & Ward, 2012; Harcourt, Ang, Sweetman,  
92 Johnstone, & Manica, 2009; Kurvers et al., 2009) and may result in social roles (Flack, Akos,  
93 Nagy, Vicsek, & Biro, 2013; Harcourt et al., 2009) that are more consistently manifested and  
94 effect group dynamics (e.g. during collective movements: Burns et al., 2012; Harcourt et al.,  
95 2009; King & Sueur, 2011; King, Sueur, Huchard, & Cowlshaw, 2011; Kurvers et al., 2009;  
96 Nagy, Akos, Biro, & Vicsek, 2010). This “Facilitation Hypothesis” therefore assumes  
97 individual differences in personality are enhanced in social settings.

98

99 The Gouldian finch (*Erythrura gouldiae*) is a colour polymorphic social bird species that  
100 exhibits two main discrete, genetically determined head-colour morphs, red and black, found  
101 at a stable 3:7 ratio in wild populations, in addition to a rare yellow-headed morph (Brush &  
102 Seifried, 1968; Gilby, Pryke, & Griffith, 2009). In its natural habitat the Gouldian finch lives in  
103 open, subtropical woodland in Australia, where they nest in loose colonies, and forage  
104 mainly on grass seeds (Dostine, Johnson, Franklin, Zhang, & Hempel, 2001), forming mobile  
105 flocks (of mixed morphs) of between 10 and 400 individuals outside the breeding season  
106 (O'Malley, 2006). In a previous study, we showed that bird head colour (red or black) is  
107 related to different personalities when tested individually: black-headed birds were bolder as  
108 measured by their latency to explore a novel object, and the time taken to return to feeding  
109 following a predator threat. Moreover, individual behaviour in these tests varied, were  
110 repeatable over time, and were correlated with each other (Williams, King, & Mettke-  
111 Hofmann, 2012). As such, the Gouldian finch provides an opportunity to test how the  
112 presence and personality of a social partner effects the expression of individual personality.

113

114 We examined pairs of Gouldian finch's tendencies to explore a novel object ('exploration'),  
115 and return to feeding following a predator threat ('risk-taking'), and compared birds  
116 responses in a pair to their responses behaviour when tested alone. Because we were  
117 interested in how the behaviour of a social partner may mediate individual personality, we  
118 calculated any change in behavioural response we observed for birds between the asocial  
119 and social contexts. If individuals altered their behaviour in line with their group-mates  
120 (conformity hypothesis), we expected to see birds' behavioural responses to converge: if  
121 birds are paired with a more exploratory, or more risk-taking partners, we expect them to  
122 become more exploratory, or more risk-taking (bolder) than when they were tested alone.  
123 Conversely, if birds are paired with a less exploratory, or a more risk-averse partners, they  
124 should become less exploratory, or a more risk-averse (shyer) than when tested alone.  
125 However, if the presence of another individual enhances individual differences (facilitation  
126 hypothesis), we expected to see individuals behavioural responses diverge, i.e. the bolder

127 bird to become bolder, and shyer bird to become shyer. Since head-colour might prove a  
128 useful cue in mediating any conformity/facilitation, we also tested whether the head-colours  
129 of interacting birds increased or decreased any changes in behaviour we observed as a  
130 function of interacting birds' individual personalities, since there is accumulating evidence of  
131 links between colour phenotype and social interactions (Healey, Uller, & Olsson, 2007;  
132 Mafli, Wakamatsu, & Roulin, 2011).

133

## 134 **METHODS**

135

### 136 *Study Subjects*

137 Forty-two wild-type and parent reared Gouldian finches were obtained from thirteen private  
138 breeders. Birds ranged in age from one to five years (information derived from closed rings  
139 and breeder information). Tarsus length (an indicator of body size, measured using callipers)  
140 ranged from 12.91cm to 15.84cm, and there were 20 males (12 red-headed; 8 black-  
141 headed) and 22 females (12 red-headed; 10 black-headed).

142

### 143 *Housing and care*

144 Birds were provided with a full spectrum light source with a cycle of 13:11 (Light:Dark), and  
145 kept at a temperature of approximately 24 °C together in three 100 x 200 x 200cm 'free-flight  
146 enclosures' (14 birds, each) in mixed head-colours and sex groups for a year prior to social  
147 experiments. Aviaries contained a variety of perches (artificial, and branches), food hoppers,  
148 bowls and water dispensers. Birds were fed Amadinen-Zucht Spezial (seed mixture for  
149 Gouldian finches), canary and millet seed, grit (all from Blattner Heimtiefutter, Ermengerst,  
150 Germany), eggshells and water *ad libitum*. Once a week they were given millet spray and  
151 supplemented with minerals and vitamins (Nekton MSA and Nekton S). Birds were checked  
152 daily for health and injuries.

153

### 154 *Experimental tests*



155 Tests were conducted in six experimental cages (80 x 120 x 100cm) which contained three  
156 perches and food and water provided *ad libitum* the same as in the holding aviaries. For  
157 testing, six pairs of birds were moved to experimental cages at a time and were given four  
158 days to habituate to their new surroundings. Birds took part in experiments from 8am until  
159 1pm for three consecutive days on two occasions separated by four weeks. Between tests  
160 birds were kept in their holding aviaries. Subjects did not have visual access to neighbours  
161 during experiments, and all experiments were recorded by digital video cameras using  
162 GeoVision 1480 for later analysis. The experimenter (LJW) was absent from the room while  
163 the experiments were being conducted. All experiments complied with ethical and welfare  
164 guidelines for animals and the legal requirements of the University and the United Kingdom.  
165 In particular, holding and experimental aviaries conformed to Home Office codes of practice  
166 and were carried out in approved facilities in the University. All experiments carried out were  
167 non-regulated by the Home Office and an Inspector's advice was sought to confirm this.  
168 After the experiments birds were returned to their holding conditions.

169

#### 170 *Pairing birds*

171 All birds had been tested four months earlier as singletons (Williams et al., 2012) and shown  
172 to have repeatable behaviour with regard to the time it took them to approach a novel object  
173 ('exploration') and return to feeding after presentation of a false predator (risk-taking). Two of  
174 these birds (ID: 9, 29) only had exploration scores, and not risk-taking scores (Williams et al.  
175 2012). We compared bird scores in these asocial contexts to their behaviour in a social  
176 setting by matching birds for sex and size, and then assigning them randomly to partner  
177 birds; one of the same head-colour and one of a different head-colour, and tested their  
178 responses with each partner four weeks apart; a time period over which novelty reactions  
179 are known to fully recover (Mettke-Hofmann et al. 2005). To ensure we controlled for  
180 sex/size differences, bird identities (IDs) 6, 8, 9, 10, 29 and 35 could be tested just once, and  
181 ID 21 was involved in three pairings; this resulted n=10 different-coloured pairs and n=10

182 same-coloured pairs taking part in our first round of tests, and n=10 same and n=9 pairs in  
183 the second round of tests (Appendix Fig. A1 provides full details).

184

#### 185 *Exploration*

186 We used a coloured plastic door-knob (4cm x 3.5cm) to test birds exploration of a novel  
187 object, following the same protocol used by Williams et al. (2012) . Half of the pairs were  
188 tested with a white knob, and half with a blue knob, which was swapped for the second  
189 round of tests four weeks later. We only changed colour but kept shape and size constant to  
190 provide objects as similar as possible since colour has been shown to have a strong novelty  
191 effect (Greenberg & Mettke-Hofmann 2001; Thomas et al. 2003). The object was hung with  
192 string from the mesh ceiling of the experimental cages, so it was in the middle of a neutral  
193 perch (a perch where no food or water was available) to give equal access to the object from  
194 both sides and thus reflect interest in the object (i.e. neophilia: Mettke-Hofmann, Ebert,  
195 Schmidt, Steiger, & Stieb, 2005). Latency to approach the object to within one body length  
196 (marked as a black line on the perch either side of the object) and latency to touch the object  
197 was recorded over a period of one hour. For all analyses, the mean of the two latencies was  
198 used (i.e. neophilia latency: Williams et al. 2012).

199

#### 200 *Risk-taking*

201 The response of birds to a false predator-stimulus was examined either one or two days  
202 after the exploration test following the same protocol used by Williams et al. (2012) for  
203 single birds. All pairs were habituated to the predator-stimulus apparatus (line and pulley  
204 system) for 24 hours before testing. One hour before the test, the feeder was removed.  
205 When the feeder was replaced, latency to feed was recorded as a control measure for both  
206 birds. After both birds had been feeding together for 10 seconds a silhouette of an avian  
207 predator was pulled up and down in front of the cage, and each bird's latency to return to the  
208 feeder and feed was recorded. The difference between the control measure and latency to  
209 feed after the predator stimulus was taken as a measure of risk-taking. All birds returned to

210 feed within one hour after the predator stimulus. We had problems with collection of video  
211 data for pairs ID1-ID37, ID1-ID15, ID3-ID18; ID5-ID15 and ID18-ID3 thus reducing our  
212 sample to n=8 (instead of 10) same colour and n=8 (instead of 10) different coloured pairs  
213 for our second round of tests.

214

#### 215 *Effect of social context: Change in behaviour*

216 We calculated the difference in the response times for an individual in the asocial and social  
217 context for both the exploration of the novel object and risk taking experiments. This change  
218 in behaviour (CIB) was calculated for every individual in each pair combination we observed  
219 (n=39 pairs) resulting in n=78 data points. Because we had a reduced sample for risk-taking  
220 trials and two birds did not have risk-taking scores as singletons (see above), risk-taking  
221 produced n=68 data points.

222

#### 223 *Inter-pair differences in personality*

224 To test for any social conformity and social facilitation effects (or no change), we calculated,  
225 for each pair, the inter-pair difference (IPD) in birds' behavioural responses when tested  
226 alone for both the exploration of the novel object and risk taking experiments. This gave us  
227 an indication of how similar or dissimilar a pair of bird's personalities were.

228

#### 229 *Statistical Analysis*

230 We tested for a general increase or decrease in CIB across our sample using non-  
231 parametric pairwise tests conducted in SPSS (v.17.0, 2009, SPSS Inc, Chicago, IL, U.S.A.).  
232 We examined individual CIB in the novel object (model 1) and risk taking (model 2)  
233 experiments using Linear Mixed Models (LMMs) conducted in MLwiN (v.2.26, 2012, Bristol  
234 University Centre for Multilevel Modelling, Bristol, U.K.). Because each trial resulted in CIB  
235 data for each bird in the pair, and birds could also appear in more than one pair (Appendix  
236 1), we fitted focal bird identity (*i*), partner identity (*j*), and trial number as cross-classified  
237 random effects; this removed the independence assumption between responses belonging

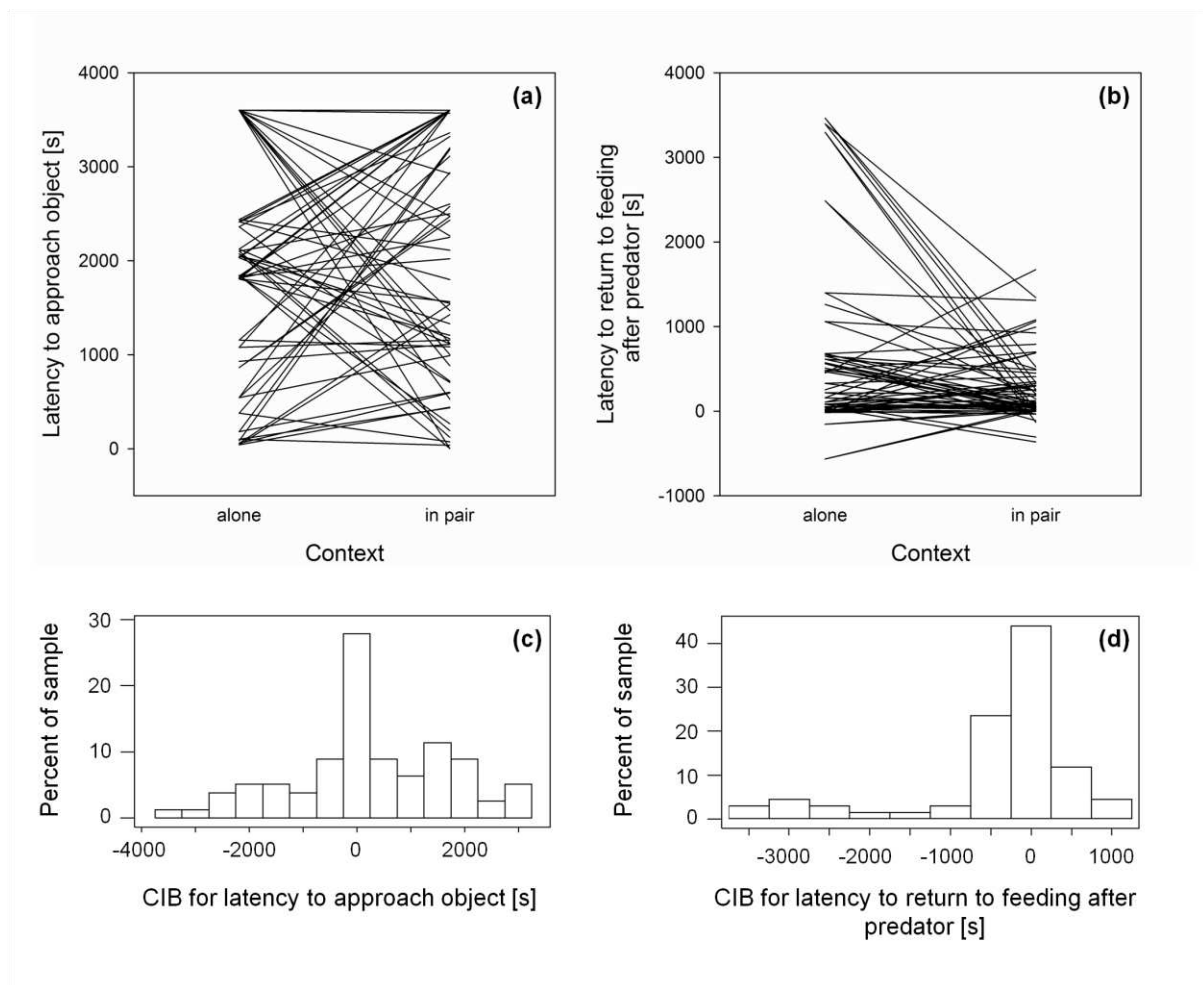
238 to a particular bird (Browne, 2009; Goldstein, Browne, & Rasbash, 2002). For each model,  
239 we entered IPD when tested alone (in novel object, or risk-taking tests respectively) as a  
240 continuous fixed effect, and fitted an interaction between IPD and head-colour pairing (red-  
241 red, black-black, red-black, black-red) to see if any effect of IPD altered with respect to  
242 partner head-colour. Finally, we also tested/controlled for sex (male, female), age  
243 (continuous), size (tarsus length, continuous) by entering these as fixed effects. Models were  
244 run for  $5 \times 10^5$  iterations using a Markov-chain Monte Carlo algorithm estimation (Browne,  
245 2009, 2012). The significance of terms were tested using a Wald statistic, evaluated against  
246 the Chi-square distribution once estimates had stabilised and their SEs reached a constant  
247 value. In all cases we present full model results in our results, and the significance of all  
248 terms are unchanged if we use a model selection procedure, or the minimum adequate  
249 model.

250

## 251 **RESULTS**

252

253 We found that birds were not, on average, faster, or slower (Figure 1a; Figure 1b) in either  
254 the novel object test (Mann Whitney Test:  $n = 78$ ,  $W = 6003$ ;  $P = 0.34$ ) or the risk-taking test  
255 (Mann Whitney Test:  $n = 68$ ,  $W = 6139$ ,  $P = 0.06$ ), despite a trend for birds to get slower in  
256 the risk taking context (Figure 1b, d).



257

258 **Figure 1. Behavioural response alone and in a pair.** (a) Latency to approach a novel  
 259 object (seconds) for birds tested alone, and as a pair (n=78). (b) Latency to return to feeding  
 260 after a predator scare compared to a control condition for birds tested alone, and as a pair  
 261 (n=68). (c) and (d) show frequency histograms illustrating the change in behaviour (CIB) for  
 262 birds between the asocial and social contexts for the exploration and risk-taking  
 263 experiments. The x-axis is the time difference (seconds) between the asocial and social  
 264 contexts.  
 265

266

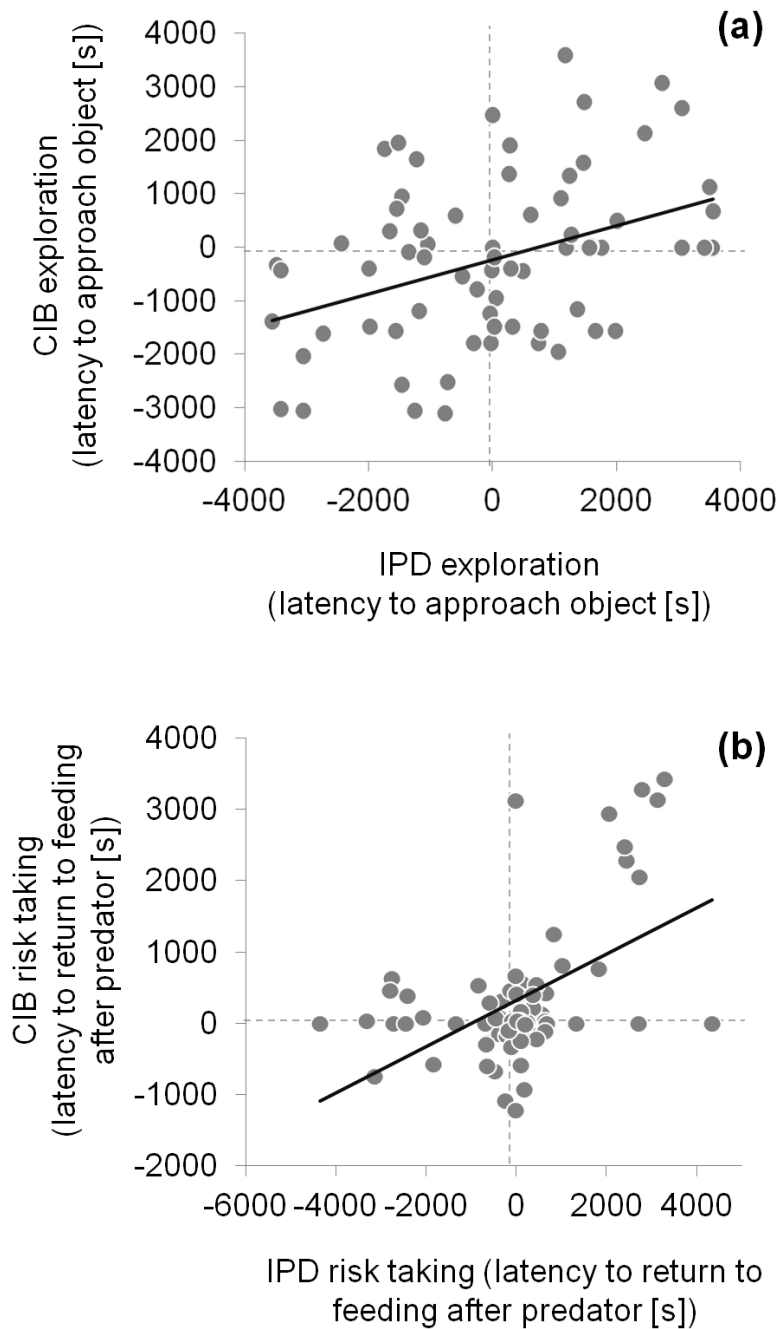
267 We found that the IPD for birds tested alone significantly and positively predicted changes in  
 268 behaviour; this was true of both the object exploration test (Figure 2a; Table 1) and the risk-  
 269 taking test (Figure 2b; Table 2). Specifically, where birds were paired with a more  
 270 exploratory, or more risk-taking partner, they themselves became more exploratory, or more  
 271 risk-taking (bolder) than when they were tested alone. Conversely, where birds were paired  
 272 with a less exploratory, or a more risk-averse partner, they became less exploratory, or a  
 273 more risk-averse (shyer) than when tested alone. We also found that in the novel object test,

274 the significant effect of IPD was absent for black-headed birds paired with red-headed  
 275 partners (Table 1; Figure 3), indicating that CIBs for black-headed birds could not be  
 276 attributed to social conformity effects in these pairs. No such effects of head-colour pairings  
 277 were seen in the risk-taking test (Table 2). Sex, age, or size did not predict CIB for either the  
 278 novel object or risk-taking experiments (Table 1, 2).

279  
 280 **Table 1.** Factors affecting CIB between asocial and social conditions during a novel object  
 281 test. Table shows Model Terms, Parameter Estimates (Effect), Standard Errors (SE),  
 282 associated Degrees of Freedom (DF), Test Statistic (Wald), and P-value. b-b = black-  
 283 headed birds paired with black-headed partner (Figure 3a); b-r = black-headed birds paired  
 284 with red-headed partner (Figure 3b); r-b = red-headed bird paired with black-headed partner  
 285 (Figure 3c); r-r = red-headed bird paired with red-headed partner (Figure 3d).  
 286

<b>Model Terms</b>	<b>Effect</b>	<b>SE</b>	<b>DF</b>	<b>Wald</b>	<b>P-value</b>
Sex			1	0.151	0.698
Female	0.000	0.000			
Male	0.039	0.100			
Age			4	4.321	0.634
5 yrs	0.000	0.000			
4 yrs	-0.414	0.291			
3 yrs	-0.123	0.236			
2 yrs	-0.175	0.238			
1 yr	-0.016	0.236			
Size	0.075	0.101			
<b>Inter-pair difference (IPD)</b>	<b>0.747</b>	<b>0.265</b>	<b>1</b>	<b>7.939</b>	<b>0.005</b>
Pair Type			3	1.447	0.695
b-b	0.000	0.000			
b-r	-0.144	0.134			
r-b	-0.129	0.138			
r-r	-0.112	0.131			
<b>IPD*Pair type<sup>^</sup></b>			<b>3</b>	<b>9.076</b>	<b>0.028</b>
PairDiff*b-b	0.000	0.000			
PairDiff*b-r	-0.771	0.309			
PairDiff*r-b	-0.472	0.313			
PairDiff*r-r	-0.157	0.321			
Intercept	-0.988	1.520			
Focal ID (random)	0.016	0.019			
Neighbour ID (random)	0.017	0.019			
Experiment no. (random)	0.119	0.029			

287  
 288 <sup>^</sup> Pair-wise comparisons revealed the effect of IPD (i.e. social conformity) was significantly  
 289 reduced for black-headed birds paired with red-headed partners (Figure 3b).  
 290



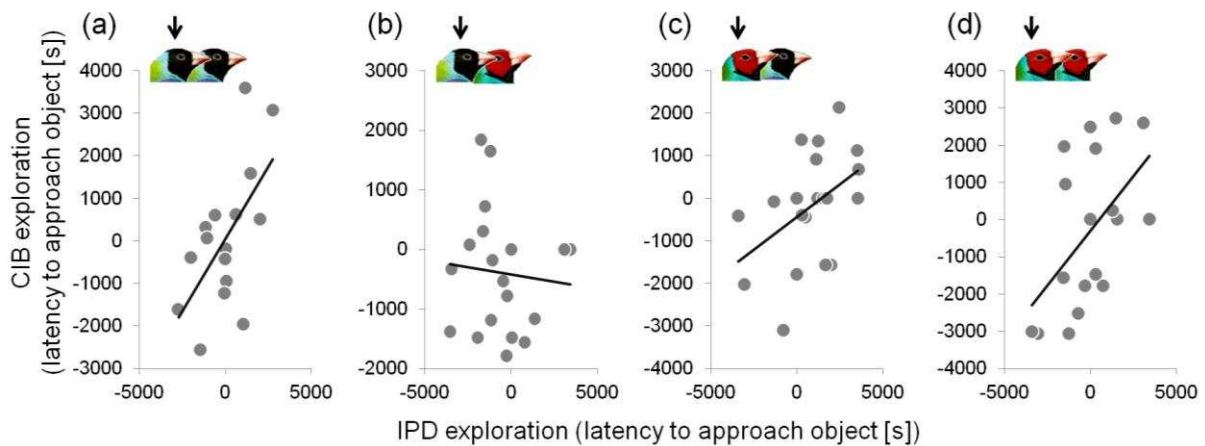
291  
 292 **Figure 2. Social conformity.** The CIB between the asocial and social contexts (see Figure  
 293 1) as a function of the inter-pair difference (IPD) in bird scores when tested alone for the (a)  
 294 exploration (novel object) and (b) risk-taking (predator) tests. The fitted lines are the  
 295 predicted effects from LMMs (see Tables 1 and 2). These relationships between IPD and  
 296 CIB for the exploration and risk-taking indicate that for a given pair of birds, e.g. bold bird, *i*  
 297 and shy bird, *j*, *i* will have a negative IPD score and tend to show a negative CIB, whilst *j* will  
 298 have a positive IPD score and tend to have a positive CIB. If *i* and *j* are similar in  
 299 personalities, they will both tend to score around zero for IPD and CIB.  
 300

301 **Table 2.** Factors affecting CIB between asocial and social conditions during a test of risk-  
 302 taking. Table shows Model Terms, Parameter Estimates (Effect), Standard Errors (SE),  
 303 associated Degrees of Freedom (DF), Test Statistic (Wald), and P-value. b-b = black-  
 304 headed birds paired with black-headed partner; b-r = black-headed birds paired with red-  
 305 headed partner; r-b = red-headed bird paired with black-headed partner; r-r = red-headed  
 306 bird paired with red-headed partner.  
 307  
 308

<b>Model Terms</b>	<b>Effect</b>	<b>SE</b>	<b>DF</b>	<b>Wald</b>	<b>P-value</b>
Sex			1	2.711	0.100
Female	0.000	0.000			
Male	0.120	0.073			
Age			4	4.702	0.319
5 yrs	0.000	0.000			
4 yrs	-0.057	0.229			
3 yrs	-0.088	0.193			
2 yrs	0.087	0.192			
1 yr	0.028	0.193			
Size	-0.049	0.068	1	0.519	0.471
<b>Inter-pair difference (IPD)</b>	<b>0.508</b>	<b>0.221</b>	<b>1</b>	<b>5.264</b>	<b>0.021</b>
Pair Type			3	1.516	0.218
b-b	0.000	0.000			
b-r	0.042	0.069			
r-b	-0.002	0.075			
r-r	-0.030	0.080			
IPD*Pair type <sup>^</sup>			3	1.987	0.575
PairDiff*b-b	0.000	0.000			
PairDiff*b-r	0.028	0.165			
PairDiff*r-b	-0.184	0.185			
PairDiff*r-r	-0.006	0.168			
Intercept	0.747	1.078			
Focal ID (random)	0.021	0.015			
Neighbour ID (random)	0.020	0.018			
Experiment no. (random)	0.011	0.007			

309  
 310





312 **Figure 3. Social conformity and pair head-colour combinations (exploration).** The CIB  
 313 between the asocial and social contexts as a function of the inter-pair difference (IPD) when  
 314 tested alone for exploration tendency (novel object). Panels show CIB for the birds indicated  
 315 by the arrow, i.e. black-headed birds paired with a black-headed partner (a), black-headed  
 316 birds paired with a red-headed partner (b), red-headed birds paired with a black-headed  
 317 partner, and red-headed bird paired with another red-headed bird (e). Lines are best fit linear  
 318 regression lines. See Table 1 for statistical tests of the effect of IPD and head-colour pairing.  
 319  
 320

## 321 DISCUSSION

322

323 We examined pairs of Gouldian finch's tendencies to explore a novel object, and return to  
 324 feeding following a predator threat, and compared these data to the same birds' behaviour  
 325 when tested alone. We found that birds were not, on average, faster to approach the novel  
 326 object or resume feeding after a predator scare, as might be predicted in accordance with  
 327 reduced perception of risk, or increased levels of competition with increasing group size  
 328 (Krause & Ruxton, 2002; Magnhagen & Bunnefeld, 2009; Webster, Ward, & Hart, 2007).  
 329 Instead, we found that some birds got faster, some got slower, and some were relatively  
 330 unchanged. Our investigations of the effect of differences in personalities within a pair upon  
 331 birds' changes in behaviour revealed that birds were adjusting their behaviour predictably  
 332 according to personality of their partners: Where a bird's partner was bolder, it became  
 333 bolder; where a bird's partner was shyer, it became shyer. Thus, our results offer support to  
 334 social conformity rather than any facilitation processes.

335

336 In the context we have studied here, conformity may arise as a consequence of negotiating  
337 risks (Hellström, Heynen, Oosten, Borcharding, & Magnhagen, 2011; Magnhagen &  
338 Bunnefeld, 2009; van Oers, Klunder, & Drent, 2005), where the faster bird slows down in its  
339 response as it reacts to the behaviour of the more cautious partner, and slower birds speed  
340 up, in response to the faster exploring bird. Such social conformity is in accordance with  
341 previous work that has shown socially induced change in individual behaviour (Grand & Dill,  
342 1999; Greenberg & Mettke-Hofmann, 2001); for example, in rainbow trout (*Onchorhynchus*  
343 *mykiss*), bolder fish observing the behaviour of shyer fish became more shy by increasing  
344 their latency to approach a novel object (Frost, Winrow-Giffen, Ashley, & Sneddon, 2007)  
345 and recent experiments by Herbert-Read et al. (2013) with mosquitofish (*Gambusia*  
346 *holbrooki*) reported repeatable individual locomotion behaviours (i.e. median speeds,  
347 variance in speeds and median turning speeds) to disappear at large group sizes.  
348 Specifically, fish in larger groups (n=8 compared to n= 2 or 4) tended to reduce their speed,  
349 and variation in speed compared to when alone. In practical terms, for the birds in this  
350 experiment, and the mosquitofish that Herbert-Read et al. studied, social conformity means  
351 individuals tend to move together, rather than independently. This process results from birds  
352 compromising their individual tendency to explore and/or return to feeding following risk;  
353 thus, where differences in individual tendencies are large, so was the degree of compromise  
354 we observed.

355

356 Since head-colour might prove a useful cue in mediating any conformity/facilitation, we also  
357 tested whether the head-colours of interacting birds had an independent effect of the change  
358 in birds' behaviour, or if there was an interaction between the pair head-colour combination  
359 and any conformity/facilitation effects observed. We did not find that head colour  
360 combinations predicted CIB, and conformity effects were consistent across pairs with the  
361 exception of black-headed birds paired with red-headed partners in the novel object test.  
362 Here, the CIB for black-headed birds was not reliably predicted by the IDBs of interacting  
363 birds. Therefore, future work needs to examine the interaction dynamics (Burns et al., 2012;

364 Harcourt et al., 2009; Kurvers et al., 2009) among the pairs of birds we have studied, rather  
365 than just their overall responses. For instance, the fact that black-headed birds show  
366 reduced social conformity when paired with a red-headed partner suggests the behaviour of  
367 black-headed birds – which are usually more explorative and take greater risk – would not  
368 be affected by their shyer red-headed flock mates and may could act as producers in  
369 exploring new resources. Conformity in red-headed birds, in contrast, would benefit them in  
370 mixed head-colour flocks by starting exploration of novel resources earlier. Therefore, where  
371 flock size and composition is variable and opportunity for engaging and monitoring the  
372 behaviour of others is limited, head-colour might prove a useful cue mediating  
373 interaction/association patterns since head colour of Gouldian finches can be used as a  
374 signal of dominance Pryke & Griffith (2006). Moreover, experiments with wild great tits  
375 (*Parus major*) have shown that variation in personality promotes within-patch movement  
376 while maintaining group cohesion (Aplin, Farine, Mann, & Sheldon, 2014), and a mix of  
377 personalities can improve the functioning of social groups in a variety of other contexts  
378 (Dyer, Croft, Morrell, & Krause, 2009; Harcourt et al., 2009; Pruitt & Riechert, 2011).

379

380 Overall, our experiments demonstrate how social context can mediate the expression of an  
381 individual's personality: Where a bird's partner was bolder, it became bolder; where a bird's  
382 partner was shyer, it become shyer. To more fully understand the functional role of individual  
383 differences in a social context experiments considering (and measuring) the costs and  
384 benefits regarding some activity (e.g. collective defence, foraging, or predator avoidance)  
385 and investigations of interaction dynamics in larger social groups is surely the way to go.  
386 Recent field experiments with social birds investigating patch exploitation and group  
387 movements using automated tracking techniques (Aplin et al., 2014) sets a benchmark for  
388 such investigations, and it will now be interesting to explore whether the conformity in  
389 behaviour we observe here relates to work describing how different personalities adopt  
390 specific social roles, e.g. leader-follower dynamics (Flack et al., 2013; Harcourt et al., 2009).

391

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399

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**Appendix 1.** Matrix showing how pairs were matched for sex and size and tested on two occasions (trial 1 and 2 are indicated in the cells); once with the same coloured head partner and once with a different coloured head partner, otherwise birds were paired randomly. The colour of the bird ID indicated its head colour red, or black (note that red birds' identity will appear grey in the journal version).