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PLOS ONE

Do MZ twins have discordant experiences of friendship? A qualitative hypothesis-generating MZ twin differences study --Manuscript Draft--

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Article Type:	Research Article
Full Title:	Do MZ twins have discordant experiences of friendship? A qualitative hypothesis-generating MZ twin differences study
Short Title:	MZ discordance in peer relationships
Corresponding Author:	Kathryn Asbury University of York YORK, UNITED KINGDOM
Keywords:	monozygotic twins; nonshared environment; peer relationships; qualitative research
Abstract:	Using a qualitative monozygotic (MZ) twin differences design we explored whether adolescent MZ twins report discordant peer relationships and, if so, whether they perceive them as causes, consequences or correlates of discordant behaviour. We gathered free-response questionnaire data from 497 families and conducted in-depth telephone interviews with 97 of them. Within this dataset n=112 families (23% of the sample) described discordant peer relationships. Six categories of discordance were identified (peer victimisation, peer rejection, fewer friends, different friends, different attitudes to friendship and dependence on co-twin). Participants described peer relationship discordance arising as a result of chance occurrences, enhanced vulnerability in one twin or discordant behaviour. Consequences of discordant peer relationships were seen as discordance in self-confidence, future plans, social isolation, mental health and interests. In all cases the twin with worse peer experiences was seen as having a worse outcome. Specific hypotheses are presented.
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Additional data availability information:



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7th June 2017

Dear Dr Branchi,

Do MZ twins have discordant experiences of friendship? A qualitative, hypothesis-generating MZ twin differences study

Thank you for your feedback on our revised version of this paper. Please find enclosed our response to reviewers and the revised manuscript. We look forward to hearing from you.

Yours sincerely

A handwritten signature in blue ink that reads "Kathryn Asbury". The signature is written in a cursive, flowing style.

On behalf of: Kathryn Asbury, Nicola Moran and Robert Plomin

MZ discordance in peer relationships

24

25

26 **Do MZ twins have discordant experiences of friendship? A**
27 **qualitative hypothesis-generating MZ twin differences study**

28 **Introduction**

29 Behavioural genetic studies have confirmed that there are both genetic and
30 environmental influences on human behaviour (1). In the majority of cases the most
31 influential environments are individual-specific, or non-shared, making us differ from those
32 we are raised with (2-4). However, non-shared environment (NSE), while recognised as a
33 major source of behavioural variation, remains poorly understood and under-explored. This
34 manuscript reports one strand of an unprecedentedly large qualitative monozygotic (MZ)
35 twin differences study which was designed to address this dearth of understanding by taking
36 an inductive approach to generating new, testable hypotheses about NSE (5). We present
37 findings related to peer relationships as one potential aspect of NSE.

38 Back in 1998 Judith Rich Harris made a case that peers are the primary agents of
39 socialisation and development, and argued that we should look to peer relationships as the
40 most likely tangible explanation of non-shared variation in personality and behaviour (6).
41 Exploring whether MZ twins have different experiences of peer relationships, and whether
42 they perceive peer-relationship discordance as related to discordant behaviour, partially
43 addresses this hypothesis. Differences between MZ twins have to be explained by NSE
44 because MZ twins share their genes and much of their upbringing. An MZ differences
45 design, based on within-pair discordance, can therefore hold constant the effects of genes and
46 many aspects of the family environment, making it possible to develop hypotheses about
47 environmentally mediated relationships between experiences and behaviour.

48 Identifying specific NSE experiences that can explain large proportions of phenotypic
49 variance has been an unsuccessful endeavour, just as identifying single genes with large
50 effects has proven a fruitless, and now abandoned, line of inquiry (7-9). While specific NSE
51 factors have certainly been identified they, like specific genes, tend to explain only a very
52 small proportion of variance (7). This consistent pattern has given rise to a hypothesis that
53 NSE variance is best explained by chance – by unpredictable, transient experiences that affect
54 individuals but do not generalise to groups (7). This hypothesis is firmly rooted in empirical
55 data and remains a genuine possibility, although it has been described as “a gloomy prospect”
56 (3). A case can still be made that small effects might accumulate to have large outcomes (10,
57 4). It also remains true that we consistently find evidence of measured NSE that can explain
58 variance in behaviour – just not very much of it, typically 1-5% (e.g. 11,12).

59 Two further hypotheses (other than all NSE variance being explained by chance) have
60 emerged in the literature: (1) that measurable NSE experiences are most likely to have causal
61 effects such that differences in experience will explain differences in behaviour (3,4); and (2)
62 that apparently NSE experiences are most likely to be the outcome of selection effects such
63 that differences in behaviour will explain differences in experience (12-14).

64 Judith Rich Harris’ thesis in *The Nurture Assumption* (6) met with a substantial
65 backlash (15,16). However, criticism was not targeted at her argument that peers are
66 important, but rather at her argument that parents aren’t. Harris was accused, with some
67 justification, of throwing the baby out with the bathwater. However, the peers hypothesis
68 was accepted without demur, most likely because it was a good fit with people’s intuitions
69 and experience as well as with empirical evidence. In addition to behavioural genetic
70 evidence pointing to the substantial importance of the NSE there is a large body of research
71 that suggests the importance of peers to healthy development, particularly in adolescence –a
72 time when exposure to peers is often very high (17,18). What is surprising is that Harris’

73 hypothesis that peer relationships should explain a substantial proportion of NSE variance has
74 not been subjected to a great deal of empirical testing.

75 That said, there has been some good research in this area and studies have yielded
76 support for peers as an agent of NSE or, at least, a genuinely environmental variable. For
77 instance, several studies have found variation in aspects of peer relationships to be primarily
78 non-shared in origin. In one study which used two independent samples – one of adoptive
79 and non-adoptive siblings and another of mixed sibling types (including twins) – 70-80% of
80 the total variance in self-reported peer group delinquency was explained by NSE effects (19).
81 These findings were later replicated with teacher- and observer-report data, offering strong
82 empirical support for Harris' theory that peer relationships represent a truly environmental
83 influence (20). The same study also found peer group popularity to be substantially
84 explained by NSE factors, albeit with some genetic influence (19). Peer group college
85 orientation, however, was found to be moderately heritable, with approximately half of the
86 variance explained by genetic factors – a finding also reported elsewhere (21).

87 It should be noted that Manke et al. also found parent-reported peer group
88 delinquency and popularity to be moderately to strongly heritable. Other studies have
89 observed the same pattern of small to moderate heritability for peer group delinquency (22-
90 25). Manke et al. (21) also used a 'best friends' measure in which positive and negative
91 dimensions of friendship were defined. The researchers found the positive dimension to be
92 moderately heritable ($h^2=.31$) but the negative dimension to be primarily explained by NSE
93 effects. Other studies have noted evidence of genotype correlation as an explanation of, for
94 instance, the association between peer victimization and physical ill health (26) and the
95 association between peer aggression and aggressive behaviour (27). In summary, the picture
96 is somewhat unclear but it is true to say that all studies find NSE factors to explain variation

97 in peer relationships. The differences between the studies are of degree, and of whether
98 significant genetic effects are also observed.

99 Studies have found that discordant friendships in adolescence can account for NSE
100 variance in externalising behaviour (28,29), aspirations (30) and adult self-reported life
101 satisfaction and relationship quality (31), lending some support to the causation hypothesis.
102 Most recently, discordant peer victimization was found to account for NSE variation in daily
103 cortisol secretions, along with discordance in the mother-child relationship (32). However,
104 most of these studies – not including Marion et al. (31) – have tended to rely on cross-
105 sectional correlational designs in which the direction of effects remains unclear. It has
106 therefore been convincingly argued that assumptions of causality – of NSE influence rather
107 than NSE selection – are premature because the direction of causation could be in either or
108 both directions (12). However, a recent longitudinal study presented findings which indicate
109 that being bullied is predictive of mental illness and, using an MZ differences model, found
110 that the association was mediated environmentally (33). This suggests that very severe peer
111 relationship problems may act as genuinely environmental influences on mental health
112 outcomes.

113 The vast majority of research in this area has focused on the relationship between
114 antisocial behaviour and deviant peer affiliation – the ‘wrong crowd’ hypothesis (28,12). By
115 contrast, in this more developed area of genetically-informed peer research, support for the
116 NSE ‘selection’ hypothesis has been clear. For instance, Burt and colleagues (12) used a
117 longitudinal cross-lagged MZ differences design to look at the relationship between
118 externalising behaviour and deviant peer affiliation at ages 14 and 17. The study found
119 moderate to strong cross-sectional associations but, longitudinally, it showed that MZ
120 discordance in externalising behaviour at age 14 predicted MZ discordance in deviant peer
121 affiliation at age 17, but not the other way around. The finding was consistent with an earlier

122 study (13) and provides strong support for the selection hypothesis. It appears, from studies
123 such as these, that an identical twin displaying higher levels of externalising behaviour at one
124 time point is more likely to have chosen or shaped worse behaved peers, relative to their co-
125 twin, at a second time point. However, it is important to note that this still leaves the
126 discordant externalising behaviour at the first time point to be explained by NSE factors. The
127 focus on deviant peer affiliation as a candidate NSE factor has led to some imbalance in the
128 field as it represents just one aspect of peer relationships, albeit an important one. A full
129 typology of peer relationships is needed and could be useful to researchers attempting to map
130 the non-shared environment. Peer relationship discordance in MZ twins is particularly
131 notable as MZ twins have been found both in early childhood (34) and adolescence (35) to
132 share more of their friends with one another than DZ twins (36,37).

133 The current study represents one strand of a larger qualitative hypothesis-generating
134 MZ twin differences study in which adolescent MZ twins (and a parent) were asked to
135 describe and explain differences between them in academic achievement, plans for the future
136 and their lives and experiences more generally. We did not ask participants directly about
137 peer relationships because a primary purpose of the study was for families to tell us their
138 theories of discordance spontaneously. Instead, we waited to see whether, in line with Judith
139 Rich Harris' 1998 claim:

- 140 (1) families would describe discordant peer relationships and, if so,
141 (2) whether they would interpret them as causes (causal hypothesis), consequences
142 (selection hypothesis) or simply correlates of discordant behaviour.

143 **Materials and methods**

144 This study was approved by the Institute of Psychiatry Ethics Committee (PNM/11/12-142).

145 **Participants**

146 We recruited a sub-sample of the UK Twins' Early Development Study (TEDS), a
147 longitudinal study of twins born in the UK between 1994 and 1996 (38). Participants were
148 recruited for this study in October 2012 and questionnaire data were gathered between
149 October and December 2012. Discordant pairs were then identified for follow-up interviews
150 which were conducted between February 2013 and February 2014. The TEDS sample has
151 been found to be reasonably representative of the UK population of same-age adolescents and
152 their parents (39). For the current qualitative study 2,162 TEDS families with MZ twins were
153 invited to take part and, of those, we received data from 497, a response rate of 23%. This
154 was lower than hoped, which may reflect sample selectivity. The relatively increased
155 proportion of girls in the current sample (from c.50% at first contact to 61%) is representative
156 of TEDS at 16, although not of wider UK society. This significant discrepancy may be the
157 result of greater willingness to engage with data collection among girls than boys at this age
158 and stage. The current sample was also significantly higher in terms of SES ($M=0.31$,
159 compared to 0.00 at first contact and 0.1 at age 16) and g (general cognitive ability: measured
160 at age 12; $M=0.11$, compared to 0.00). All group mean differences were assessed with t -
161 tests. TEDS families have been studied throughout their lives but this was the first occasion
162 on which we had asked a sample of them to provide free-response data. There are indications
163 that the approach was off-putting to some, potentially leading to a slightly biased sample.
164 Although this does not matter in one sense, because our interest was in within-pair not
165 between-family differences, it is important to bear the evidence of sample selectivity in mind.
166 It remains possible that NSE influences are different for families in different circumstances.

167 Free-response questionnaire data were gathered from the $n=497$ participating families
168 with identical twins (61% female). Zygosity was confirmed using DNA for 84%

169 (questionnaire data) and 85% (interview data) of participants. In the remaining cases
170 zygosity was assigned via a questionnaire that has been found to be 95% accurate in the
171 TEDS sample (40).

172 Three questionnaires were posted to each family and, in most cases, we received self-
173 report data from a parent (usually mother) and both twins. The twins' average age was 17.3
174 (range 16.2–18.9). After analysis of the questionnaires, telephone interviews were conducted
175 with 97 families (both twins and one parent in most cases) who were selected because the
176 twins reportedly showed strong signs of discordance in one or more aspects of achievement,
177 behaviour or experience, suggesting NSE influence. In the course of the interviews and
178 questionnaires n=112 families spontaneously mentioned discordant experiences of peer
179 relationships and these 112 families are the subject of the current study. To clarify, the
180 sample included pairs who were not invited to take part in a telephone interview as well as
181 those that were. Families were included in the current study if they spontaneously referred to
182 discordance in peer relationships in either their questionnaire responses or during a telephone
183 interview. Peer-d discordance was usually described spontaneously in relation to another area
184 of discordance, rather than in response to a direct question.

185 **Measures**

186 New measures were developed for the current study and, other than information
187 regarding zygosity and gender, existing TEDS data were not used. We took an inductive
188 approach that was not rooted in previously gathered data. A 5-item screening questionnaire
189 was designed to identify potential sources of discordance between identical twins towards the
190 end of compulsory education. The first item asked whether twins performed differently in
191 their General Certificates of Secondary Education (GCSEs) overall and, if so, what the
192 differences were and how they might be explained. GCSEs are the public examinations taken

193 by most UK students at the end of the academic year in which they turn 16. Most students
194 take GCSEs in a broad range of academic subjects typically including English, Maths,
195 Science, Humanities, Arts and, often, Languages. The second item focused on discordance in
196 core GCSE subjects – English, Maths and Science – and asked whether there was a difference
197 of at least two grades (e.g. A*/B or D/F) and how such discordance might be explained. The
198 third question asked about discordance in next steps after GCSEs, namely whether students
199 planned to pursue traditional academic qualifications (A Levels), vocational qualifications or
200 work-based opportunities such as apprenticeships. The fourth item focused on discordance in
201 hopes for the future and the fifth was a catch-all item: *What are the major differences (not*
202 *already described) that you notice between Twin 1 and Twin 2, and how do you explain these*
203 *differences?* Before sending the questionnaire to study participants we conducted a
204 feasibility test with a small convenience sample of sixteen year olds in order to ensure that
205 the items were suitable and clear for the age group. Small changes were made on the basis of
206 this feasibility study. Data for the current study were drawn from answers to all items; that
207 is, we noted evidence and discussion of peer discordance wherever it was spontaneously
208 mentioned by twins or their parents. All items were open-ended as the aim was to ask
209 families for their hypotheses about perceived discordance in a way that would not be leading.

210 Telephone interviews with twins and their parents were conducted by two
211 experienced interviewers. Because of the hypothesis-generating nature of this study bespoke
212 interview guides were drawn up by the researchers for each participant, focusing on the
213 differences and explanations identified in the questionnaire. Researchers read the completed
214 free-response questionnaires provided by each family selected for interview on the grounds of
215 discordance (in a range of behaviours and experiences). They then documented all reasons
216 offered by each member of the family to explain this discordance and turned the explanations
217 into questions followed by a series of relevant probes. This formed a semi-structured

218 interview schedule that differed by family. Also, when potential hypotheses were suggested
219 in the interviews that had not been mentioned previously, interviewers probed for a full
220 account of each participant's view. This flexible approach was taken so that participants
221 could give a full account of their beliefs about why one twin differed from the other,
222 unrestricted by closed or standardised questions. Evidence and discussion of discordant
223 experiences of friendship was documented as it arose.

224

225 **Procedure**

226 Families invited to participate in the study received an information letter, consent
227 form and three questionnaires – one for a parent and two for the twins. Separate envelopes
228 for each participant were included so that individuals would be able to keep their responses
229 private. Families returning completed sets of questionnaires received a £15 voucher. On
230 receipt, questionnaire data were transcribed and entered into Excel.

231 Analysis of questionnaire data served two related purposes: (i) to indicate areas of
232 discordance and possible explanatory factors for discordance between identical twins; and (ii)
233 to aid selection of a sub-sample of families to be contacted for follow-up interviews.

234 Families selected for interview were contacted by telephone and asked for consent to
235 participate. Times were then arranged to interview all three family members participating in
236 the study. In cases where all family members were interviewed during the same telephone
237 call they were asked not to be in the same room to ensure individual privacy. All interviews
238 were recorded and transcribed with the full consent of participants.

239

240 **Analysis**

241 All questionnaires and interview transcripts were initially coded by one researcher for
242 evidence of within-pair discordance in peer relationships. In order to establish the reliability
243 of coding, approximately 10% (50/497) of the questionnaires and 15% (15/97) of the
244 interviews were then coded independently by a second researcher. There was a good degree
245 of congruence (88% for questionnaires and 87% for interviews).

246

247 A more fine-grained approach to coding was then taken to the 112 families (23% of
248 the full sample) who had described within-pair peer discordance (85 in their questionnaires;
249 11 in interviews; and 16 in both). Full data for each of these families was charted using the
250 Framework approach (41) to order and synthesise the data through five stages:
251 familiarisation; identifying conceptual themes; indexing; charting; and mapping. The
252 Framework approach allows the sequential organisation and interpretation of qualitative data.
253 A table is created which displays cases in rows, and themes or categories in columns. Taken
254 together the rows and columns suggest explanations. The primary column in this analysis
255 related to the type of discordance described and six categories of discordance were identified.
256 In order to check inter-rater reliability a second researcher independently coded 10% of the
257 dataset into the six types of peer-relationship discordance, and 92% congruence was achieved
258 between raters. Small disagreements were discussed and minor adjustments made to the
259 coding framework. The other columns in the Framework related to perceived causes and
260 perceived consequences of the reported peer-relationship discordance.

261 MZ differences in experiences of friendship were then analysed in detail using each of
262 the Framework's categories to generate specific hypotheses about what MZ discordance in
263 peer relationships looks like in this sample (a proposed typology); and what participants saw
264 as the causes and consequences of the observed discordance. Interpretations and potential

265 hypotheses were checked against the raw data and verified via on-going discussions between
266 researchers.

267

268 **Results**

269 Six categories of peer-relationship discordance were identified in questionnaire and/or
270 interview data gathered from 112 families (See Table 1).

271

272 Table 1: A Proposed Typology of Friendship Discordance in MZ twins

Discordance Category	Number of families described
Discordant peer victimisation	15
Discordant peer rejection	7
Fewer friends	39
Different friends	23
Different attitudes to friendship	23
Dependence on co-twin	5
N 112	

273

274

275 Data for each of these categories were analysed separately. Before presenting the
 276 results of these analyses it is important to note that the data represent a series of case studies;
 277 although they can be used as the basis for testable hypotheses about peer relationships as an
 278 aspect of NSE, they do not in themselves speak to direction of effects. In this Results section
 279 all numbers in parentheses represent the number of families who reported a particular cause,
 280 correlate or consequence of the type of peer discordance being presented. Also, where
 281 diagnoses such as ADHD, eating disorders or social phobia are mentioned, they represent
 282 self-report data.

283 **Discordant peer victimisation**

284 Twins were categorised as discordant for peer victimisation when they reported one
 285 twin being affected by the *actions* of others who deliberately and actively set out to hurt
 286 them. It can be differentiated from discordant peer rejection which was the code applied

287 when one twin was affected by the *attitudes* of others, who may have ignored or disliked
288 them. Fifteen twin pairs were categorised as discordant for peer victimisation.

289 Evidence of discordant peer victimisation in this sample included name-calling,
290 cyberbullying and physical bullying which, in some cases, was persistent and very severe.
291 One example of name-calling involved a twin who had been badly scarred by meningitis:

292 *“He’s had to cope with the ... nickname “Scar Boy”.”*

293 In the most severe case of bullying the boy’s mother said:

294 *“... he was beaten up most days on the bus, [they] punched his head against the windows,
295 shouted abuse at him, chased him through the estate.”*

296 Her bullied son added:

297 *“...the police got involved because it became so bad. They’d jump me as I got off the bus,
298 there’d be about 20 of them waiting for me.”*

299 These fifteen families reported causes or sources of discordant bullying that included:
300 discordance in sexuality (2); behavioural disorders (e.g. ADHD, ASD) (3); appearance (e.g.
301 weight, skin problems) (5); other relationships (e.g being liked by a bully’s girlfriend) (2); or
302 chance (e.g. being placed in a class with bullies) (6). In general we did not include cases in
303 which both twins experienced peer victimisation. However, we did include three cases in
304 which both twins were bullied because participants reported either discordant causes or
305 consequences of the reported victimisation. For example, in the case shared above,
306 discordant responses to shared bullying led to worse attacks for one twin; this family reported
307 how the fact that he stood up to the bullies (while his brother did not) led to violence
308 escalating while the bullies left his co-twin alone.

309 In summary, in the current sample, MZ twins reported discordant experiences of peer
310 victimisation that they perceived as being based on either chance occurrences or enhanced
311 vulnerability (standing out in a way that others perceived as negative).

312 Participants reported the consequences of discordant peer victimisation as:
313 discordance in confidence (6); mental health (including eating disorders, self-harm, anxiety,
314 suicide attempts, social phobia) (6); future plans (4); and social isolation (3). In all cases the
315 victimised twin reported worse outcomes. Alongside the negative outcomes there were three
316 pairs in which a positive outcome was also acknowledged. This positive outcome was
317 usually the result of escaping from the situation rather than of the bullying *per se*. For
318 example, one bullied twin's confidence improved when he left school for college. However,
319 he still self-harmed and saw this as a result of being victimised at school. Perceived
320 consequences of victimisation were very pronounced. In one case where the bullied twin had
321 ADHD (which his mother explained with reference to twin-to-twin transfusion and perinatal
322 experiences) she said:

323 *He used to have marks on his arms and stuff from where he used to bite himself ... He didn't*
324 *like himself very much.*

325 Another mother, whose daughter had cut herself and taken an over-dose said:

326 *Twin 2 is dissatisfied with herself and would like to reinvent herself somewhere else where*
327 *her life would be more 'beautiful'.*

328 While her mother attributed her difficulties to her personality as well as her peer problems
329 her daughter said:

330 *In my comprehensive school I had an unfortunate friendship which led to some bullying. This*
331 *destroyed my confidence and relationships with other people ... my anxiety, I feel, limits my*
332 *career paths.*

333 These data suggest that peer victimisation may have NSE effects on mental health, self-
334 confidence, social isolation and future plans.

335 **Discordant peer rejection**

336 Twins were coded as discordant for peer rejection when one twin experienced feeling
337 left out, ignored or disliked by their peer group. This was evident in seven families. In one
338 case the rejection was said to be imagined:

339 *When Twin 2 was 3 years old she suffered severe hearing loss, eased by grommets. However,*
340 *having had many months of not hearing, she didn't feel she had any friends as she never*
341 *heard them when they were asking her to play. She changed from a wonderful, confident*
342 *devil-may-care child to an introvert. She now has reduced hearing from scar tissue and her*
343 *self-esteem has taken many years to recover-- she is nearly there!*

344 In most cases, however, family members agreed that one twin was in fact less
345 accepted by their peer group. All presented theories for discordant acceptance of the twins.
346 However, these causes were unsystematic and showed no clear pattern, all being mentioned
347 in only one or two cases. Suggested causes included: discordant character judgement;
348 sexuality; mental health problems (associated with school absence); protecting a vulnerable
349 co-twin; and chance.

350 In terms of perceived consequences, again there was no systematic pattern except in
351 the sense that outcomes tended to be more negative for the rejected twin. Suggested
352 outcomes included: social isolation; reduced confidence “[she] lost some of her sparkle”;
353 and changed future plans:

354 *My twin doesn't want kids or anyone in her life, she just wants to move abroad.*

355 As with victimisation, where outcomes were positive this was seen as the result of escaping
356 the situation. One case, for example, involved gender dysphoria (a disorder in which
357 individuals experience distress caused by a mismatch between their biological sex and their
358 gender identity). The twin in question, who returned to school after the summer identifying as
359 male and was subject to “snide comments”, said:

360 *I think due to the discrimination I have faced since coming out in public and mainly school, I*
361 *have become much more vulnerable and scared.*

362 However, he also said that on going to university his confidence improved. As with
363 victimisation the hypothetical causes of discordant peer rejection appear to be related to
364 chance and enhanced vulnerability, and the consequences were generally negative and serious
365 for the rejected twin. It may be possible to combine hypotheses related to peer victimisation
366 and peer rejection.

367 **Fewer friends**

368 Thirty-nine families reported one twin having fewer friends than the other. In a
369 minority of cases (7) this was considered to be a positive situation in which each twin had a
370 friendship group of a size and closeness that suited their personality and preferences. In all of
371 these cases participants cited personality and preference as the cause of discordance in peer
372 group size. However, in all other cases (32), having fewer friends was perceived as a
373 negative experience. One girl, who had missed a lot of school because of mental health
374 problems, said:

375 *I'm probably going to end up with no friends because of the panic disorder. That's something*
376 *I haven't said before. No friends, and a crap job makes for a grim future, doesn't it?*

377 When offering explanations for why one twin had fewer friends than the other, most
378 participants cited pre-existing behavioural or psychological discordance. For example, 22
379 families cited reasons related to discordant personality, confidence and self-esteem.

380 *Even as a baby, Twin 1 was always much quieter and less secure-- he never wandered off at*
381 *playgroups. Twin 2 is more easy-going.*

382 Seven families cited discordant physical or psychological health as the reason why one twin
383 had fewer friends. Differences included Attention Deficit Disorder, anxiety, autism, epilepsy
384 and scoliosis.

385 *I have scoliosis (from birth) which means I'm less flexible and less agile. I had to miss about*
386 *3 months of school in Year 10 so I missed out on lots of school trips. It also means I'm not as*
387 *good at sport because it hurts to run and jump a lot. My twin is really good at sports like*
388 *lacrosse, which I wish I could be good at I feel like she has more friends and people*
389 *prefer her.*

390 A smaller number of families cited discordant interests (1) or appearance (2).

391 The environmental hypotheses for discordant size of friendship group included:
392 chance events (e.g. having a best friend leave, being in a different class) (5); falling out with a
393 group of peers (1); and having a boyfriend (5). In all five cases where having a boyfriend
394 was cited as the reason that one twin ended up with fewer friends, participants said that the
395 twin with the boyfriend ended up being more socially isolated and, in one particularly
396 difficult case, one twin required counselling when her boyfriend committed suicide.

397 As with peer victimisation and peer rejection, having fewer friends than a co-twin was
398 generally viewed as a negative non-shared experience that was triggered by behavioural
399 discordance much more often than by discordant experience. It is important to note,
400 however, that behavioural discordance in MZ twins must have NSE roots.

401 Perceived consequences of having fewer friends that were cited by more than three
402 participants were: reduced confidence (5); future plans (8); and social isolation (10).

403 *I am ready to leave home and become more independent, something that Uni life will offer*
404 *me. My twin is happy to be in the comfort of home and a local college.*

405 *I have a lot more confidence compared to my twin, she rarely answers questions in lessons*
406 *and never goes out apart from school. She lacks self-confidence and never starts*
407 *conversations with people at parties and social gatherings. Her friendship circle tends to*
408 *change every few months and doesn't have a particularly close relationship with anyone*
409 *apart from me.*

410 These data suggest the hypothesis that being unpopular (or less popular than others)
411 may have NSE effects on outcomes including social isolation, confidence and future plans.
412 However, it is also important to note that some people prefer small, close friendship groups
413 and the data do not suggest any negative outcomes of this. On the contrary, these young
414 people were more likely to be described as confident, independent, more likely to value
415 friends and less subject to peer pressure. Popularity was not a key issue in their cases.

416 **Different friends**

417 In 23 families twins and/or parents stated that the twins had different friends, without
418 adding that one had fewer friends or that one was rejected or victimised by peers. In 17 of
419 these cases they said that the reason for the twins having different friendship groups was that,
420 at some point in their education, they had been split up and were therefore exposed to
421 different peer groups. In seven of these cases they were split up by choice because they
422 actively wanted the opportunity to be treated as individuals. For example, in one family one
423 twin:

424 *was keen to gain a little more independence and possibly to make a wider circle of friends*
425 *not shared with her sister.*

426 In eight cases they were split up by chance, in that they were allocated to different
427 classes or educational settings (e.g. a different boarding house). In the remaining two cases
428 in which twins were said to have different friends as a result of being split up, the reason for
429 the split was unspecified. In addition, two families mentioned discordant personality and
430 confidence as a reason for having different friendship groups; one mentioned discordant
431 interests; and a final family cited parental encouragement to be individuals.

432 In terms of consequences the most common discordance reported by participants as a
433 perceived result of having different friends was discordance in personality and confidence
434 (13). In general, the twin who had been more successful in making friends who were a good
435 fit for them, and with whom they could be themselves, were reported to be more confident
436 and/or outgoing than their co-twin.

437 *We have had different friendship groups which have encouraged different personalities ... My*
438 *friends and family say that my twin is more mature and I am 'crazier'. I am more self*
439 *confident.*

440 In another family in which one twin had missed a lot of school as a result of cardiac surgery
441 and other health problems, her co-twin said:

442 *Her health problems cause a lot of her stress, especially around friends as she missed a year*
443 *of school due to it, whereas I continued going to school and gained greater independence and*
444 *confidence socially.*

445 In four cases families perceived discordant interests to be an outcome of different peer groups
446 and, in a further five, discordance in future plans. For instance, one twin said:

447 *A lot of it is down to our friend differences. The people we spend time with generally*
448 *influence our behaviour somewhat. They have led to us finding our own separate interests.*

449 Finally, in three families in which one twin had made friends who were a better fit for them,
450 discordance in friendship quality and social life was reported as a perceived outcome of
451 having different friends.

452 In summary, different friendship groups were primarily seen as the natural outcome of
453 being split up and exposed to different peers. Non-shared peer groups were hypothesised to
454 explain (a causal relationship) discordance in personality, confidence, interests and friendship
455 quality. Exploring whether having different friends can explain variance in these outcomes
456 using a quantitative design is indicated.

457 **Different attitudes to friendship**

458 In 23 families participants described discordance in attitudes to friendship. These
459 families' responses were characterised by a specific focus on attitude to having and being a
460 friend, rather than the actual make-up of the peer group. In some cases the twins shared a
461 friendship group and in others they did not. Five different explanations for discordant
462 attitudes to friendship were suggested. In 11 cases participants said that one twin was more
463 willing to make an effort to socialise than the other:

464 *My twin likes to go out more than me. We both have the same 'friend group' but sometimes if*
465 *an opportunity to go out turns up then I might say no and my twin would normally say yes.*

466 In eight cases families said that one twin was motivated by a greater need for peer approval.
467 For example:

468 *Twin 1 wants to be accepted and in with the cool crowd. Twin 2 [is] more inwardly confident,*
469 *not so worried what people think of him.*

470 Five families said that discordant attitudes to friendship were driven by discordant confidence
471 (caused by earlier discordance in, for example, OCD and anorexia) and four by discordant
472 personality. Finally, two families said that discordant attitudes to friendship were triggered
473 by the twin relationship and, in particular, within-pair comparisons.

474 Discordant outcomes of these different attitudes were suggested by 16 of the 23
475 families and included: discordance in social life (6); future plans (3); study habits (3); a
476 preference for fewer, closer friends (3); personality (1); and stability of friendships (1). It
477 was interesting to note that in 18 of the 23 cases discordance in outcome was either not
478 specified (5) or was neutral in content (13). That is, neither twin was seen as having gained
479 an advantage over the other by their attitude to friendship.

480 In the remaining five cases worse outcomes were described for one twin and were
481 seen as the result of their attitude to friendship, or of the situation or behaviour that was seen
482 as underpinning their attitude to friendship. In one case the less sociable twin decided not to
483 go to university as he did not feel confident enough to leave home. In one, the more sociable
484 twin lacked focus on his studies and in another the twin who needed more peer approval was
485 less open to trying new things. One twin reported losing social confidence as a result of
486 anorexia:

487 *I think when I developed anorexia at 13 my confidence and social skills and health suffered,*
488 *and has lead us to be different types of people. My twin is how I believe I would have been if I*
489 *hadn't got anorexia.*

490 These responses support the selection hypothesis in that families reported behavioural
491 discordance as underpinning different attitudes to friendship. In most cases participants were
492 relaxed about what they saw as the ensuing discordance, feeling, in general, that it simply

493 reflected individual preferences. It was notable that the reported outcome discordance also
494 appeared to be the result of behavioural selection.

495 **Dependence on co-twin**

496 Five families described discordance in experience of peer relations in the sense that
497 one twin was dependent on the other; that is, one twin made friends and the other just ‘tagged
498 along’. In four cases this was seen as the result of discordance in personality (factors such as
499 extraversion) and in one the result of chance. In the pair where chance was cited the twins
500 had previously attended separate schools and when they came together one knew more
501 people than the other. When the twin who was new to the school tried to ‘tag along’ with her
502 sister this caused some friction. Other than this, all five families described the outcome of
503 this discordance within the twin relationship as a concern about how the dependent twin
504 would cope in Further or Higher Education when they would be split from their co-twin.
505 Hypotheses from this aspect of discordant peer relationships are not applicable beyond twins.

506 **Discussion**

507 A substantial minority (23%) of participants in this wide-ranging study spontaneously
508 described and discussed discordance in friendships and peer relationships when asked about
509 within MZ twin pair differences. Their responses suggested six categories of discordance of
510 which four (peer victimisation, peer rejection, fewer friends and different friends) can be
511 interpreted as environmental variables. The other two categories were different attitudes to
512 friendship and dependence on a co-twin, and these are more easily interpreted as behavioural
513 variables, albeit with non-shared roots and flowers. Together they suggest avenues for future
514 research into experiences of friendship as components of the non-shared environment.

515 **Discordant peer victimisation and peer rejection**

516 A recent MZ differences study identified being bullied as an NSE experience that was
517 predictive of psychiatric dysfunction for environmental (NSE) reasons (33). A minority of
518 participating families (n=22; 4.4% of the full sample) in the current study described situations
519 in which one twin was exposed to bullying or rejection by their peers. It was clear from
520 families' descriptions that they saw this discordance as the result of either chance or
521 enhanced vulnerability in one twin and that, either way, they saw the experience as being
522 linked to negative outcomes. In the current sample the types of enhanced vulnerability
523 described included: one twin being gay; coming to terms with gender dysphoria; and
524 discordance in appearance. In these cases the more vulnerable twin was described as evoking
525 more hostile or negative reactions from their peer group. This offers support to the selection
526 hypothesis but as an evocative rather than an active process. Previous research has found
527 antisocial adolescents to choose or shape antisocial peers. These case studies suggest that
528 vulnerability can evoke negative treatment. These families perceived peer victimisation and
529 rejection (which they saw as an outcome of chance or discordant vulnerability) as having a
530 causal influence on self-confidence, future plans and social isolation. Their perceptions align
531 well with Silberg et al.'s finding that being bullied exerts a negative environmental influence
532 and we suggest that this may be true even if the bullying (or rejection) is partially explained
533 by a genetically influenced phenotype (enhanced vulnerability). Knowing that a link is
534 mediated by environment to a much greater extent than by genes has implications for
535 intervention which could be relevant to clinical psychologists and educational practitioners.
536 For instance, if a screening questionnaire could identify children and young people who feel
537 isolated, or simply have fewer friends than they would like, then schools may be able
538 intervene in a way that is beneficial for the young person and enhances non-cognitive,
539 educationally-relevant traits. In addition families suggested a causal NSE relationship
540 between peer victimisation and mental health difficulties, offering further support to Silberg

541 et al's findings (33). In summary, the current data provide support for both the selection and
542 the causal hypotheses of non-shared peer relationships and suggest that peer relationships can
543 explain NSE variance in a range of outcomes. Testable hypotheses suggested by these case
544 studies are:

- 545 1. Enhanced vulnerability can explain NSE variance in peer victimisation and peer
546 rejection.
- 547 2. Peer victimisation and peer rejection can explain NSE variance in self-confidence,
548 future plans and social isolation.
- 549 3. Peer victimisation can explain NSE variance in mental health.

550 It will be possible to test these hypotheses empirically, in a longitudinal design, in the context
551 of the Twins' Early Development Study (TEDS).

552 Our study and that of Silberg et al. (33) also raise the question of whether severity of
553 experience is linked with severity of outcome (if a causal relationship can be identified). Our
554 data do not suggest that one type of peer relationship discordance is likely to explain more
555 NSE variance than another but that more serious peer problems may be more likely to explain
556 variance in more serious outcomes (e.g. diagnosed mental health problems rather than
557 undiagnosed self-confidence issues). This too can be explored in the longitudinal research
558 proposed above.

559 **Fewer friends**

560 In 32 of the 39 cases in which one twin was said to have fewer friends than the other
561 it would be reasonable to suggest that discordant popularity was being described. It is
562 important to note though that in the remaining seven cases the twin with fewer friends was
563 seen as happy, and sometimes happier, than their co-twin. In these cases the twin with fewer
564 friends felt that their peer group was a good fit for them. In the 32 cases in which one twin

565 was reported as being more popular than the other the majority of families suggested
566 discordance in factors variously described as personality, confidence and self-esteem as a
567 cause. It would be interesting to explore the antecedents of this discordance as it must
568 necessarily be explained by NSE factors. A further seven families cited health discordance –
569 a type of enhanced vulnerability which, in some cases, was linked to prolonged absence from
570 school. Chance and romantic relationships were also cited as reasons for discordant
571 popularity. In this case we can see evidence for the selection hypothesis involving both
572 active (more confident young people developed bigger friendship groups) and evocative
573 processes (ill and often absent young people attracted fewer friends).

574 As with peer rejection, discordance in popularity was said to also have a causal role
575 and, in fact, to lead to discordance in the same outcomes: self-confidence, social isolation and
576 popularity. Popularity can therefore join peer victimisation and peer rejection in hypotheses
577 1 and 2. These variables were perceived by the families in this study as being the outcomes
578 of discordant chance, behaviour and vulnerability, and the cause of discordance in outcomes.

579 **Different friends**

580 In some families participants said that the twins had different friends to each other.
581 While it is true that twins in the other categories also often had different friends, in those
582 cases families specified that one had fewer friends or was bullied or rejected. The 23 families
583 in this category only said that they had different friends, not that the relationships were
584 unequal. The vast majority (17) said that they had been split up and exposed to different
585 peers either by chance or by choice. The remaining families suggested discordance in
586 confidence, personality, interests and parental encouragement to be individuals as the reason
587 the twins had different friendship groups.

588 Families did describe perceived causal NSE effects of having different friends. In
589 particular they described discordance in confidence. This tended to be the outcome of
590 discordance in finding friends who were perceived as a good 'fit' with whom individuals felt
591 they could be themselves. Other perceived consequences included discordance in interests
592 and future plans. These data therefore suggest a testable hypothesis that:

593 4. Friendships can explain NSE variance in confidence, interests and future plans.

594 This hypothesis can also be investigated within TEDS, controlling for genetic and shared
595 environmental effects.

596 **Different attitudes to friendship and dependence on co-twin**

597 These observed categories of discordance were quite different to the others and appear
598 to represent causes or correlates of different experiences of friendship rather than describing
599 the experience *per se*. Because dependence on a co-twin is not a relevant experience for the
600 non-twin population of adolescents this category is not discussed here.

601 The different attitudes to friendship cited by families included: discordance in effort
602 to socialise; need for peer approval; confidence; personality; and reactions to the twin
603 relationship. These attitudes were seen as being associated with social life, future plans and
604 study habits. It was interesting to note though that in most cases families did not see one twin
605 as disadvantaged by their experience. In only 5 of 16 cases were outcomes presented as
606 worse for one twin than the other. In most cases families suggested that each twin had
607 accessed peer experiences that they were comfortable with and that suited them as
608 individuals. Social life and study habits could be added to hypothesis 4.

609 **Selection or causation?**

610 These data suggest evidence for both the selection and causation hypotheses of peer
611 relationships. MZ discordance in experience of peer relationships is necessarily caused by
612 NSE effects. In this study we have seen hypotheses relating to factors such as: enhanced
613 vulnerability (health, sexuality, appearance); personality or confidence; and chance. It is
614 notable that selection appeared, in the current study, to be more often mediated by evocative
615 than active processes, something that has arguably been overlooked in the field's focus on
616 antisocial behaviour and deviant peers.

617 Discordant peer relationships that favoured one twin over the other were perceived by
618 twins and their parents as having a causal relationship with discordance in self-confidence,
619 future plans, social isolation and mental health. If we can pin down the environmental
620 influences on discordant peer relationships, and both identify and understand the
621 environmental mechanisms underpinning relationships between peer problems and a range of
622 outcomes, we will enhance our ability to intervene to support those who are disadvantaged by
623 problematic relationships with their peers. Discordant peer relationships in which one twin
624 was not advantaged over the other – relationships where the peer experience was seen as
625 different in kind rather than in quality – were seen as explaining discordance in confidence,
626 interests, future plans, social life and study habits. We therefore have grounds for continuing
627 to consider both processes in genetically-informed studies of the peer relationship.

628 **Limitations**

629 We took an inductive approach in the current study. In one sense this was a strength
630 of the research as it allowed us to identify explanations that emerged spontaneously.
631 However, it remains likely that we would have received different answers had we taken a
632 more deductive approach and asked specific questions about peer relationships. For example,
633 more pairs may have provided information about their friendships had we asked for it

634 directly. They may also have been triggered to identify peer relationship discordance as part
635 of a multi-faceted explanation for behavioural discordance if asked directly. Furthermore,
636 this case study design can suggest hypotheses but cannot speak to direction of effects.

637 A further limitation, mentioned earlier, is that our sample was not representative of
638 UK adolescents. Although this does not matter for within-pair comparisons it would
639 strengthen our study if we could seek the spontaneous views of people not fully represented
640 in the data we have gathered here. On this point it is a limitation that we discovered that
641 TEDS families were less willing to provide open-response data than they are to provide the
642 closed-response data that we more typically gather. This may have biased our sample and
643 may be reflected, for instance, in the higher levels of g and SES observed in the current study
644 (compared to TEDS data more generally). It is possible that this problem applies more to
645 written than verbal responses and this is something we could explore in future qualitative
646 work.

647 The genetically informed typology of peer relationships that emerged from these data
648 does not contain anything very surprising in the sense that these aspects of peer relationships
649 have been linked with life outcomes in non-genetic literature for many years (e.g. 17). The
650 novel contribution made here is that we present a basis for empirically testing their role as
651 aspects of NSE experience, and for studying the environmental mediation of relationships
652 between peer experiences and a range of outcomes. This will help us to understand the
653 mechanisms of associations between peer relationships and outcomes, and will also help us to
654 map the non-shared environment so that it begins to emerge as a set of named experiences
655 rather than a non-specific proportion of variance. Furthermore, the current findings offer
656 support to Silberg et al.'s empirical finding (33) that bullying appears to have a causal and
657 truly environmental influence on mental illness. This matters because NSE influences are
658 likely to be particularly susceptible to well-designed interventions.

659 Finally, the results of this study are merely descriptive and, to have any impact, need
660 to be used as a basis for theory building about NSE, and taken forward to empirical testing.
661 In particular, theory that links the severity of a peer problem with the severity of outcome (if
662 prediction can be established and is environmentally mediated) may form a useful basis for
663 future studies of the origins of mental health and wellbeing.

664 **Future Research**

665 Our next step will be to take some of the hypotheses generated by this study and test
666 them using a quantitative design and a genetically-sensitive sample such as TEDS. There are
667 two approaches that can be considered here. One is to focus on experience of friendship as a
668 predictor of the range of outcomes identified in this hypothesis-generating study: self-
669 confidence; future plans; social isolation; mental health; and interests. Another would be to
670 focus on a particular outcome and explore the extent to which aspects of the friendship
671 experience can explain NSE variance in this outcome. Future plans or self-confidence
672 represent particularly interesting variables to study in this way as they were mentioned as
673 outcomes of almost all categories of friendship discordance. Equally, studying the role of
674 peer victimisation, rejection and unpopularity in explaining NSE variance in social isolation,
675 confidence and mental health could be a fruitful and beneficial line of inquiry.

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795

796 **Supporting information**

797 **S1 File. Parent and twin screening questionnaires.**

798 **S2 MZ differences screening questionnaire (parent)**

799 **S3 MZ differences screening questionnaire (twin)**

800



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Supporting Information
S2 MZ DIFFERENCES SCREENING
QUESTIONNAIRE- parent FINAL.pdf



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Supporting Information

S3 MZ DIFFERENCES SCREENING QUESTIONNAIRE

twin FINAL.pdf





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Friendship Peer MZ Diffs Table.xlsx



MZ discordance in peer relationships

1 **Do MZ twins have discordant experiences of friendship? A qualitative**
2 **hypothesis-generating MZ twin differences study**

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11 **Abstract**

12 Using a qualitative monozygotic (MZ) twin differences design we explored whether
13 adolescent MZ twins report discordant peer relationships and, if so, whether they perceive
14 them as causes, consequences or correlates of discordant behaviour. We gathered free-
15 response questionnaire data from 497 families and conducted in-depth telephone interviews
16 with 97 of them. Within this dataset n=112 families (23% of the sample) described
17 discordant peer relationships. Six categories of discordance were identified (peer
18 victimisation, peer rejection, fewer friends, different friends, different attitudes to friendship
19 and dependence on co-twin). Participants described peer relationship discordance arising as a
20 result of chance occurrences, enhanced vulnerability in one twin or discordant behaviour.
21 Consequences of discordant peer relationships were seen as discordance in self-confidence,
22 future plans, social isolation, mental health and interests. In all cases the twin with worse
23 peer experiences was seen as having a worse outcome. Specific hypotheses are presented.

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26 **Do MZ twins have discordant experiences of friendship? A**
27 **qualitative hypothesis-generating MZ twin differences study**

28 **Introduction**

29 Behavioural genetic studies have confirmed that there are both genetic and
30 environmental influences on human behaviour (1). In the majority of cases the most
31 influential environments are individual-specific, or non-shared, making us differ from those
32 we are raised with (2-4). However, non-shared environment (NSE), while recognised as a
33 major source of behavioural variation, remains poorly understood and under-explored. This
34 manuscript reports one strand of an unprecedentedly large qualitative monozygotic (MZ)
35 twin differences study which was designed to address this dearth of understanding by taking
36 an inductive approach to generating new, testable hypotheses about NSE (5). We present
37 findings related to peer relationships as one potential aspect of NSE.

38 Back in 1998 Judith Rich Harris made a case that peers are the primary agents of
39 socialisation and development, and argued that we should look to peer relationships as the
40 most likely tangible explanation of non-shared variation in personality and behaviour (6).
41 Exploring whether MZ twins have different experiences of peer relationships, and whether
42 they perceive peer-relationship discordance as related to discordant behaviour, partially
43 addresses this hypothesis. Differences between MZ twins have to be explained by NSE
44 because MZ twins share their genes and much of their upbringing. An MZ differences
45 design, based on within-pair discordance, can therefore hold constant the effects of genes and
46 many aspects of the family environment, making it possible to develop hypotheses about
47 environmentally mediated relationships between experiences and behaviour.

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48 ~~In her diary Anaïs Nin captured the non-shared (or unique) essence and effects of~~
49 ~~friendship, writing: “Each friend represents a world in us, a world possibly not born until~~
50 ~~they arrive, and it is only by this meeting that a new world is born” (7). C.S. Lewis~~
51 ~~expressed a related idea in *The Four Loves*: “In friendship ... we think we have chosen our~~
52 ~~peers. In reality a few years’ difference in the dates of our births, a few more miles between~~
53 ~~certain houses, the choice of one university instead of another ... the accident of a topic being~~
54 ~~raised or not raised at a first meeting—any of these chances might have kept us apart” (8).~~
55 ~~Friendship, Lewis claimed, is subject to the whims of fortune. But what about genetically~~
56 ~~identical individuals with the same date of birth and the same house: MZ twins brought up~~
57 ~~together?~~

58 Identifying specific NSE experiences that can explain large proportions of phenotypic
59 variance has been an unsuccessful endeavour, just as identifying single genes with large
60 effects has proven a fruitless, and now abandoned, line of inquiry (97-119). While specific
61 NSE factors have certainly been identified they, like specific genes, tend to explain only a
62 very small proportion of variance (97). This consistent pattern has given rise to a hypothesis,
63 ~~exemplified by C.S. Lewis’ comment,~~ that NSE variance is best explained by chance – by
64 unpredictable, transient experiences that affect individuals but do not generalise to groups
65 (97). This hypothesis is firmly rooted in empirical data and remains a genuine possibility,
66 although it has been described as “a gloomy prospect” (3). A case can still be made that
67 small effects might accumulate to have large outcomes (1210, 4). It also remains true that we
68 consistently find evidence of measured NSE that can explain variance in behaviour – just not
69 very much of it, typically 1-5% (e.g. 1311,1412).

70 Two further hypotheses (other than all NSE variance being explained by chance) have
71 emerged in the literature: (1) that measurable NSE experiences are most likely to have causal
72 effects such that differences in experience will explain differences in behaviour (3,4); and (2)

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73 that apparently NSE experiences are most likely to be the outcome of selection effects such
74 that differences in behaviour will explain differences in experience (~~1412-1614~~).

75 Judith Rich Harris' thesis in *The Nurture Assumption* (6) met with a substantial
76 backlash (~~1715,1816~~). However, criticism was not targeted at her argument that peers are
77 important, but rather at her argument that parents aren't. Harris was accused, with some
78 justification, of throwing the baby out with the bathwater. However, the peers hypothesis
79 was accepted without demur, most likely because it was a good fit with people's intuitions
80 and experience as well as with empirical evidence. In addition to behavioural genetic
81 evidence pointing to the substantial importance of the NSE there is a large body of research
82 that suggests the importance of peers to healthy development, particularly in adolescence →
83 a time when exposure to peers is often very high (~~1917,2018~~). What is surprising is that
84 Harris' hypothesis that peer relationships should explain a substantial proportion of NSE
85 variance has not been subjected to a great deal of empirical testing.

86 That said, there has been some good research in this area and studies have yielded
87 support for peers as an agent of NSE or, at least, a genuinely environmental variable. For
88 instance, several studies have found variation in aspects of peer relationships to be primarily
89 non-shared in origin. In one study which used two independent samples – one of adoptive
90 and non-adoptive siblings and another of mixed sibling types (including twins) – 70-80% of
91 the total variance in self-reported peer group delinquency was explained by NSE effects
92 (~~2119~~). These findings were later replicated with teacher- and observer-report data, offering
93 strong empirical support for Harris' theory that peer relationships represent a truly
94 environmental influence (~~2220~~). The same study also found peer group popularity to be
95 substantially explained by NSE factors, albeit with some genetic influence (~~2119~~). Peer
96 group college orientation, however, was found to be moderately heritable, with

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97 approximately half of the variance explained by genetic factors – a finding also reported
98 elsewhere (2321).

99 It should be noted that Manke et al. also found parent-reported peer group
100 delinquency and popularity to be moderately to strongly heritable. Other studies have
101 observed the same pattern of small to moderate heritability for peer group delinquency (2422-
102 2725). Manke et al. (2321) also used a ‘best friends’ measure in which positive and negative
103 dimensions of friendship were defined. The researchers found the positive dimension to be
104 moderately heritable ($h^2=.31$) but the negative dimension to be primarily explained by NSE
105 effects. Other studies have noted evidence of genotype correlation as an explanation of, for
106 instance, the association between peer victimization and physical ill health (26) and the
107 association between peer aggression and aggressive behaviour (27). In summary, the picture
108 is somewhat unclear but it is true to say that all studies find NSE effects on factors to explain
109 variation in peer discordance relationships. The differences between the studies are of degree,
110 and of whether significant genetic effects are also observed.

111 Studies have found that discordant friendships in adolescence can account for NSE
112 variance in externalising behaviour (2828,2929), aspirations (3030) and adult self-reported
113 life satisfaction and relationship quality (3431), lending some support to the causation
114 hypothesis. Most recently, discordant peer victimization was found to account for NSE
115 variation in daily cortisol secretions, along with discordance in the mother-child relationship
116 (32). However, most of these studies – not including Marion et al. (3431) – have tended to
117 rely on cross-sectional correlational designs in which the direction of effects remains unclear.
118 It has therefore been convincingly argued that assumptions of causality – of NSE influence
119 rather than NSE selection – are premature because the direction of causation could be in
120 either or both directions (4412). However, a recent longitudinal study presented findings
121 which indicate that being bullied is predictive of mental illness and, using an MZ differences

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122 model, found that the association was mediated environmentally (3233). This suggests that
123 very severe peer relationship problems may act as genuinely environmental influences on
124 mental health outcomes.

125 The vast majority of research in this area has focused on the relationship between
126 antisocial behaviour and deviant peer affiliation – the ‘wrong crowd’ hypothesis (2828,4412).
127 By contrast, in this more developed area of genetically-informed peer research, support for
128 the NSE ‘selection’ hypothesis has been clear. For instance, Burt and colleagues (4412) used
129 a longitudinal cross-lagged MZ differences design to look at the relationship between
130 externalising behaviour and deviant peer affiliation at ages 14 and 17. The study found
131 moderate to strong cross-sectional associations but, longitudinally, it showed that MZ
132 discordance in externalising behaviour at age 14 predicted MZ discordance in deviant peer
133 affiliation at age 17, but not the other way around. The finding was consistent with an earlier
134 study (4513) and provides strong support for the selection hypothesis. It appears, from
135 studies such as these, that an identical twin displaying higher levels of externalising
136 behaviour at one time point is more likely to have chosen or shaped worse behaved peers,
137 relative to their co-twin, at a second time point. However, it is important to note that this still
138 leaves the discordant externalising behaviour at the first time point to be explained by NSE
139 factors. The focus on deviant peer affiliation as a candidate NSE factor has led to some
140 imbalance in the field as it represents just one aspect of peer relationships, albeit an important
141 one. A full typology of peer relationships is needed and could be useful to researchers
142 attempting to map the non-shared environment. Peer relationship discordance in MZ twins is
143 particularly notable as MZ twins have been found both in early childhood (3334) and
144 adolescence (3435) to share more of their friends with one another than DZ twins
145 (3536,3637).

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146 The current study represents one strand of a larger qualitative hypothesis-generating
147 MZ twin differences study in which adolescent MZ twins (and a parent) were asked to
148 describe and explain differences between them in academic achievement, plans for the future
149 and their lives and experiences more generally. We did not ask participants directly about
150 peer relationships because a primary purpose of the study was for families to tell us their
151 theories of discordance spontaneously. Instead, we waited to see whether, in line with Judith
152 Rich Harris' 1998 claim:

- 153 (1) families would describe discordant peer relationships and, if so,
154 (2) whether they would interpret them as causes (causal hypothesis), consequences
155 (selection hypothesis) or simply correlates of discordant behaviour.

156 **Materials and methods**

157 This study was approved by the Institute of Psychiatry Ethics Committee (PNM/11/12-142).

158 **Participants**

159 We recruited a sub-sample of the UK Twins' Early Development Study (TEDS), a
160 longitudinal study of twins born in the UK between 1994 and 1996 ([3738](#)). Participants were
161 recruited for this study in October 2012 and questionnaire data were gathered between
162 October and December 2012. Discordant pairs were then identified for follow-up interviews
163 which were conducted between February 2013 and February 2014. The TEDS sample has
164 been found to be reasonably representative of the UK population of same-age adolescents and
165 their parents ([3839](#)). For the current qualitative study 2,162 TEDS families with MZ twins
166 were invited to take part and, of those, we received data from 497, a response rate of 23%.
167 This was lower than hoped, which may reflect sample selectivity. The relatively increased
168 proportion of girls in the current sample (from c.50% at first contact to 61%) is representative

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169 of TEDS at 16, although not of wider UK society. This significant discrepancy may be the
170 result of greater willingness to engage with data collection among girls than boys at this age
171 and stage. The current sample was also significantly higher in terms of SES ($M=0.31$,
172 compared to 0.00 at first contact and 0.1 at age 16) and g (general cognitive ability: measured
173 at age 12; $M=0.11$, compared to 0.00). All group mean differences were assessed with t-
174 tests. TEDS families have been studied throughout their lives but this was the first occasion
175 on which we had asked a sample of them to provide free-response data. There are indications
176 that the approach was off-putting to some, potentially leading to a slightly biased sample.
177 Although this does not matter in one sense, because our interest was in within-pair not
178 between-family differences, it is important to bear the evidence of sample selectivity in mind.
179 It remains possible that NSE influences are different for families in different circumstances.

180 Free-response questionnaire data were gathered from the $n=497$ participating families
181 with identical twins (61% female). Zygosity was confirmed using DNA for 84%
182 (questionnaire data) and 85% (interview data) of participants. In the remaining cases
183 zygosity was assigned via a questionnaire that has been found to be 95% accurate in the
184 TEDS sample (3940).

185 Three questionnaires were posted to each family and, in most cases, we received self-
186 report data from a parent (usually mother) and both twins. The twins' average age was 17.3
187 (range 16.2–18.9). After analysis of the questionnaires, telephone interviews were conducted
188 with 97 families (both twins and one parent in most cases) who were selected because the
189 twins reportedly showed strong signs of discordance in one or more aspects of achievement,
190 behaviour or experience, suggesting NSE influence. In the course of the interviews and
191 questionnaires $n=112$ families spontaneously mentioned discordant experiences of peer
192 relationships and these 112 families are the subject of the current study. ~~The current study,~~
193 ~~therefore, drew upon both questionnaire and interview data.~~ To clarify, the sample included

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194 pairs who were not invited to take part in a telephone interview as well as those that were.
195 Families were included in the current study if they spontaneously referred to discordance in
196 peer relationships in either their questionnaire responses or during a telephone interview.

197 Peer-discardance was ~~often~~usually described spontaneously in relation to another area of
198 discordance, rather than in response to a direct question.

199 **Measures**

200 New measures were developed for the current study and, other than information
201 regarding zygosity and gender, existing TEDS data were not used. We took an inductive
202 approach that was not rooted in previously gathered data. A 5-item screening questionnaire
203 was designed to identify potential sources of discordance between identical twins towards the
204 end of compulsory education. The first item asked whether twins performed differently in
205 their General Certificates of Secondary Education (GCSEs) overall and, if so, what the
206 differences were and how they might be explained. GCSEs are the public examinations taken
207 by most UK students at the end of the academic year in which they turn 16. Most students
208 take GCSEs in a broad range of academic subjects typically including English, Maths,
209 Science, Humanities, Arts and, often, Languages. The second item focused on discordance in
210 core GCSE subjects – English, Maths and Science – and asked whether there was a difference
211 of at least two grades (e.g. A*/B or D/F) and how such discordance might be explained. The
212 third question asked about discordance in next steps after GCSEs, namely whether students
213 planned to pursue traditional academic qualifications (A Levels), vocational qualifications or
214 work-based opportunities such as apprenticeships. The fourth item focused on discordance in
215 hopes for the future and the fifth was a catch-all item: *What are the major differences (not*
216 *already described) that you notice between Twin 1 and Twin 2, and how do you explain these*
217 *differences?* Before sending the questionnaire to study participants we conducted a

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218 feasibility test with a small convenience sample of sixteen year olds in order to ensure that
219 the items were suitable and clear for the age group. Small changes were made on the basis of
220 this feasibility study. Data for the current study were drawn from answers to all items; that
221 is, we noted evidence and discussion of peer discordance wherever it was spontaneously
222 mentioned by twins or their parents. All items were open-ended as the aim was to ask
223 families for their hypotheses about perceived discordance in a way that would not be leading.

224 Telephone interviews with twins and their parents were conducted by two
225 experienced interviewers. Because of the hypothesis-generating nature of this study bespoke
226 interview guides were drawn up by the researchers for each participant, focusing on the
227 differences and explanations identified in the questionnaire. Researchers read the completed
228 free-response questionnaires provided by each family selected for interview on the grounds of
229 discordance (in a range of behaviours and experiences). They then documented all reasons
230 offered by each member of the family to explain this discordance and turned the explanations
231 into questions followed by a series of relevant probes. This formed a semi-structured
232 interview schedule that differed by family. Also, when potential hypotheses were suggested
233 in the interviews that had not been mentioned previously, interviewers probed for a full
234 account of each participant's view. This flexible approach was taken so that participants
235 could give a full account of their beliefs about why one twin differed from the other,
236 unrestricted by closed or standardised questions. Evidence and discussion of discordant
237 experiences of friendship was documented as it arose.

238

239 **Procedure**

240 Families invited to participate in the study received an information letter, consent
241 form and three questionnaires – one for a parent and two for the twins. Separate envelopes
242 for each participant were included so that individuals would be able to keep their responses

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243 private. Families returning completed sets of questionnaires received a £15 voucher. On
244 receipt, questionnaire data were transcribed and entered into Excel.

245 Analysis of questionnaire data served two related purposes: (i) to indicate areas of
246 discordance and possible explanatory factors for discordance between identical twins; and (ii)
247 to aid selection of a sub-sample of families to be contacted for follow-up interviews.

248 Families selected for interview were contacted by telephone and asked for consent to
249 participate. Times were then arranged to interview all three family members participating in
250 the study. In cases where all family members were interviewed during the same telephone
251 call they were asked not to be in the same room to ensure individual privacy. All interviews
252 were recorded and transcribed with the full consent of participants.

253

254 **Analysis**

255 All questionnaires and interview transcripts were initially coded by one researcher for
256 evidence of within-pair discordance in peer relationships. In order to establish the reliability
257 of coding, approximately 10% (50/497) of the questionnaires and 15% (15/97) of the
258 interviews were then coded independently by a second researcher. There was a good degree
259 of congruence (88% for questionnaires and 87% for interviews).

260

261 A more fine-grained approach to coding was then taken to the 112 families (23% of
262 the full sample) who had described within-pair peer discordance (85 in their questionnaires;
263 11 in interviews; and 16 in both). Full data for each of these families was charted using the

264 Framework approach (4041) to order and synthesise the data through five stages:

265 familiarisation; identifying conceptual themes; indexing; charting; and mapping. The

266 Framework approach allows the sequential organisation and interpretation of qualitative data.

267 A table is created which displays cases in rows, and themes or categories in columns. Taken

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268 together the rows and columns suggest explanations. The primary column in this analysis
269 related to the type of discordance described and six categories of discordance were identified.
270 In order to check inter-rater reliability a second researcher independently coded 10% of the
271 dataset into the six types of peer-relationship discordance, and 92% congruence was achieved
272 between raters. Small disagreements were discussed and minor adjustments made to the
273 coding framework. The other columns in the Framework related to perceived causes and
274 perceived consequences of the reported peer-relationship discordance.

275 MZ differences in experiences of friendship were then analysed in detail using each of
276 the Framework's categories to generate specific hypotheses about what MZ discordance in
277 peer relationships looks like in this sample (a proposed typology); and what participants saw
278 as the causes and consequences of the observed discordance. Interpretations and potential
279 hypotheses were checked against the raw data and verified via on-going discussions between
280 researchers.

281

282 **Results**

283 Six categories of peer-relationship discordance were identified in questionnaire and/or
284 interview data gathered from 112 families (See Table 1).

285

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286 Table 1: A Proposed Typology of Friendship Discordance in MZ twins

Discordance Category	Number of families described
Discordant peer victimisation	15
Discordant peer rejection	7
Fewer friends	39
Different friends	23
Different attitudes to friendship	23
Dependence on co-twin	5
N 112	

287

288

289 Data for each of these categories were analysed separately. Before presenting the
290 results of these analyses it is important to note that the data represent a series of case studies;
291 although they can be used as the basis for testable hypotheses about peer relationships as an
292 aspect of NSE, they do not in themselves speak to direction of effects. In this Results section
293 all numbers in parentheses represent the number of families who reported a particular cause,
294 correlate or consequence of the type of peer discordance being presented. Also, where
295 diagnoses such as ADHD, eating disorders or social phobia are mentioned, they represent
296 self-report data.

297 **Discordant peer victimisation**

298 Twins were categorised as discordant for peer victimisation when they reported one
299 twin being affected by the *actions* of others who deliberately and actively set out to hurt
300 them. It can be differentiated from discordant peer rejection which was the code applied

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301 when one twin was affected by the *attitudes* of others, who may have ignored or disliked
302 them. Fifteen twin pairs were categorised as discordant for peer victimisation.

303 Evidence of discordant peer victimisation in this sample included name-calling,
304 cyberbullying and physical bullying which, in some cases, was persistent and very severe.
305 One example of name-calling involved a twin who had been badly scarred by meningitis:

306 *“He’s had to cope with the ... nickname “Scar Boy”.”*

307 In the most severe case of bullying the boy’s mother said:

308 *“... he was beaten up most days on the bus, [they] punched his head against the windows,*
309 *shouted abuse at him, chased him through the estate.”*

310 Her bullied son added:

311 *“...the police got involved because it became so bad. They’d jump me as I got off the bus,*
312 *there’d be about 20 of them waiting for me.”*

313 These fifteen families reported causes or sources of discordant bullying that included:
314 discordance in sexuality (2); behavioural disorders (e.g. ADHD, ASD) (3); appearance (e.g.
315 weight, skin problems) (5); other relationships (e.g being liked by a bully’s girlfriend) (2); or
316 chance (e.g. being placed in a class with bullies) (6). In general we did not include cases in
317 which both twins experienced peer victimisation. However, we did include three cases in
318 which both twins were bullied because participants reported either discordant causes or
319 consequences of the reported victimisation. For example, in the case shared above,
320 discordant responses to shared bullying led to worse attacks for one twin; this family reported
321 how the fact that he stood up to the bullies (while his brother did not) led to violence
322 escalating while the bullies left his co-twin alone.

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323 In summary, in the current sample, MZ twins reported discordant experiences of peer
324 victimisation that they perceived as being based on either chance occurrences or enhanced
325 vulnerability (standing out in a way that others perceived as negative).

326 Participants reported the consequences of discordant peer victimisation as:
327 discordance in confidence (6); mental health (including eating disorders, self-harm, anxiety,
328 suicide attempts, social phobia) (6); future plans (4); and social isolation (3). In all cases the
329 victimised twin reported worse outcomes. Alongside the negative outcomes there were three
330 pairs in which a positive outcome was also acknowledged. This positive outcome was
331 usually the result of escaping from the situation rather than of the bullying *per se*. For
332 example, one bullied twin's confidence improved when he left school for college. However,
333 he still self-harmed and saw this as a result of being victimised at school. Perceived
334 consequences of victimisation were very pronounced. In one case where the bullied twin had
335 ADHD (which his mother explained with reference to twin-to-twin transfusion and perinatal
336 experiences) she said:

337 *He used to have marks on his arms and stuff from where he used to bite himself ... He didn't*
338 *like himself very much.*

339 Another mother, whose daughter had cut herself and taken an over-dose said:

340 *Twin 2 is dissatisfied with herself and would like to reinvent herself somewhere else where*
341 *her life would be more 'beautiful'.*

342 While her mother attributed her difficulties to her personality as well as her peer problems
343 her daughter said:

344 *In my comprehensive school I had an unfortunate friendship which led to some bullying. This*
345 *destroyed my confidence and relationships with other people ... my anxiety, I feel, limits my*
346 *career paths.*

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347 These data suggest that peer victimisation may have NSE effects on mental health, self-
348 confidence, social isolation and future plans.

349 **Discordant peer rejection**

350 Twins were coded as discordant for peer rejection when one twin experienced feeling
351 left out, ignored or disliked by their peer group. This was evident in seven families. In one
352 case the rejection was said to be imagined:

353 *When Twin 2 was 3 years old she suffered severe hearing loss, eased by grommets. However,*
354 *having had many months of not hearing, she didn't feel she had any friends as she never*
355 *heard them when they were asking her to play. She changed from a wonderful, confident*
356 *devil-may-care child to an introvert. She now has reduced hearing from scar tissue and her*
357 *self-esteem has taken many years to recover-- she is nearly there!*

358 In most cases, however, family members agreed that one twin was in fact less
359 accepted by their peer group. All presented theories for discordant acceptance of the twins.
360 However, these causes were unsystematic and showed no clear pattern, all being mentioned
361 in only one or two cases. Suggested causes included: discordant character judgement;
362 sexuality; mental health problems (associated with school absence); protecting a vulnerable
363 co-twin; and chance.

364 In terms of perceived consequences, again there was no systematic pattern except in
365 the sense that outcomes tended to be more negative for the rejected twin. Suggested
366 outcomes included: social isolation; reduced confidence “[she] lost some of her sparkle”;
367 and changed future plans:

368 *My twin doesn't want kids or anyone in her life, she just wants to move abroad.*

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369 As with victimisation, where outcomes were positive this was seen as the result of escaping
370 the situation. One case, for example, involved gender dysphoria (a disorder in which
371 individuals experience distress caused by a mismatch between their biological sex and their
372 gender identity). The twin in question, who returned to school after the summer identifying as
373 male and was subject to “snide comments”, said:

374 *I think due to the discrimination I have faced since coming out in public and mainly school, I*
375 *have become much more vulnerable and scared.*

376 However, he also said that on going to university his confidence improved. As with
377 victimisation the hypothetical causes of discordant peer rejection appear to be related to
378 chance and enhanced vulnerability, and the consequences were generally negative and serious
379 for the rejected twin. It may be possible to combine hypotheses related to peer victimisation
380 and peer rejection.

381 **Fewer friends**

382 Thirty-nine families reported one twin having fewer friends than the other. In a
383 minority of cases (7) this was considered to be a positive situation in which each twin had a
384 friendship group of a size and closeness that suited their personality and preferences. In all of
385 these cases participants cited personality and preference as the cause of discordance in peer
386 group size. However, in all other cases (32), having fewer friends was perceived as a
387 negative experience. One girl, who had missed a lot of school because of mental health
388 problems, said:

389 *I'm probably going to end up with no friends because of the panic disorder. That's something*
390 *I haven't said before. No friends, and a crap job makes for a grim future, doesn't it?*

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391 When offering explanations for why one twin had fewer friends than the other, most
392 participants cited pre-existing behavioural or psychological discordance. For example, 22
393 families cited reasons related to discordant personality, confidence and self-esteem.

394 *Even as a baby, Twin 1 was always much quieter and less secure-- he never wandered off at*
395 *playgroups. Twin 2 is more easy-going.*

396 Seven families cited discordant physical or psychological health as the reason why one twin
397 had fewer friends. Differences included Attention Deficit Disorder, anxiety, autism, epilepsy
398 and scoliosis.

399 *I have scoliosis (from birth) which means I'm less flexible and less agile. I had to miss about*
400 *3 months of school in Year 10 so I missed out on lots of school trips. It also means I'm not as*
401 *good at sport because it hurts to run and jump a lot. My twin is really good at sports like*
402 *lacrosse, which I wish I could be good at I feel like she has more friends and people*
403 *prefer her.*

404 A smaller number of families cited discordant interests (1) or appearance (2).

405 The environmental hypotheses for discordant size of friendship group included:
406 chance events (e.g. having a best friend leave, being in a different class) (5); falling out with a
407 group of peers (1); and having a boyfriend (5). In all five cases where having a boyfriend
408 was cited as the reason that one twin ended up with fewer friends, participants said that the
409 twin with the boyfriend ended up being more socially isolated and, in one particularly
410 difficult case, one twin required counselling when her boyfriend committed suicide.

411 As with peer victimisation and peer rejection, having fewer friends than a co-twin was
412 generally viewed as a negative non-shared experience that was triggered by behavioural
413 discordance much more often than by discordant experience. It is important to note,
414 however, that behavioural discordance in MZ twins must have NSE roots.

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415 Perceived consequences of having fewer friends that were cited by more than three
416 participants were: reduced confidence (5); future plans (8); and social isolation (10).

417 *I am ready to leave home and become more independent, something that Uni life will offer*
418 *me. My twin is happy to be in the comfort of home and a local college.*

419 *I have a lot more confidence compared to my twin, she rarely answers questions in lessons*
420 *and never goes out apart from school. She lacks self-confidence and never starts*
421 *conversations with people at parties and social gatherings. Her friendship circle tends to*
422 *change every few months and doesn't have a particularly close relationship with anyone*
423 *apart from me.*

424 These data suggest the hypothesis that being unpopular (or less popular than others)
425 may have NSE effects on outcomes including social isolation, confidence and future plans.
426 However, it is also important to note that some people prefer small, close friendship groups
427 and the data do not suggest any negative outcomes of this. On the contrary, these young
428 people were more likely to be described as confident, independent, more likely to value
429 friends and less subject to peer pressure. Popularity was not a key issue in their cases.

430 **Different friends**

431 In 23 families twins and/or parents stated that the twins had different friends, without
432 adding that one had fewer friends or that one was rejected or victimised by peers. In 17 of
433 these cases they said that the reason for the twins having different friendship groups was that,
434 at some point in their education, they had been split up and were therefore exposed to
435 different peer groups. In seven of these cases they were split up by choice because they
436 actively wanted the opportunity to be treated as individuals. For example, in one family one
437 twin:

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438 *was keen to gain a little more independence and possibly to make a wider circle of friends*
439 *not shared with her sister.*

440 In eight cases they were split up by chance, in that they were allocated to different
441 classes or educational settings (e.g. a different boarding house). In the remaining two cases
442 in which twins were said to have different friends as a result of being split up, the reason for
443 the split was unspecified. In addition, two families mentioned discordant personality and
444 confidence as a reason for having different friendship groups; one mentioned discordant
445 interests; and a final family cited parental encouragement to be individuals.

446 In terms of consequences the most common discordance reported by participants as a
447 perceived result of having different friends was discordance in personality and confidence
448 (13). In general, the twin who had been more successful in making friends who were a good
449 fit for them, and with whom they could be themselves, were reported to be more confident
450 and/or outgoing than their co-twin.

451 *We have had different friendship groups which have encouraged different personalities ... My*
452 *friends and family say that my twin is more mature and I am 'crazier'. I am more self*
453 *confident.*

454 In another family in which one twin had missed a lot of school as a result of cardiac surgery
455 and other health problems, her co-twin said:

456 *Her health problems cause a lot of her stress, especially around friends as she missed a year*
457 *of school due to it, whereas I continued going to school and gained greater independence and*
458 *confidence socially.*

459 In four cases families perceived discordant interests to be an outcome of different peer groups
460 and, in a further five, discordance in future plans. For instance, one twin said:

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461 *A lot of it is down to our friend differences. The people we spend time with generally*
462 *influence our behaviour somewhat. They have led to us finding our own separate interests.*

463 Finally, in three families in which one twin had made friends who were a better fit for them,
464 discordance in friendship quality and social life was reported as a perceived outcome of
465 having different friends.

466 In summary, different friendship groups were primarily seen as the natural outcome of
467 being split up and exposed to different peers. Non-shared peer groups were hypothesised to
468 explain (a causal relationship) discordance in personality, confidence, interests and friendship
469 quality. Exploring whether having different friends can explain variance in these outcomes
470 using a quantitative design is indicated.

471 **Different attitudes to friendship**

472 In 23 families participants described discordance in attitudes to friendship. These
473 families' responses were characterised by a specific focus on attitude to having and being a
474 friend, rather than the actual make-up of the peer group. In some cases the twins shared a
475 friendship group and in others they did not. Five different explanations for discordant
476 attitudes to friendship were suggested. In 11 cases participants said that one twin was more
477 willing to make an effort to socialise than the other:

478 *My twin likes to go out more than me. We both have the same 'friend group' but sometimes if*
479 *an opportunity to go out turns up then I might say no and my twin would normally say yes.*

480 In eight cases families said that one twin was motivated by a greater need for peer approval.

481 For example:

482 *Twin 1 wants to be accepted and in with the cool crowd. Twin 2 [is] more inwardly confident,*
483 *not so worried what people think of him.*

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484 Five families said that discordant attitudes to friendship were driven by discordant confidence
485 (caused by earlier discordance in, for example, OCD and anorexia) and four by discordant
486 personality. Finally, two families said that discordant attitudes to friendship were triggered
487 by the twin relationship and, in particular, within-pair comparisons.

488 Discordant outcomes of these different attitudes were suggested by 16 of the 23
489 families and included: discordance in social life (6); future plans (3); study habits (3); a
490 preference for fewer, closer friends (3); personality (1); and stability of friendships (1). It
491 was interesting to note that in 18 of the 23 cases discordance in outcome was either not
492 specified (5) or was neutral in content (13). That is, neither twin was seen as having gained
493 an advantage over the other by their attitude to friendship.

494 In the remaining five cases worse outcomes were described for one twin and were
495 seen as the result of their attitude to friendship, or of the situation or behaviour that was seen
496 as underpinning their attitude to friendship. In one case the less sociable twin decided not to
497 go to university as he did not feel confident enough to leave home. In one, the more sociable
498 twin lacked focus on his studies and in another the twin who needed more peer approval was
499 less open to trying new things. One twin reported losing social confidence as a result of
500 anorexia:

501 *I think when I developed anorexia at 13 my confidence and social skills and health suffered,*
502 *and has lead us to be different types of people. My twin is how I believe I would have been if I*
503 *hadn't got anorexia.*

504 These responses support the selection hypothesis in that families reported behavioural
505 discordance as underpinning different attitudes to friendship. In most cases participants were
506 relaxed about what they saw as the ensuing discordance, feeling, in general, that it simply

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507 reflected individual preferences. It was notable that the reported outcome discordance also
508 appeared to be the result of behavioural selection.

509 **Dependence on co-twin**

510 Five families described discordance in experience of peer relations in the sense that
511 one twin was dependent on the other; that is, one twin made friends and the other just ‘tagged
512 along’. In four cases this was seen as the result of discordance in personality (factors such as
513 extraversion) and in one the result of chance. In the pair where chance was cited the twins
514 had previously attended separate schools and when they came together one knew more
515 people than the other. When the twin who was new to the school tried to ‘tag along’ with her
516 sister this caused some friction. Other than this, all five families described the outcome of
517 this discordance within the twin relationship as a concern about how the dependent twin
518 would cope in Further or Higher Education when they would be split from their co-twin.
519 Hypotheses from this aspect of discordant peer relationships are not applicable beyond twins.

520 **Discussion**

521 A substantial minority (23%) of participants in this wide-ranging study spontaneously
522 described and discussed discordance in friendships and peer relationships when asked about
523 within MZ twin pair differences. Their responses suggested six categories of discordance of
524 which four (peer victimisation, peer rejection, fewer friends and different friends) can be
525 interpreted as environmental variables. The other two categories were different attitudes to
526 friendship and dependence on a co-twin, and these are more easily interpreted as behavioural
527 variables, albeit with non-shared roots and flowers. Together they suggest avenues for future
528 research into experiences of friendship as components of the non-shared environment.

529 **Discordant peer victimisation and peer rejection**

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530 A recent MZ differences study identified being bullied as an NSE experience that was
531 predictive of psychiatric dysfunction for environmental (NSE) reasons (3233). A minority of
532 participating families (n=22; 4.4% of the full sample) in the current study described situations
533 in which one twin was exposed to bullying or rejection by their peers. It was clear from
534 families' descriptions that they saw this discordance as the result of either chance or
535 enhanced vulnerability in one twin and that, either way, they saw the experience as being
536 linked to negative outcomes. In the current sample the types of enhanced vulnerability
537 described included: one twin being gay; -coming to terms with gender dysphoria; and
538 discordance in appearance. In these cases the more vulnerable twin was described as evoking
539 more hostile or negative reactions from their peer group. This offers support to the selection
540 hypothesis but as an evocative rather than an active process. Previous research has found
541 antisocial adolescents to choose or shape antisocial peers. These case studies suggest that
542 vulnerability can evoke negative treatment. These families perceived peer victimisation and
543 rejection (which they saw as an outcome of chance or discordant vulnerability) as having a
544 causal influence on self-confidence, future plans and social isolation. Their perceptions align
545 well with Silberg et al.'s finding that being bullied exerts a negative environmental influence
546 and we suggest that this may be true even if the bullying (or rejection) is partially explained
547 by a genetically influenced phenotype (enhanced vulnerability). Knowing that a link is
548 mediated by environment to a much greater extent than by genes has implications for
549 intervention which could be relevant to clinical psychologists and educational practitioners.
550 For instance, if a screening questionnaire could identify children and young people who feel
551 isolated, or simply have fewer friends than they would like, then schools may be able
552 intervene in a way that is beneficial for the young person and enhances non-cognitive,
553 educationally-relevant traits. In addition families suggested a causal NSE relationship
554 between peer victimisation and mental health difficulties, offering further support to Silberg

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555 et al's findings (3233). In summary, the current data provide support for both the selection
556 and the causal hypotheses of non-shared peer relationships and suggest that peer relationships
557 can explain NSE variance in a range of outcomes. Testable hypotheses suggested by these
558 case studies are:

- 559 1. Enhanced vulnerability can explain NSE variance in peer victimisation and peer
560 rejection.
- 561 2. Peer victimisation and peer rejection can explain NSE variance in self-confidence,
562 future plans and social isolation.
- 563 3. Peer victimisation can explain NSE variance in mental health.

564 It will be possible to test these hypotheses empirically, in a longitudinal design, in the context
565 of the Twins' Early Development Study (TEDS).

566 Our study and that of Silberg et al. (3233) also raise the question of whether severity
567 of experience is linked with severity of outcome (if a causal relationship can be identified).
568 Our data do not suggest that one type of peer relationship discordance is likely to explain
569 more NSE variance than another but that more serious peer problems may be more likely to
570 explain variance in more serious outcomes (e.g. diagnosed mental health problems rather than
571 undiagnosed self-confidence issues). This too can be explored in the longitudinal research
572 proposed above.

573 **Fewer friends**

574 In 32 of the 39 cases in which one twin was said to have fewer friends than the other
575 it would be reasonable to suggest that discordant popularity was being described. It is
576 important to note though that in the remaining seven cases the twin with fewer friends was
577 seen as happy, and sometimes happier, than their co-twin. In these cases the twin with fewer
578 friends felt that their peer group was a good fit for them. In the 32 cases in which one twin

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579 was reported as being more popular than the other the majority of families suggested
580 discordance in factors variously described as personality, confidence and self-esteem as a
581 cause. It would be interesting to explore the antecedents of this discordance as it must
582 necessarily be explained by NSE effects factors. A further seven families cited health
583 discordance – a type of enhanced vulnerability which, in some cases, was linked to
584 prolonged absence from school. Chance and romantic relationships were also cited as
585 reasons for discordant popularity. In this case we can see evidence for the selection
586 hypothesis involving both active (more confident young people developed bigger friendship
587 groups) and evocative processes (ill and often absent young people attracted fewer friends).

588 As with peer rejection, discordance in popularity was said to also have a causal role
589 and, in fact, to lead to discordance in the same outcomes: self-confidence, social isolation and
590 popularity. Popularity can therefore join peer victimisation and peer rejection in hypotheses
591 1 and 2. These variables were perceived by the families in this study as being the outcomes
592 of discordant chance, behaviour and vulnerability, and the cause of discordance in outcomes.

593 **Different friends**

594 In some families participants said that the twins had different friends to each other.
595 While it is true that twins in the other categories also often had different friends, in those
596 cases families specified that one had fewer friends or was bullied or rejected. The 23 families
597 in this category only said that they had different friends, not that the relationships were
598 unequal. The vast majority (17) said that they had been split up and exposed to different
599 peers either by chance or by choice. The remaining families suggested discordance in
600 confidence, personality, interests and parental encouragement to be individuals as the reason
601 the twins had different friendship groups.

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602 Families did describe perceived causal NSE effects of having different friends. In
603 particular they described discordance in confidence. This tended to be the outcome of
604 discordance in finding friends who were perceived as a good ‘fit’ with whom individuals felt
605 they could be themselves. Other perceived consequences included discordance in interests
606 and future plans. These data therefore suggest a testable hypothesis that:

607 4. Friendships can explain NSE variance in confidence, interests and future plans.

608 This hypothesis can also be investigated within TEDS, controlling for genetic and shared
609 environmental effects.

610 **Different attitudes to friendship and dependence on co-twin**

611 These observed categories of discordance were quite different to the others and appear
612 to represent causes or correlates of different experiences of friendship rather than describing
613 the experience *per se*. Because dependence on a co-twin is not a relevant experience for the
614 non-twin population of adolescents this category is not discussed here.

615 The different attitudes to friendship cited by families included: discordance in effort
616 to socialise; need for peer approval; confidence; personality; and reactions to the twin
617 relationship. These attitudes were seen as explaining variance being associated with ~~in~~ social
618 life, future plans and study habits. It was interesting to note though that in most cases
619 families did not see one twin as disadvantaged by their experience. In only 5 of 16 cases
620 were outcomes presented as worse for one twin than the other. In most cases families
621 suggested that each twin had accessed peer experiences that they were comfortable with and
622 that suited them as individuals. Social life and study habits could be added to hypothesis 4.

623 **Selection or causation?**

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624 These data suggest evidence for both the selection and causation hypotheses of peer
625 relationships. MZ discordance in experience of peer relationships is necessarily caused by
626 NSE effects. In this study we have seen hypotheses relating to factors such as: enhanced
627 vulnerability (health, sexuality, appearance); personality or confidence; and chance. It is
628 notable that selection appeared, in the current study, to be more often mediated by evocative
629 than active processes, something that has arguably been overlooked in the field's focus on
630 antisocial behaviour and deviant peers.

631 Discordant peer relationships that favoured one twin over the other were perceived by
632 twins and their parents as having a causal relationship with discordance in self-confidence,
633 future plans, social isolation and mental health. If we can pin down the environmental
634 influences on discordant peer relationships, and both identify and understand the
635 environmental mechanisms underpinning relationships between peer problems and a range of
636 outcomes, we will enhance our ability to intervene to support those who are disadvantaged by
637 problematic relationships with their peers. Discordant peer relationships in which one twin
638 was not advantaged over the other – relationships where the peer experience was seen as
639 different in kind rather than in quality – were seen as explaining discordance in confidence,
640 interests, future plans, social life and study habits. We therefore have grounds for continuing
641 to consider both processes in genetically-informed studies of the peer relationship.

642 **Limitations**

643 We took an inductive approach in the current study. In one sense this was a strength
644 of the research as it allowed us to identify explanations that emerged spontaneously.
645 However, it remains likely that we would have got/received different answers had we taken a
646 more deductive approach and asked specific questions about peer relationships. For example,
647 more pairs may have provided information about their friendships had we asked for it

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648 directly. They may also have been triggered to identify peer relationship discordance as part
649 of a multi-faceted explanation for behavioural discordance if asked directly. Furthermore,
650 this case study design can suggest hypotheses but cannot speak to direction of effects.

651 A further limitation, mentioned earlier, is that our sample was not representative of
652 UK adolescents. Although this does not matter for within-pair comparisons it would
653 strengthen our study if we could seek the spontaneous views of people not fully represented
654 in the data we have gathered here. On this point it is a limitation that we discovered that
655 TEDS families were less willing to provide open-response data than they are to provide the
656 closed-response data that we more typically gather. This may have biased our sample and
657 may be reflected, for instance, in the higher levels of g and SES observed in the current study
658 (compared to TEDS data more generally). It is possible that this problem applies more to
659 written than verbal responses and this is something we could explore in future qualitative
660 work.

661 The genetically informed typology of peer relationships that emerged from these data
662 does not contain anything very surprising in the sense that these aspects of peer relationships
663 have been linked with life outcomes in non-genetic literature for many years (e.g. Bukowski
664 et al., 1996; Hartup, 200017). The novel contribution made here is that we present a basis for
665 empirically testing their role as aspects of NSE experience, and for studying the
666 environmental mediation of relationships between peer experiences and a range of outcomes.
667 This will help us to understand the mechanisms of associations between peer relationships
668 and outcomes, and will also help us to map the non-shared environment so that it begins to
669 emerge as a set of named experiences rather than a non-specific proportion of variance.
670 Furthermore, the current findings offer support to Silberg et al.'s empirical finding (3233)
671 that bullying appears to have a causal and truly environmental influence on mental illness.

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672 This matters because NSE influences are likely to be particularly susceptible to well-designed
673 interventions.

674 Finally, the results of this study are merely descriptive and, to have any impact, need
675 to be used as a basis for theory building about ~~the non-shared environment~~NSE, and taken
676 forward to empirical testing. In particular, theory that links the severity of a peer problem
677 with the severity of outcome (if prediction can be established and is environmentally
678 mediated) may form a useful basis for future studies of the origins of mental health and
679 wellbeing.

680 **Future Research**

681 Our next step will be to take some of the hypotheses generated by this study and test
682 them using a quantitative design and a genetically-sensitive sample such as TEDS. There are
683 two approaches that can be considered here. One is to focus on experience of friendship as a
684 predictor of the range of outcomes identified in this hypothesis-generating study: self-
685 confidence; future plans; social isolation; mental health; and interests. Another would be to
686 focus on a particular outcome and explore the extent to which aspects of the friendship
687 experience can explain NSE variance in this outcome. Future plans or self-confidence
688 represent particularly interesting variables to study in this way as they were mentioned as
689 outcomes of almost all categories of friendship discordance. Equally, studying the role of
690 peer victimisation, rejection and unpopularity in explaining NSE variance in social isolation,
691 confidence and mental health could be a fruitful and beneficial line of inquiry.

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697

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MZ discordance in peer relationships

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816 **Supporting information**

817 **S1 File. Parent and twin screening questionnaires.**

818 **S2 MZ differences screening questionnaire (parent)**

819 **S3 MZ differences screening questionnaire (twin)**

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7th June 2017

Dear Dr Branchi and Reviewers,

Do MZ twins have discordant experiences of friendship? A qualitative, hypothesis-generating MZ twin differences study

Thank you for your feedback on our revised version of this paper. We are glad to hear you were happy with the revisions that we made and have now addressed your remaining concerns in full.

Reviewer 2

We have clarified the N for this study in the following way:

To clarify, the sample included pairs who were not invited to take part in a telephone interview as well as those that were. Families were included in the current study if they spontaneously referred to discordance in peer relationships in either their questionnaire responses or during a telephone interview.

Reviewer 3

We completely agree that the excellent and very relevant work of the Montréal group should have been covered in this paper and apologise for the oversight. We have now incorporated several of these references, prioritising those with adolescent samples, into our Introduction. Thank you very much for noting this important omission.

Minor concerns

1. We have removed the section on C.S. Lewis and Anais Nin's writings on friendship.

2. We have removed all inappropriate references to causality.
3. We have now included a statement regarding some families' apparent reluctance to provide free response data in the Limitations section of the Discussion. We say:

It is a limitation that we discovered that TEDS families were less willing to provide open-response data than they are to provide the closed-response data that we more typically gather. This may have biased our sample and may be reflected, for instance, in the higher levels of g and SES observed in the current study (compared to TEDS data more generally).

It is possible that this problem applies more to written than verbal responses and this is something we could explore in future qualitative work.

4. We have elaborated on what we mean when we say that a deductive approach may have yielded different responses. We say:

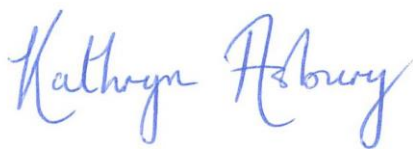
For example, more pairs may have provided information about their friendships had we asked for it directly. They may also have been triggered to identify peer relationship discordance as part of a multi-faceted explanation for behavioural discordance if asked directly.

5. We have removed “explaining variance” and, instead, refer to attitudes “being associated with” social life etc.

6. We have now abbreviated non-shared environment to NSE.

We hope that all of your concerns have now been addressed in full and we look forward to hearing from you. Thank you for your very constructive suggestions. We believe that the peer review process has made this a stronger paper.

Yours sincerely



On behalf of: Kathryn Asbury, Nicola Moran and Robert Plomin