

The influence of prosocial priming on visual perspective taking and automatic imitation

Newey, Rachel; Koldewyn, Kami; Ramsey, Richard

PLoS ONE

DOI:

[10.1101/333880](https://doi.org/10.1101/333880)

[10.1371/journal.pone.0198867](https://doi.org/10.1371/journal.pone.0198867)

Published: 23/01/2019

Peer reviewed version

[Cyswllt i'r cyhoeddiad / Link to publication](#)

Dyfyniad o'r fersiwn a gyhoeddwyd / Citation for published version (APA):

Newey, R., Koldewyn, K., & Ramsey, R. (2019). The influence of prosocial priming on visual perspective taking and automatic imitation. *PLoS ONE*, 14(1), e0198867. Article 0198867. <https://doi.org/10.1101/333880>, <https://doi.org/10.1371/journal.pone.0198867>

Hawliau Cyffredinol / General rights

Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal ?

Take down policy

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

1 The influence of prosocial priming on visual perspective taking and automatic imitation

2

3

4

5 Rachel Newey¹✉, Kami Koldewyn¹✉* & Richard Ramsey¹✉*

6

7

8 ¹ Wales Institute for Cognitive Neuroscience, School of Psychology, Bangor University,
9 Bangor, Gwynedd, Wales, LL57 2AS, United Kingdom.

10

11 ✉ These authors contributed equally to this work.

12

13

14

15 * Corresponding authors

16 E-mail: r.ramsey@bangor.ac.uk (RR)& k.koldewyn@bangor.ac.uk (KK)

17

18 **Abstract**

19

20 Imitation and perspective taking are core features of non-verbal social interactions. We imitate
21 one another to signal a desire to affiliate and consider others' points of view to better
22 understand their perspective. Prior research suggests that a relationship exists between
23 prosocial behaviour and imitation. For example, priming prosocial behaviours has been shown
24 to increase imitative tendencies in automatic imitation tasks. Despite its importance during
25 social interactions, far less is known about how perspective taking might relate to either
26 prosociality or imitation. The current study investigates the relationship between automatic
27 imitation and perspective taking by testing the extent to which these skills are similarly
28 modulated by prosocial priming. Across all experimental groups, a surprising ceiling effect

29 emerged in the perspective taking task (the Director's Task), which prevented the investigation
30 of prosocial priming on perspective taking. A comparison of other studies using the Director's
31 Task shows wide variability in accuracy scores across studies and is suggestive of low task
32 reliability. In addition, despite using a high-power design, and contrary to three previous
33 studies, no effect of prosocial prime on imitation was observed. Meta-analysing all studies to
34 date suggests that the effects of prosocial primes on imitation are variable and could be small.
35 The current study, therefore, offers caution when using the computerised Director's Task as a
36 measure of perspective taking with adult populations, as it shows high variability across studies
37 and may suffer from a ceiling effect. In addition, the results question the size and robustness
38 of prosocial priming effects on automatic imitation. More generally, by reporting null results
39 we hope to minimise publication bias and by meta-analysing results as studies emerge and
40 making data freely available, we hope to move towards a more cumulative science of social
41 cognition.

42

43 **Introduction**

44 Social interactions involve a number of cognitive processes and behaviours, including imitation
45 and perspective taking. While both of these social skills have been studied extensively in
46 isolation, the relationship between imitation and perspective taking has received less attention.
47 In addition, although social context can modulate imitation [1, 2, 3] much less is known
48 regarding potential influences on perspective taking. A better understanding of how context
49 can affect perspective taking skills may not only help to elucidate the relationship between
50 various interacting social processes but also provide insight into how real-world social
51 interaction skills could be enhanced. The current study considers this issue by testing the extent
52 to which imitation and perspective taking are similarly modulated by prosocial priming.

53 Automatic imitation is a common occurrence during social encounters, and involves
54 spontaneous copying of others' actions and gestures [4]. Mimicry is a form of automatic
55 imitation that is typically studied in social contexts using overt copying behaviours and facial
56 movements. In contrast, other measures of automatic imitation have been developed using
57 stimulus-response compatibility (SRC) paradigms to provide a reaction time signature of
58 automatic imitation (see [2, 5, 6] for reviews). Although imitative behaviour rarely reaches
59 conscious awareness for either interaction partner, it subconsciously signals a desire to affiliate
60 and build rapport [7]. For example, people who are imitated are bigger tippers [8], donate more
61 to charity [9], engage in prosocial behaviours [9, 10, 11,12] and indicate liking people who
62 imitate them more than those that do not [8]. Clearly, then, imitation can play an important role
63 in guiding social interactions. To clarify the role imitation can play across different social
64 contexts, recent research has started to identify its antecedents [1, 2]. For example, prosocial
65 priming can increase imitative behaviour [1]. Thus, there exists a bi-directional relationship
66 between imitation and prosociality; those who are imitated behave more prosocially and those
67 who are prosocially primed imitate more. Studies investigating automatic imitation and
68 prosocial behaviour have primarily employed observational techniques to study imitation, with
69 the measurement being the frequency of observed copying behaviours during live social
70 interaction.

71 The reaction time based automatic imitation task [13, 14] is an example of a stimulus-
72 response compatibility paradigm, referring to the fact that people cannot help but be affected
73 by the presence of an irrelevant stimulus feature [15, 16]. In one well-established automatic
74 imitation task, individuals are instructed to respond to a number cue by lifting their index or
75 middle finger. Concurrently, participants either observe a congruent or incongruent finger
76 movement. Reactions times (RT) are longer in the incongruent compared to congruent
77 condition and this difference is thought to signify the cost of inhibiting an imitative response

78 [1, 17]. Here, then, imitation is captured as the time it takes to suppress the urge to copy an
79 observed action and prioritise one's own action. The tendency towards imitation (incongruent
80 RT less congruent RT) will hereafter be referred to as the congruency effect.

81 A handful of studies have explored the effects of prosocial priming on automatic
82 imitation [18, 19, 20]. Priming is thought to operate by subtly triggering a goal that
83 unconsciously guides behaviour [21]. These studies used semantic primes (scrambled
84 sentences) of a prosocial nature to create a goal to behave in a prosocial manner [22]. The
85 logic being that a goal to affiliate and work well with others would be achieved by increasing
86 the tendency to imitate [18]. Despite using slightly different variants of the automatic imitation
87 task and different experimental designs, each study reported an effect of prosocial priming on
88 automatic imitation; priming increased the congruency effect. More specifically, the prosocial
89 prime had to be self-related to increase imitation (e.g., 'I am prosocial'); when using third
90 person primes (e.g., 'Alex is prosocial') the congruency effect did not differ from controls [18].
91 These results suggest that a specific type of social prime can modulate automatic imitation;
92 when individuals are personally primed to be prosocial, people find it harder to suppress their
93 imitative tendencies.

94 Like imitation, accurate representation of another's perspective is inherently
95 intertwined with successful social interactions. Perspective taking has been shown to correlate
96 with social competence [23] and successful communication requires both the ability to
97 understand an interaction partner's viewpoint and the ability to separate our own knowledge or
98 beliefs from that point of view [24]. Perspective taking takes many forms, with visual
99 perspective taking referring to situations where one must evaluate *what* someone else sees or
100 *how* they see the environment [25]. Typically, individuals adopt an egocentric bias during
101 social interactions, such that their own view is prioritised relative to others' viewpoints [26,
102 27, 28].

103 Unsurprisingly, such egocentrism can interfere with judgements about others'
104 perspectives [29, 30, 31, 32]. The Director's Task [30, 31] requires participants to follow the
105 instructions of another, the "Director". In this task, a set of shelves, comprising sixteen slots,
106 stand between the Director and a participant. The slots house a variety of familiar items (for
107 example keys and cups), some of which are present in multiples of three and vary in size, and
108 all of which were visible to the participant. However, a number of slots have a backing, such
109 that any objects they contain are occluded from the Director's view. The Director selects
110 objects for the participant to remove from the shelves. On critical trials, the Director is not able
111 to see the object that matches the description according to the participant's view and it is on
112 these trials that participants are required to deduce the item to which the Director is referring
113 (e.g. select the second largest cup if the actual largest cup is not visible to the Director). The
114 task indexes perspective taking by measuring the number of egocentric errors participants make
115 when there is a conflict between their and the Director's perspectives. Even when it is made
116 explicitly clear that the Director cannot not see the same objects that the participants can see,
117 egocentric errors are still made [31]. This suggests that while people may be capable of seeing
118 things from another's point of view, they do not always do so, with people often presuming
119 another's perspective is the same as their own [27, 28]. As Gillespie and Richardson [28] put
120 it; "although perspective taking is central to social life, people are not particularly good at it".
121 Identifying ways of improving its application should, therefore, enhance social interactions.

122 Although visual perspective taking has been studied extensively, how social context
123 influences visual perspective taking and how visual perspective taking relates to other
124 dimensions of social cognition, such as automatic imitation, have not been studied to date.
125 Further, there is reason to suggest that automatic imitation and visual perspective taking may,
126 in part, rely on a shared cognitive mechanism that distinguishes self from other. To succeed in
127 automatic imitation tasks, a person must suppress the other's action and promote their own.

128 Conversely, for visual perspective taking, a person must suppress their own knowledge or
129 belief and enhance the other's perspective. Success at both tasks, then, requires a person to be
130 able to quickly and flexibly distinguish between themselves and another. This is known as the
131 'self-other distinction' (see [33]). One study has directly addressed whether automatic imitation
132 and visual perspective taking rely on a partially shared mechanism. Santiesteban and
133 colleagues [34] found that training on a task that required a self-other distinction (imitation
134 inhibition) transferred to a different self-other task; the Director's Task. Even though automatic
135 imitation and visual perspective taking may rely on a common mechanism, no research to date
136 has shown that social context influences automatic imitation and visual perspective taking in a
137 similar manner.

138 The current study, therefore, has three aims. First, drawing from studies exploring the
139 effects of prosocial priming on automatic imitation, we will investigate the effects of prosocial
140 priming on visual perspective taking. Does activating a goal to affiliate enhance one's ability
141 to readily adopt another's visual perspective? Second, we will explore whether visual
142 perspective taking and automatic imitation are correlated following prosocial priming. Does
143 prosocial priming affect them in a similar manner? Third, we will perform a conceptual
144 replication of previous studies, which showed an effect of first person, prosocial priming on
145 automatic imitation [18, 19, 20]. Does activating a goal to affiliate increase automatic imitation
146 in a subsequent RT task? Previous studies exploring this question have been conceptual
147 replications of one another. While each used a different automatic imitation task, they all
148 targeted and found the same main effect, indicating that the specific SRC task is not critical to
149 the success of the prime. In addition, an effect was found irrespective of whether designs were
150 within-subject [18] or between-subjects [19, 20] designs. Here then, a conceptual replication
151 refers to studies using the same priming procedure to target the same effect while deviating on
152 the precise automatic imitation task employed.

153 To test visual perspective taking abilities, we will use the Director's Task [30, 31]. We
154 will include both first person and third person prime conditions, to test whether self-relatedness
155 influences prosocial priming of visual perspective taking in the same way as automatic
156 imitation. Firstly, we predict that prosocially primed groups will achieve higher accuracy on
157 the Director's Task as compared to controls. Secondly, we predict that first person, prosocial
158 priming will produce a positive correlation between visual perspective taking accuracy and
159 larger congruency effects from the automatic imitation task. Finally, in line with previous
160 findings, we expect that first person, prosocial priming will produce a larger congruency effect
161 than both third person and control conditions. Together, these results will test the extent to
162 which social context influences automatic imitation and visual perspective taking in a similar
163 manner and therefore provide insight into the extent to which these core social abilities rely on
164 a shared cognitive mechanism.

165
166

167 **Method**

168

169 **Participants**

170 Data from 153 individuals (111 female, mean age = 20.9, SD = 3.8, range 18-41) were
171 collected in return for course credit; with 52 in the first person, prosocial (PS-1st) group, 52 in
172 third person, prosocial (PS-3rd) and 49 controls. Ages ranged from 18 to 41 with average ages
173 of 21.58 (SD 5.2) for PS-1st, 20.42 (SD 3.0) for PS-3rd and 20.71 (SD 2.4) for the control group.
174 Ethical approval was granted by the Research Ethics and Governance Committee of the School
175 of Psychology at Bangor University. All participants gave their explicit informed consent and
176 were free to withdraw from the study at any time.

177

178 **Sample Size & Power Calculation**

179 No previous studies have explored the influence of prosocial priming on visual
180 perspective taking, which means the expected effect size cannot be estimated from such data.
181 Instead, the difference in congruency effects found by previous studies researching prosocial
182 priming and automatic imitation was used to determine our sample size. These prior studies
183 found medium to large effects (Cohen's d of 0.53 - 0.75). However, evidence would suggest
184 that published studies overestimate effect sizes [35, 36]. With this in mind, we powered our
185 study to detect effect sizes at the lowest range of those found previously [37]. A sensitivity
186 analysis in G*Power [38] using a one-tailed test, based on a mean difference between two
187 independent groups (PS-1st and control), with an alpha of .05 and 80% power to detect a
188 medium effect size (Cohen's $d=0.5$) or larger, returned a sample size of 50 participants per
189 group. Therefore, we aimed to test 150 participants (50 per group) making our sample size
190 much larger than previous studies.

191

192 **Procedure and Stimuli**

193 Prior to testing, participants were told they were taking part in a study investigating
194 people's accuracy rates and reaction time across three types of tasks. Testing was performed
195 in one session, lasted approximately 45 minutes. Participants were randomly assigned to a
196 group; first person prosocial (PS-1ST), third person prosocial (PS-3RD) or control. The order of
197 tasks was kept the same for all participants (see Fig 1 below).

198

199 **Fig 1: Order of tasks**

200

201 As our primary task of interest was the perspective taking task, we did not counterbalance the
202 Director's Task with the automatic imitation task as we did not want any effects of imitation
203 to confound any effects on perspective taking. Moreover, the Director's task takes only
204 around four minutes to complete (whereas the automatic imitation task takes over double

205 that) meaning any effects of priming should survive the procedure and goal priming is
206 thought to have a reasonably slow rate of decay [22].

207

208 **Demographics & Questionnaires**

209 Prior to priming, each participant completed a brief demographics information sheet
210 (age, gender, handedness and first language) together with three previously validated
211 questionnaires; the Short Autism Spectrum Quotient (AQ-10 Adult) questionnaire [39], a self-
212 esteem questionnaire [40] and the interpersonal reactivity index (IRI) [23]. Questionnaire data
213 was collected for another study and is not discussed here. For completeness, the results are
214 provided in supplementary materials (S1 Table).

215

216 **Prosocial Priming Stimuli**

217 Prosocial priming was implemented through a scrambled sentences task [41] using
218 sentence stimuli previously used to study automatic imitation [e.g. 18]. Three booklets, each
219 containing 20 sentences, were used and each participant received only one booklet; either PS-
220 1st, PS-3rd or the non-social control. Taking around 10-15 minutes, the task consisted of
221 partially completed sentences with a list of words above them, with one word being irrelevant.
222 Participants were instructed to select the correct words to write a grammatically correct
223 sentence. PS-1st and PS-3rd sentences contained words such as together, collaborate,
224 affectionate, share and help, which were designed to drive a prosocial attitude towards the self
225 or the other respectively. All PS-1st sentences started with 'I' whereas PS-3rd used other people
226 such that it was another person performing the prosocial act. For example, a completed first
227 person, prosocial sentence might read "I always comfort my friends when they are upset"
228 whereas the same sentence in the third person would read "David always comforts his friends

229 when they are upset”. To produce a neutral attitude, control sentences were purely factual (e.g.,
230 “London is the capital of England”).

231

232 **Visual Perspective Taking**

233 Following priming, the Director’s Task was administered. We used a computerized
234 version of the Director’s Task [42], originally designed by Keysar and colleagues [30, 31]. The
235 specific stimuli that we used were kindly shared with us by Dumontheil and colleagues [43].
236 Displayed on screen was a picture of a block of shelves (4x4 configuration) housing a number
237 of recognisable objects, all of which were visible to the participant. Some shelves had a back
238 on them such that anyone standing on the other side could not see the items in those slots. A
239 person (the “Director”) was positioned on the other side of the shelves. The Director would
240 issue an instruction (e.g. “Move the mouse down”) which the participant was required to follow
241 by selecting the named object with the mouse and dragging it to the appropriate slot. Three
242 practice trials were presented prior to the test beginning. Participants were explicitly made
243 aware of the backing on some shelves and told that someone on the other side would not be
244 able to see all of the items.

245 For the main task, there were 48 trials in total; 32 control trials (one object, visible to
246 both participant and director, see Fig 2A), 8 non-conflict (NC) trials (more than one object of
247 varying size, all visible to both participant and Director) and 8 conflict/experimental trials
248 (more than one object of varying size, all visible to the participant but not all visible to the
249 Director). To be correct on an experimental trial, the participant had to identify and move the
250 object to which the Director was referring (see Fig 2B). Trials were presented in blocks of three
251 with participants only being given a short amount of time to respond before the next trial would
252 automatically begin. The task was presented by ePrime version 2 and lasted for around four
253 minutes.

254 **Fig 2:** An example of a control trial (one item) in the Director’s task (“Move the
255 mouse down”) (A) and an experimental trial in the Director’s task (“Move the small
256 dice up”) (B)
257

258 **Automatic Imitation Task**

259 Next, participants completed the automatic imitation task, based on the task designed
260 by Brass and colleagues [13, 14]. Instructions were provided orally by the experimenter as well
261 as in written form at the beginning of the task. At the start of each trial, participants were
262 instructed to keep their index and middle fingers of their right hand pressed down on keys n
263 and m respectively. Prior to each trial onset, the screen displayed a small fixation cross in the
264 centre of the screen for 500ms. The image of a hand in a neutral position would then appear.
265 Participants were instructed to raise their index finger when the number ‘1’ appeared on screen.
266 When the number ‘2’ appeared, they were to raise their middle finger. Instructions were to
267 respond as fast and as accurately as possible. To be correct on a trial, participants had to raise
268 the finger that matched the number; index for ‘1’, middle for ‘2’. At the same time as the
269 number appeared, the hand in the background would raise either its index or middle finger. For
270 congruent trials, the stimulus hand would raise the same finger as the participant. For
271 incongruent trials, the stimulus hand would raise a different finger to the participant (Fig 3).

272 **Fig 3:** An example of a CONGRUENT (left) and INCONGRUENT (right) trial in the
273 automatic imitation task
274
275

276 Data for 32 practice trials was collected prior to priming but not analysed. In the main
277 task, there were 128 experimental trials in total, displayed in a random order, comprising 64
278 congruent trials (32 index and 32 middle) and 64 incongruent trials (32 index and 32 middle).
279 Trials were presented in four blocks of 32 trials with an opportunity for a break being provided
280 between each block. The task took around eight minutes to complete in total. In order to prevent
281 participants from anticipating when the stimulus would appear, inter-stimulus intervals of 500,

282 700 and 1,000 milliseconds were randomly applied to the neutral hand before the next image
283 appeared. The image of the hand and number would remain on screen until the participant lifted
284 their finger or after 2,000ms, whichever came first, before returning to the fixation cross. The
285 task was written in Matlab and presented using Psychophysics Toolbox.

286

287 Following completion of all tasks, participants were debriefed on the nature of the
288 experiment. When asked, no participants reported guessing what the experiment was
289 investigating and all were unaware that the scrambled sentences were trying to prime a
290 prosocial attitude.

291

292 **Data analysis**

293 **Visual Perspective Taking task – The Director’s task**

294 In the version of the director’s task that we used, we anticipated that reaction time
295 would not be an instructive measure. With no fixed starting point for the mouse at the beginning
296 of each trial, participants would not have necessarily all started in the same place. As such,
297 reaction time did not solely index the length of mental processing time; it also indexed the
298 distance the mouse had to travel to select the correct item. Further, participants could freely
299 move the mouse during the instruction phase, meaning some could place the cursor over an
300 object before the instruction had finished while others might have waited until they had heard
301 the whole request before moving. For these reasons, we considered accuracy data to be our
302 primary measure of interest.

303 The accuracy of performance as a function of trial type and group was analysed. For
304 each trial, participants could be correct, wrong or not answer (omit). Overall accuracy, based
305 on correct responses for all 48 trials, was calculated for each participant. The mean accuracy
306 and SD of each group was calculated. To control for outliers, participants with an average
307 accuracy of less than three SD from their group’s mean were removed from their group. This

308 resulted in seven participants being removed in total (PS-1st: 2; PS-3rd: 3; and Control: 2) and
309 146 being taken forward for analysis. For completeness, we also ran the analysis without
310 removing outliers; no differences were noted. Independent analysis of variance tests
311 (ANOVAs) were used to explore differences in accuracy across the experimental groups.

312

313 **Automatic Imitation Task**

314 In the automatic imitation task, reaction time was measured as the time taken from the
315 appearance of the imperative cue (“1” or “2”) to when the finger was released. Trials were
316 defined as accurate if the finger lifted matched the target number cue and incorrect if there was
317 a mismatch between finger movement and target number cue. All incorrect responses were
318 removed prior to analysis (<4% congruent trials and <10% of incongruent trials). Trials with a
319 reaction time of less than 250ms or more than 2,000ms were also removed (<.1% of overall
320 trials) as these were suggestive of expectancy errors and lapses in attention, respectively. Data
321 for index and middle finger responses were collapsed. Accuracy and reaction time were
322 calculated for each participant for each trial type; congruent and incongruent. Participants’
323 congruency effects were calculated by subtracting congruent reaction time from incongruent
324 reaction time.

325 Outliers were considered in the context of both the individual (deviation from their own
326 mean) and their group (deviation from the group mean). At participant level, trials falling
327 outside of three SD either side of their mean reaction time were removed. Reaction time and
328 accuracy for each participant was recalculated and taken forward into the group calculations.
329 Group reaction time and accuracy means were then calculated and participants falling outside
330 of three SD of their group’s mean (for either reaction time or accuracy) were removed from
331 further analysis. This resulted in six participants (PS-1ST: 1; PS-3RD: 1; and control: 4) being
332 removed from further analysis and 147 being taken forward. ANOVAs were used to test for

333 differences in accuracy, reaction times and congruency effects across the experimental groups.
 334 To ensure that the removal of outliers did not affect the outcome of our results, analyses were
 335 repeated on the complete dataset. No differences were noted.

336
 337

338 Results

339

340 Visual Perspective Taking Task

341 Accuracy for all trial types across all groups are reported in Table 1. Performance on
 342 the task was high across all groups, with average accuracy exceeding 90% for experimental
 343 trials (Fig 4). Errors on experimental trials were rare and trials that were omitted (left
 344 unanswered) were more common (Fig 5). This would suggest that, of the trials completed, there
 345 was a ceiling effect present in performance (117 participants scored 100%, 26 scored 87.5%
 346 and the remaining 10 scored 75% or less). Accuracy for control and experimental trials (conflict
 347 between participant's and Director's perspective) were compared between groups. Using group
 348 as the between subject's factor, two one-way ANOVAs on trial type revealed no significant
 349 differences between groups for accuracy on control $F(2,143)= 2.31, p=.103, \eta^2=.031$ or, more
 350 importantly, experimental $(F(2,143)= 0.53, p=.587, \eta^2=.007)$ trials.

351

352 **Table 1.** Summary of accuracy (%) results from the Director's Task.

	Trial Type		Overall Accuracy
	Control	Experimental	
PS-1 st	99.3 (1.7)	97.3 (5.2)	97.7 (2.8)
PS-3 rd	98.5 (3.6)	97.2 (6.4)	97.6 (3.8)
Control	97.8 (4.5)	95.7 (11.4)	96.3 (5.2)

353 Mean accuracy (%) for control and experimental trials, together with overall accuracy, for
 354 each group are provided (sd in brackets)
 355

356 **Fig 4: Accuracy (%) for control and experimental trials on the Director's Task for**

357 each group. Bars represent SEM

358

359 **Fig 5: Omissions (%) for control and experimental trials on the Director's Task for**
360 **each group. Bars represent SEM**

361

362 To be certain that we did not miss any potential group differences that might be more evident
363 in RTs than in accuracy, the same analyses were performed on RTs for control and
364 experimental trials. In line with accuracy data, there were no group differences in RTs for
365 control ($F(2,143)= 0.123, p=.884, \eta^2=.002$) or experimental ($F(2,143)= 0.085, p=.919,$
366 $\eta^2=.001$) trials (S1 Fig).

367

368 Given the overall high accuracy across all groups, which is indicative of a ceiling effect,
369 further analyses of the relationship between visual perspective taking and automatic imitation
370 were not performed as they would not be instructive.

371

372 The Director's task was used because many studies report substantial error rates when
373 using it and, as such, a ceiling effect was not expected. Near perfect scores across all
374 experimental groups in this study prompted a (non-exhaustive) review of studies using the
375 same task with adult participants (S2 Table). The search revealed that the task returns a variety
376 of results ranging from 54-88% accuracy. Worth noting is the fact that the task only includes
377 eight experimental trials, thus this range translates to one to four errors. For instance, accuracy
378 of 87.5% (7/8) would be achieved if only one mistake was made.

378

379 **Automatic Imitation task**

380

381 Mean reaction times for congruent and incongruent trials, as well as the congruency
382 effect (CE) are reported in Table 2. As can be seen, participants were faster and more accurate
383 on congruent trials (Figs 6 and 7). A repeated-measures ANOVA for RT was performed with
384 trial type (congruent and incongruent) as the within-subjects factor and group (PS-1st, PS-3rd
and control) as the between-subjects factor. There was a significant main effect of trial type

385 $F(1,144)=647.759$, $p<.001$, $\eta^2=.818$, with congruent trials being significantly faster than
386 incongruent trials. There was also an unexpected significant effect of group $F(2,144)=7.882$,
387 $p=.001$, $\eta^2=.099$. RTs were collapsed across congruent and incongruent trials for each group
388 to produce mean RTs. As a post-hoc exploratory analysis, these were compared using t-tests.
389 These showed that the PS-3rd group was significantly faster than both the PS-1st $t(100)=3.65$,
390 $p<.001$ and control $t(94)=3.32$, $p=.001$ groups (see Fig 6). There was no mean RT difference
391 between the PS-1st and Control group $t(94)=.004$, $p=.997$. While intriguing, this effect was
392 unexpected. We think it most likely to be a result of sampling error (i.e., people in the 3rd party
393 group just happened to be faster across all conditions than the other groups), but it is possible
394 that it is a genuine effect of our manipulation. Crucially, there was no interaction between
395 congruency and group $F(2,144)=0.943$, $p=.392$, $\eta^2=.013$ indicating there was no differential
396 effect of priming on congruency between groups.

397

398 **Table 2. Summary of results from the automatic imitation task.**

	PS-1 st		PS-3 rd		Control	
	RT	Accuracy	RT	Accuracy	RT	Accuracy
Congruent Trials	411 (42)	96.58 (2.9)	382 (38)	96.09 (3.6)	414 (50)	96.44 (3.7)
Incongruent Trials	482 (59)	90.13 (6.8)	445 (54)	89.15 (7.5)	479 (63)	91.80 (8.6)
Congruency Effect	71 (29)	N/A	63 (26)	N/A	65 (39)	N/A

399 Reaction times (ms) and accuracy rates (%) for each trial type and the congruency effect
400 (incongruent RT – congruent RT) for each group (sd in brackets)

401

402

403 **Fig 6: Reaction times (ms) for the Automatic Imitation task for congruent and**
404 **incongruent trials for each group. Bars represent SEM**

405

406 **Fig 7: Accuracy rates (%) for the Automatic Imitation task for congruent and**
407 **incongruent trials for each group. Bars represent SEM**

408

409 A repeated-measures ANOVA for accuracy was performed with trial type (congruent and
410 incongruent) as the within-subjects factor and group (PS-1st, PS-3rd and control) as the between-
411 subjects factor (Fig 7). There was a significant main effect of trial type $F(1,144)=127.811$,
412 $p<.001$, $\eta^2=.470$, with congruent trials being significantly more accurate than incongruent
413 trials. Again, crucially, there was no accuracy*group interaction ($F(2,144)= 1.660$, $p=.194$,
414 $\eta^2=.023$).

415
416

417 As prior studies analysed the congruency effect [18, 19, 20] we carried out an
418 independent one-way ANOVA on congruency effect as a function of group (Fig 8). There was
419 no significant difference between the groups' congruency effects $F(2,144)=0.96$, $p=.387$,
420 $\eta^2=.013$. To ensure that the removal of outliers had not changed the results, we ran the same
421 test with all participants (except for one who did not complete the task) included. The result
422 was the same $F(2,149)=1.24$, $p=.291$, $\eta^2=.016$. In addition, we wanted to ensure that English
423 language proficiency did not impact priming effects. When removing non-native English
424 speakers ($N=29$), there was still no effect of priming on imitation $F(2,121)=1.2$, $p=.304$.

425
426
427
428

Fig 8: Congruency Effects (CE) – incongruent RT less congruent RT – for each group for the Automatic Imitation task. Bars represent SEM

429 To provide quantitative evidence for the null hypothesis, a Bayesian analysis was
430 performed [44] in JASP using the independent t-test function [45]. The returned Bayes factor
431 BF^{01} provides an estimate of how likely the null hypothesis (0) is compared to the experimental
432 hypothesis (1), given the data. A Bayes factor of 3.3 was returned. This suggests that the null
433 hypothesis was three times more likely than the experimental hypothesis [46].

434

435 **Meta-Analysis of automatic imitation results: PS-1st vs Control groups**

436 To put our automatic imitation result in context, we performed a meta-analysis. The
 437 three previous studies using first person, prosocial priming (scrambled sentences) to investigate
 438 the effects on automatic imitation were included in the meta-analysis, along with the current
 439 study (Table 3). While these studies covered both within- [18] and between- [19, 20] subject
 440 designs and employed slightly different methods for testing automatic imitation, they shared
 441 sufficient similarity to be directly compared. All four studies used scrambled sentences to
 442 prime prosociality and measured imitation via an SRC index of automatic imitation. Therefore,
 443 while these studies are not direct replications of each other, they have substantial
 444 methodological similarity and all target the same primary effect, such that we consider them
 445 conceptual replications of each other. We meta-analysed the difference in congruency effect
 446 for first person priming compared to control. We were able to obtain raw data from one study
 447 [18]. In the absence of raw data for all studies, we used the values available from the published
 448 studies to compute standard deviations, standard errors and effect sizes. Cohen's d [47] was
 449 calculated as the mean group difference divided by the pooled standard deviation.

450

451 **Table 3. Summary of studies included in the meta-analysis.**

Study	Design	Stimuli		Sample /Group size	PS-1 st (2) CE	Control (1) CE	Effect Size (d) (2-1)/pooled sd
Wang & Hamilton (2013)	Within	Fingers	Spatial	16	28 (16)	16 (16)	0.75
Cook & Bird (2011)	Between	Fingers	Orthogonal	28	71 (63)	38 (37)	0.66
Leighton et al (2010)	Between	Hands	Spatial	12	38 (31)	26 (14)	0.53
Current study	Between	Fingers	Spatial	45-51*	71 (39)	65 (29)	0.18

452 Mean congruency effects (CE) for PS-1st and control groups (sd in brackets) are used to
 453 calculate the standardised effect size (Cohen's d). (* PS1st (51) and Control (45) were
 454 different sample sizes). Spatial stimuli introduce both a spatial and imitative component to
 455 the design. Orthogonal stimuli rotate the stimuli to reduce (but not remove) the spatial
 456 component.

457

458 The meta-analysis was performed using Exploratory Software for Confidence Intervals
459 [48]. ESCI calculates a weighted contribution for each study based on sample size and variance,
460 with larger sample sizes and smaller variance receiving the highest weighting. Based on
461 Cumming's recommendations [48], we used a random effects model to estimate the likely
462 population effect size in original units (ms), as well as standardized units. 95% CIs are reported
463 as a measure of precision for these population estimates. The results from these two
464 calculations are reported here using forest plots (Fig 9).

465 **Fig 9: Forest plots of meta-analysis for Original units (ms) (A) and Standardised**
466 **units (Cohen's d) (B)**
467 **Lines represent 95% confidence intervals. The random effects model indicates the**
468 **likely population effect.**

470
471
472

473 The estimated difference in priming between first person and control is 11ms [95% CI
474 4, 19] (Fig 9A). As can be seen from Fig 9A, two of the four studies in the MA have confidence
475 intervals (CI) that cross over the zero line and the effect sizes range from 4 to 19ms. The
476 standardized effect size is $d=0.43$ [0.15, 0.7] (Fig 9B), and varies across the four studies, with
477 interval estimates touching or crossing zero in three of the studies. These results suggest that
478 the effect is imprecise and it is possible that the true effect size may be close to zero. Prior to
479 running this study, the cumulative effect size based on three prior studies was $d=0.64$. Adding
480 the current study, which has a much larger sample size than all prior studies, reduces the
481 cumulative effect size by a third to $d=0.43$ (Fig 9B).

482

483 **Open data**

484 To aid future meta-analyses and power estimates, data from the current experiment are
485 available online for all dependent measures (osf.io/bseky).

486

487

488 **Discussion**

489

490 Due to a ceiling effect using the Director's Task, we were unable to investigate the effects of
491 prosocial priming on visual perspective taking. A comparison of other studies using the
492 Director's Task shows wide variability in accuracy scores. Accordingly, we suggest that the
493 reliability of the measure may be low and future research should test this formally. In addition,
494 and contrary to previous studies and our expectations, we found no effect of prosocial priming
495 on automatic imitation. To better understand this unexpected result, we performed a meta-
496 analysis of the effects of prosocial priming on automatic imitation. The result indicates that if
497 a relationship does exist between prosocial priming and automatic imitation, it is likely smaller
498 and more variable than the results of any one previous study would suggest. Therefore, we
499 offer caution when using the Director's Task as a measure of perspective taking and reduce the
500 strength of evidence in favour of social priming modulating automatic imitation. More
501 generally, the current study demonstrates the utility of replicating and meta-analysing main
502 effects in an effort to build a more cumulative science of social cognition.

503

504 **Prosocial priming and Visual Perspective Taking**

505 We found an unexpected ceiling effect in the Director's Task and, therefore, could not
506 perform our primary analyses of interest. We reviewed published studies that have
507 administered the Director's Task to adults (over 18) and reported their accuracy rates (S2
508 Table). This brief review found that the task returns a range of results (54-88%). These findings
509 suggest that the Director's Task could have low reliability, such that task performance appears
510 to vary quite substantially from study to study. There have also been concerns over the validity
511 of the Director's Task as an actual measure of visual perspective taking [49, 50, 51, 52], For
512 example, it has been proposed that the Director's Task can be approached using a simple trial

513 and error strategy [49]. Indeed, researchers who have used the Director’s Task in the past have,
514 more recently, questioned whether or not it requires mentalising [52]. As such, we recommend
515 that future studies should formally evaluate the reliability and validity of the measure before
516 using it further.

517 We also note other features of the Director’s Task that are worth further consideration
518 in future research. Not all studies using the Director’s Task specifically state the number of
519 trials analysed, so it is possible that accuracy scores vary across studies because of
520 methodological differences in the way the task was administered. Further, when interpreting
521 accuracy scores, it is important to note that there are only eight experimental trials; a factor we
522 did not fully consider when designing the study. Scores of 75% and 87.5% may seem
523 substantially different, but in this task, the difference is only one error. This does not bode well
524 for studies such as ours, which aim to improve perspective taking scores through experimental
525 manipulations or training (in this case, through prosocial priming). There simply is not enough
526 “room” to measure any true increase in the skill with adult participants. It could be argued that
527 more trials are needed in the experimental condition, however, given the accuracy rates
528 returned in our data, participants seem to reach ceiling quickly, rendering the data from those
529 extra trials superfluous.

530 A further feature that is worthy of consideration is that the original study using the
531 Director’s task [30, 31] included a real-life human director who was present in the room and a
532 real set of shelves. This afforded the researchers the ability to measure quasi-errors whereby
533 participants reached for an incorrect object but did not necessarily move the wrong object. Our
534 computerised version of the task did not afford such an opportunity; it only captured actual
535 errors. One possible solution to this is that users of the task include mouse tracking or eye
536 tracking measures capable of detecting egocentric ‘quasi-mistakes’ that are made before the
537 correct item is eventually selected. However, it could be argued that ‘looking’ does not

538 constitute a true error. If one cannot help but locate the object fulfilling the instruction's criteria
539 first – the so called 'curse of knowledge' [29] – then this may be a necessary step that one
540 performs before identifying the appropriate item. This fits with a trial and error approach [49]
541 as, upon identifying the technically correct object, one notes whether or not its shelf has a
542 backing. If it does, discount it and continue looking. If it does not, select it. Finally, given the
543 linguistic nature of the task, such concrete instructions as "move the large ball" may render it
544 impossible to not look at the actual largest ball. In sum, we offer caution to those interested in
545 studying visual perspective taking using the computerised version of the Director's Task,
546 especially if the research question relies on score variability or manipulation.

547

548 **Prosocial priming and Automatic Imitation**

549 Previous studies have shown that PS-1st priming leads to increased congruency effects
550 on automatic imitation tasks [18, 19, 20]. Although the current study had the power to detect
551 effects smaller than those previously observed, we did not observe an effect. While we did find
552 a small reaction time difference (6ms) between the PS-1st priming and control groups in the
553 same direction as previous studies, the difference was not distinguishable from zero. Further,
554 a Bayesian analysis provided three times more support for the null over the experimental
555 hypothesis.

556 Of the four studies included in the meta-analysis, one has a 95% confidence interval
557 that touches the zero line and two actually cross the line (Fig 9). This is suggestive of an
558 imprecise estimate of a population effect size, which could be small in size (close to zero) and
559 paints a different picture to the way in which effects were interpreted by each individual study.
560 Overall, the pattern of results is in keeping with suggestions in the literature that published
561 effects are commonly over-estimated [35, 36] and underscores the value of meta-analytic
562 thinking when aiming to synthesise prior findings [48, 53]. It is more than likely that the actual
563 effect of prosocial priming on automatic imitation is smaller than previously reported as the

564 meta-analysis suggests a population effect size of $d=0.43$. The meta-analysis also illustrates
565 the variability of findings to date, with confidence intervals for the standardised effect size
566 ranging from 0.15 to 0.70. In addition, viewing our null result ($d=0.18$) within the context of
567 the meta-analysis ($d=0.43$) suggests that the effect of first person, prosocial priming on
568 automatic imitation is indeed prone to variation.

569

570 **Limitations and future directions**

571 One potential limitation of the current study is the imitation task used has a spatial
572 compatibility component, which might introduce ‘noise’ to the data that could interact with the
573 imitative tendencies of the participants [2, 54, 55]. Although possible, it is unlikely to have
574 been the reason behind our null results. Prior studies used the same task and were able to show
575 effects of the same social priming technique on congruency effects [18]. Therefore, while we
576 do not think it can account for the current null results, separating imitative tendencies from
577 spatial compatibility would be a useful future direction for research investigating automatic
578 imitation more generally [54, 56, 57].

579 One further limitation concerns the sequencing of tasks. To avoid any influence of the
580 imitation task on the Director’s Task, we used a fixed order across participants. It is therefore
581 possible that, by administering the Director’s Task prior to the automatic imitation task, we
582 unwittingly introduced another prosocial prime that interfered with the effects of the intended
583 prosocial prime. That is to say, taking someone else’s perspective may itself serve as a prosocial
584 prime that increases the tendency to imitate. However, if the prosocial prime and the visual
585 perspective taking task both activated a goal to affiliate, we might still expect to observe overall
586 greater imitative tendencies in the first person, prosocial group; the effects on behaviour from
587 both primes might be expected to be additive. This possibility is not supported by the current

588 data due to the fact that the control group returned the same congruency effects as the
589 prosocially primed group.

590 Conversely, if participants did have a goal to act prosocially, the completion of the
591 Director's task could have satisfied this goal and, in essence, 'switched off' the prime (see 22
592 for a review of priming procedures). Again, this explanation could account for the lack of group
593 differences in the automatic imitation task as all groups could have been returned to baseline.
594 If this were the case, it would still not encourage thinking of goal priming as a robust method
595 for increasing prosocial behaviour; as soon as one completes the goal, they return to a neutral
596 position. Alternatively, the visual perspective taking task could have diluted, or even
597 overwritten, any effects the prosocial priming task may have generated, which would account
598 for the lack of group differences. However, with only eight trials among 48 actually requiring
599 the participant to take someone else's perspective, the visual perspective taking task would need
600 to exhibit strong effects to remove those created by the prosocial priming task administered
601 just five minutes previously. Ultimately, a future study is required to determine whether the
602 Director's Task can function as a prosocial prime that modulates imitative tendencies.

603 In summary, the order effect created three possibilities that could in theory account for
604 this study failing to find the same effect on automatic imitation following prosocial priming as
605 that found by other studies. Either 1) the goal from priming was satisfied by completing the
606 Director's task, 2) the Director's task exerts effects strong enough to return all groups to
607 baseline (or equally primed) or 3) the effects of prosocial priming are too weak to survive an
608 intervening task. While no firm conclusions can be drawn at this moment, when considering
609 these possibilities and the highly variable effect highlighted by the meta-analysis, it is prudent
610 to say that the influence of prosocial priming on automatic imitation is unlikely to be robust.

611

612 **Conclusion**

613 Due to an unforeseen ceiling effect in the Director’s Task, we could not evaluate whether
614 prosocial priming modulates visual perspective taking and this question remains open for future
615 studies to address. Instead, we suggest that when investigating visual perspective taking using
616 the Director’s Task, the possibility that the task has low reliability and validity should be given
617 due consideration and formally tested. The current study also questions the robustness of
618 prosocial priming effects on automatic imitation. Indeed, meta-analysing all studies to date
619 suggests that the effects of prosocial primes on imitation are variable and could be small.
620 Finally, by reporting null results we hope to avoid the file drawer problem and inherent bias in
621 the published literature [58, 59]. Also, by meta-analysing results as studies emerge [48, 53] and
622 by making raw data freely available [60], we hope to move towards a more cumulative science
623 of social cognition that future studies can build upon.

624

625

626 **Acknowledgments**

627

628 This research was performed as part of an all-Wales ESRC Doctoral Training Centre 1+3
629 PhD studentship.

630

631

632

633 **References**

634

635 1. Chartrand TL, Lakin JL. The Antecedents and Consequences of Human Behavioral Mimicry.
636 Annual Review of Psychology. 2012; 64: 18.1–18.24.

637

638 2. Heyes C. Automatic imitation. Psychological Bulletin. 2011; 137: 463–483. pmid:21280938

639

640 3. van Baaren R, Janssen L, Chartrand TL, Dijksterhuis A. Where is the love? The social aspects of
641 mimicry. Philosophical Transactions of the Royal Society B: Biological Sciences. 2009; 364: 2381–
642 2389.

643

644 4. Chartrand TL, Bargh JA. The chameleon effect: The perception-behavior link and social
645 interaction. Journal of Personality & Social Psychology. 1999; 76: 893–910.

646

647 5. Ramsey R. What are reaction time indices of automatic imitation measuring? Consciousness &

- 648 Cognition. 2018; 65: 240-254.
649
- 650 6. Hale J, Hamilton, AF. Cognitive mechanisms for responding to mimicry from others. *Neuroscience*
651 & *Biobehavioral Reviews*.2016; 63, 106
652 123.<https://www.sciencedirect.com/science/article/pii/S0149763415302426>
653
- 654 7. Lakin JL, Jefferis VE, Cheng CM, Chartrand TL. The chameleon effect as social glue: Evidence for
655 the evolutionary significance of nonconscious mimicry. *Journal of Nonverbal Behavior* .2003; 27: 145–
656 162.
657
- 658 8. van Baaren R, Holland RW, Steenaert B, Van Knippenberg A. Mimicry for money: Behavioral
659 consequences of imitation. *Journal of Experimental Social Psychology* 2003; 39: 393–398.
660
- 661 9. Van Baaren RB, Holland RW, Kawakami K, Van Knippenberg A. Mimicry and prosocial behavior.
662 *Psychological science*. 2004 Jan;15(1):71-4.
663
- 664 10. Carpenter M, Uebel J, Tomasello M. Being mimicked increases prosocial behavior in 18-month-
665 old infants. *Child development*. 2013 Sep 1;84(5):1511-8.
666
- 667 11. Macrae CN, Johnston L. Help, I need somebody: Automatic action and inaction. *Social Cognition*.
668 1998 Dec;16(4):400-17.
669
- 670 12. Müller BC, Maaskant AJ, Van Baaren RB, Dijksterhuis AP. Prosocial consequences of imitation.
671 *Psychological reports*. 2012 Jun;110(3):891-8.
672
- 673 13. Brass M, Bekkering H, Wohlschläger A, Prinz W. Compatibility between observed and executed
674 finger movements: comparing symbolic, spatial, and imitative cues. *Brain and Cognition*. 2000; 44:
675 124–143. pmid:11041986
676
- 677 14. Brass M, Bekkering H, Prinz W. Movement observation affects movement execution in a simple
678 response task. *Acta Psychologica*. 2001; 106: 3–22. pmid:11256338
679
- 680 15. Boyer TW, Longo MR, Bertenthal BI. Is automatic imitation a specialized form of stimulus–
681 response compatibility? Dissociating imitative and spatial compatibilities. *Acta Psychologica*. 2012
682 Mar 1;139(3):440-8.
683
- 684 16. Prinz W. Perception and action planning. *European journal of cognitive psychology*. 1997; 9: 129–
685 154.
686
- 687 17. Brass M, Heyes C. Imitation: is cognitive neuroscience solving the correspondence problem?
688 *Trends in Cognitive Sciences*. 2005; 9(10), 489–495. pmid:16126449
689
- 690 18. Wang Y, Hamilton A. Understanding the role of the ‘self’ in the social priming of mimicry.
691 *PloS one*. 2013; 8: e60249. pmid:23565208
692
- 693 19. Cook J, Bird G. Social attitudes differentially modulate imitation in adolescents and adults.
694 *Experimental Brain Research*. 2011; 211: 601–612. pmid:21336831
695
- 696 20. Leighton J, Bird G, Orsini C, Heyes C. Social attitudes modulate automatic imitation. *Journal of*
697 *Experimental Social Psychology*. 2010; 46: 905–910.
698
- 699 21. Bargh JA, Gollwitzer PM, Lee-Chai A, Barndollar K, Trötschel R. The automated will:
700 nonconscious activation and pursuit of behavioral goals. *Journal of personality and social psychology*.
701 2001; 81: 1014–1027.
702

- 703 22. Förster J, Liberman N, Friedman R. What do we prime? On distinguishing between semantic
704 priming, procedural priming, and goal priming. In: Morsella, E, Bargh, JA, Gollwitzer, PM, editors.
705 Oxford handbook of human action. Oxford University Press; 2009. pp. 173-196.
706
- 707 23. Davis MH. Measuring individual differences in empathy: Evidence for a multidimensional
708 approach. *Journal of personality and social psychology*. 1983; Jan;44(1):113.
709
- 710 24. Leslie AM. ToMM, ToBy, and Agency: Core architecture and domain specificity. Mapping the
711 mind: Domain specificity in cognition and culture. 1994; Apr 29:119-48.
712
- 713 25. Flavell JH, Omanson RC, Latham C. Solving spatial perspective-taking problems by rule versus
714 computation: A developmental study. *Developmental Psychology*. 1978 Sep;14(5):462.
715
- 716 26. Birch SA, Bloom P. Understanding children's and adults' limitations in mental state reasoning.
717 *Trends in cognitive sciences*. 2004 Jun 1;8(6):255-60.
718
- 719 27. Epley N, Caruso EM. Perspective Taking: Misstepping Into Others' Shoes. *Handbook of*
720 *imagination and mental simulation*. 2008 Dec 15:295.
721
- 722 28. Gillespie A, Richardson B. Exchanging social positions: Enhancing perspective taking within a
723 cooperative problem solving task. *European journal of social psychology*. 2011 Aug 1;41(5):608-16.
724
- 725 29. Birch SA, Bloom P. The curse of knowledge in reasoning about false beliefs. *Psychological*
726 *Science*. 2007 May;18(5):382-6.
727
- 728 30. Keysar B, Barr DJ, Balin JA, Brauner JS. Taking perspective in conversation: The role of mutual
729 knowledge in comprehension. *Psychological Science*. 2000 Jan;11(1):32-8.
730
- 731 31. Keysar B, Lin S, Barr DJ. Limits on theory of mind use in adults. *Cognition*. 2003 Aug 1;89(1):25-
732 41.
733
- 734 32. Surtees AD, Apperly IA. Egocentrism and automatic perspective taking in children and adults.
735 *Child Development*. 2012 Mar 1;83(2):452-60.
736
- 737 33. Steinbeis N. The role of self–other distinction in understanding others' mental and emotional
738 states: neurocognitive mechanisms in children and adults. *Phil. Trans. R. Soc. B*. 2016 Jan
739 19;371(1686):20150074.
740
- 741 34. Santiesteban I, White S, Cook J, Gilbert SJ, Heyes C, Bird G. Training social cognition: from
742 imitation to theory of mind. *Cognition*. 2012 Feb 1;122(2):228-35.
743
- 744 35. Ioannidis JP. Why most published research findings are false. *PLoS medicine*. 2005 Aug
745 30;2(8):e124.
746
- 747 36. Open Science Collaboration. Estimating the reproducibility of psychological science. *Science*.
748 2015 Aug 28;349(6251):aac4716.
749
- 750 37. Albers C, Lakens D. When power analyses based on pilot data are biased: Inaccurate effect size
751 estimators and follow-up bias. *Journal of Experimental Social Psychology*. 2018 Jan 31;74:187-95.
752
- 753 38. Faul F, Erdfelder E, Buchner A, Lang AG. Statistical power analyses using G*Power 3.1: Tests for
754 correlation and regression analyses. *Behavior Research Methods* 2009; 41, 1149–1160
755 pmid:19897823
756

- 757 39. Allison C, Auyeung B, Baron-Cohen S. Toward brief “red flags” for autism screening: The short
758 autism spectrum quotient and the short quantitative checklist in 1,000 cases and 3,000 controls.
759 *Journal of the American Academy of Child & Adolescent Psychiatry*. 2012; 51(2), 202–212.
760
- 761 40. Rosenberg M. Rosenberg self-esteem scale (RSE). Acceptance and commitment therapy.
762 *Measures package*. 1965; 61:52.
763
- 764 41. Srull TK, Wyer RS. The role of category accessibility in the interpretation of information about
765 persons: Some determinants and implications. *Journal of Personality and Social Psychology* 1979;
766 37: 1660–1672.
767
- 768 42. Apperly IA, Carroll DJ, Samson D, Humphreys GW, Qureshi A, Moffitt G. Why are there limits on
769 theory of mind use? Evidence from adults’ ability to follow instructions from an ignorant speaker.
770 *Quarterly Journal of Experimental Psychology*. 2010 Jun;63(6):1201-17.
771
- 772 43. Dumontheil I, Hillebrandt H, Apperly IA, Blakemore SJ. Developmental differences in the control of
773 action selection by social information. *Journal of Cognitive Neuroscience*. 2012 Oct;24(10):2080-95.
774
- 775 44. Dienes Z. How Bayes factors change scientific practice. *Journal of Mathematical Psychology*.
776 2016 Jun 1;72:78-89.
777
- 778 45. JASP Team. JASP (Version 0.7. 5.5)[Computer software]. Google Scholar. 2016.
779
- 780 46. Jeffreys H (1961) *Theory of probability*. Clarendon Press, Oxford.
781
- 782 47. Cohen J. (1992). A power primer. *Quantitative Methods in Psychology*, 112(1), 155–159.
783
- 784 48. Cumming G. *Understanding the new statistics: Effect sizes, confidence intervals, and meta-*
785 *analysis*. Routledge; 2013 Jun 19.
786
- 787 49. Rubio-Fernández P. The director task: A test of Theory-of-Mind use or selective attention?
788 *Psychonomic bulletin & review*. 2017 Aug 1;24(4):1121-8.
789
- 790 50. Heyes C. Submentalizing: I am not really reading your mind. *Perspectives on Psychological*
791 *Science*. 2014 Mar;9(2):131-43.
792
- 793 51. Symeonidou I, Dumontheil I, Chow WY, Breheny R. Development of online use of theory of mind
794 during adolescence: An eye-tracking study. *Journal of experimental child psychology*. 2016 Sep
795 1;149:81-97.
796
- 797 52. Santiesteban I, Shah P, White S, Bird G, Heyes C. Mentalizing or submentalizing in a
798 communication task? Evidence from autism and a camera control. *Psychonomic bulletin & review*.
799 2015 Jun 1;22(3):844-9.
800
- 801 53. Zwaan RA, Etz A, Lucas RE, Donnellan MB. Making replication mainstream. *Behavioral and Brain*
802 *Sciences*. 2017 Oct:1-50.
803
- 804 54. Shaw DJ, Czekóová K, Porubanová M. Orthogonal-compatibility effects confound automatic
805 imitation: implications for measuring self–other distinction. *Psychological research*. 2017 Nov
806 1;81(6):1152-65.
807
- 808 55. Jiménez L, Recio S, Méndez A, Lorda MJ, Permuy B, Méndez C. Automatic imitation and spatial
809 compatibility in a key-pressing task. *Acta Psychologica*. 2012; 141: 96–103. pmid:22864312
810
- 811 56. Gowen E, Bolton E, Poliakoff E. Believe it or not: Moving non-biological stimuli believed to have
812 human origin can be represented as human movement. *Cognition*. 2016 Jan 1;146:431-8.

- 813
814 57. Catmur C, Heyes C. Time course analyses confirm independence of imitative and spatial
815 compatibility. *Journal of Experimental Psychology: Human Perception and Performance*. 2011; 37:
816 409–421. PMID:20731523
817
818 58. Rosenthal R. The file drawer problem and tolerance for null results. *Psychological bulletin*. 1979
819 May; 86(3):638.
820
821 59. Ferguson CJ, Heene M. A vast graveyard of undead theories: Publication bias and psychological
822 science's aversion to the null. *Perspectives on Psychological Science*. 2012 Nov;7(6):555-61.
823
824 60. Munafò MR, Nosek BA, Bishop DV, Button KS, Chambers CD, du Sert NP, Simonsohn U,
825 Wagenmakers EJ, Ware JJ, Ioannidis JP. A manifesto for reproducible science. *Nature Human*
826 *Behaviour*. 2017 Jan 10;1:0021.
827
828 61. Dumontheil I, Küster O, Apperly IA, Blakemore SJ. Taking perspective into account in a
829 communicative task. *Neuroimage*. 2010 Oct 1;52(4):1574-83.
830
831 62. Dumontheil I, Apperly IA, Blakemore SJ. Online usage of theory of mind continues to develop in
832 late adolescence. *Developmental science*. 2010 Mar 1;13(2):331-8.
833
834
835

836 **Supporting Information**

- 837
838 S1 Table: Summary of scores for each questionnaire for each group
839
840 S2 Table: Studies using the Director's Task with adult populations [51, 52, 54, 61, 62]
841
842 S1 Fig: Reaction time data for the Director's Task
843