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Flocking together and thinking apart: Gendered friendships and decision-making in adolescence

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ABSTRACT

This study explored if adolescents' style of decision-making is related to the sex composition of their friendship groups. Using data on 13,413 members of the Millennium Cohort Study at ages 11 and 14 years, we explored reciprocal associations between decision-making, measured with the Cambridge Gambling Task, and own-sex and other- or mixed-sex companionship. Cross-lagged models showed that girls whose friends at 11 were mainly girls showed better quality of decision-making, more risk adjustment, shorter deliberation time and less delay aversion at age 14, compared to girls in mixed-sex or other-sex friendship groups at 11. For boys, having predominantly male friends was associated only with more risk adjustment. Conversely, decision-making style at age 11 did little to predict keeping own-sex company at age 14. It appears that same-sex friendships may help develop better decision-making in adolescence, but only for girls.

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The extent and outcomes of peer influence in adolescence have received much research attention. According to Social Learning Theory (SLT; Bandura, 1977), for example, adolescents observe and imitate the behaviour of those peers they consider as important role models. In turn, according to identity-based theories, such imitation (effectively the emulation of valued or idealized others' behaviour and adherence to perceived social norms within a valued reference group) confers a favourable sense of self (Abrams & Hogg, 1990). Results from studies examining empirically the role of peer influence indicate that adolescents take more risks when their same-sex peers encourage them to do so (Reynolds et al., 2014). Such influences are more prominent among young adolescents for deliberation-based decisions, and among middle/

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late adolescents for emotion-based decisions (Somerville et al., 2018). In terms of sex differences in susceptibility to and extent of peer influence, there is evidence suggesting that girls are more likely to resist peer influence (Steinberg & Monahan, 2007) while boys experience greater social pressure to conform (Suls & Green, 2003).

This study investigates whether decision-making in early and middle adolescence affects or is affected by the sex composition of a young person's friendship group. This period, with the onset of puberty, brain reshaping, transfer to secondary school and growing independence from parents (Blakemore et al., 2010), is a time where gender and sex differences emerge or increase, with boys tending to show more risky behaviour (Jacobs et al., 2016) and girls more emotional problems (Nolen-Hoeksema & Girgus, 1994). In early adolescence boys are also more likely than girls to disengage from education, sex differences in career choice persist (though are weakening over time), and boys and girls tend to flock together in friendship groups with their own separate interests (Maccoby, 1998; Symons et al., 2014). The gendering of teenage life doubtless has complex roots where biological and social factors intertwine (Blakemore & Choudhury, 2006). It is also a reality confronting parents, educators, health professionals, youth workers and others seeking to support successful passage through the years of transition.

Sex differences and the role of gender

Decision-making is generally considered gendered. In adolescence, sex differences in risky decision-making, and especially risk-taking behaviours, have attracted much attention (Gardner & Steinberg, 2005; Harakeh & De Boer, 2019; O'Brien et al., 2011; Van Hoorn et al., 2016). Risk-taking appears to have strong genetic underpinnings (Llewellyn, 2008; Roiser et al., 2009), to rise post-puberty and to increase further, among adolescents only, in the presence of peers (Gardner & Steinberg, 2005). There is also evidence for the importance of the sex composition of the friendship group for risk-taking but also other aspects of decision-making. However, the opposite direction in the link has yet to be studied: whether an adolescent's style of decision-making can 'predict' the sex composition of their friendship group. This is a significant gap given that studies on the role of same- vs. mixed-sex or other-sex peer groups in two much-studied behavioural manifestations of poor decision-making in adolescence, delinquency (Molloy et al., 2014; Weerman & Bijleveld, 2007) and health

risk-taking – such as tobacco, drug and alcohol use (Grard et al., 2018; Jacobs et al., 2016) – show support for both directions. Of particular relevance here are the protective effects of same-sex friendships for adolescent girls with respect to substance use (Grard et al., 2018) and the greater tendency of both delinquent boys and delinquent girls to prefer other-sex friends (Weerman & Bijleveld, 2007). There are several reasons that might explain the findings for the association between other-sex friendships and health risk-taking and delinquency (Molloy et al., 2014). For example, girls might adopt delinquent behaviours such as substance use – that are more commonly adopted by boys as a way of expressing masculine identity (Dempster, 2011) – in order to achieve self-disclosure (Malow-Iroff, 2006) or as a way of facilitating contact with other-sex peers (Mullen et al., 2009). At the same time, delinquent boys are more popular than non-delinquents among girls (Weerman & Bijleveld, 2007) and, hence, are more likely to be found in other-sex friendship groups. Nonetheless, as Jacobs et al. (2016) discuss, there are generally few studies on health risk-taking in adolescence that specifically consider the sex of both the individual and the network. To the best of our knowledge, there is none on adolescent decision-making, a gap we attempted to fill with this study.

The present study

The aim of this study was to explore, using longitudinal data, sex differences in decision-making in adolescence (at ages 11 and 14 years), measured with the Cambridge Gambling Task (CGT; Atkinson, 2015; Rogers et al., 1999), in relation to belonging to a same-sex friendship group or not. The CGT characterizes decision-making in terms of sensitivity to reward and punishment under uncertainty, as measured outside a learning context. (The task, described in detail in Method, produces the following outcome measures: risk-taking, quality of decision-making, deliberation time, risk adjustment, delay-aversion, and overall proportion bet.) Performing advantageously on this task requires, as in real life, dealing with uncertainty in a context of punishment and reward, with some choices being advantageous in the short term (high reward) but disadvantageous in the long run (higher punishment), while others are less attractive in the short term (low reward) but advantageous in the long run (lower punishment) (Yazdi et al., 2019). A focus on the anatomy of decision-making is of particular interest for early and middle adolescence,

when young people are increasingly making decisions for themselves, may be embarking on romantic and/or sexual relationships, and are exposed to the opportunities and dangers of taking risks (Defoe et al., 2015; Deutsch et al., 2014; Steinberg, 2008). This is also the age when the influence of peers may eclipse that of the immediate family (Steinberg & Monahan, 2007) and reinforce gender identity.

In terms of research hypotheses, we expected that, in line with the literature, females in mixed-sex or other-sex friendship groups would score significantly higher in risk-taking and lower in quality of decision-making and risk adjustment compared to females with predominantly female peers. We also investigated whether the sex of friends may reflect preferences arising from the young person's style of decision-making. We expected youths showing lower quality of decision-making and those more sensitive to reward (i.e., those scoring higher on risk-taking) to find themselves, later in adolescence, in other- or mixed-sex peer groups, in line with the literature on delinquent youths' selection of mixed-sex groups (Molloy et al., 2014). Thus, this is the first study to explore the potential reciprocal associations between an adolescent's 'objectively measured' decision-making and the sex composition of his or her friendship group.

Method

Sample

The data came from the Millennium Cohort Study (MCS), a population-based longitudinal study of a cohort born in the UK in 2000–2002 (www.cls.ioe.ac.uk/mcs). Children were around 9 months old at Sweep 1, and around 3, 5, 7, 11 and 14 years old at the next five sweeps. In total, 19,244 families participated in MCS. At the age 11 and age 14 sweeps, MCS carried out, for the first time, an electronic assessment of decision-making, the CGT, our main outcome. At those sweeps, families numbered 13,287 and 11,714, respectively. The analytic sample for this study was adolescents (singletons and first-born twins or triplets) with valid data on decision-making or sex composition of friendship groups in at least one of Sweeps 5 or 6 or with valid data on at least one of the covariates (N = 13,413, of whom 6,740 (50%) were male). Ethical approval was gained from NHS Multi-Centre Ethics Committees. Parents gave informed consent before interviews took place and cohort members gave assent.

Measures

Decision-making at ages 11 and 14 years was assessed with the CGT, which measures decision-making under risk. The CGT is a neurocognitive measure proven sensitive to deficits in reward-based decision-
making and is considered a relatively pure measure of reward-based decision-making with explicit outcome probabilities. The task was administered in the homes of the MCS cohort members as part of the main interview. In a series of five stages, the MCS participant is presented with a row of 10 red or blue boxes across the top of the screen, appearing in varying combinations. During the first stage (decision-only) the participant is asked to guess whether a yellow token is hidden in a red or a blue box. In the remaining four (gambling) stages, the participant must additionally select a portion of 100 points given to them at the beginning of the trial to gamble on their confidence in the location of the token. The ratios of red:blue boxes vary from 1:9 to 9:1 in pseudorandom order. Thus, the odds of guessing correctly are presented explicitly by varying the ratios of colours among boxes that may contain the hidden token. Participants are informed that correct bets will be added onto their points score (and incorrect ones will be taken away) and that they should try to win as many points as possible. They are asked to bet some proportion of their points (between 5% and 95%) on the certainty of their decision by selecting from an array of possible bets presented in ascending and descending sequences. Two of the gambling stages are practice sessions so that participants' performance is ultimately assessed by the last two gambling stages. The CGT produces six outcome measures. *Risk-taking* is the mean proportion of points bet on trials where the most likely box colour was chosen. Higher scores reflect higher reward sensitivity (or lower punishment sensitivity). *Quality of decision-making* is the mean proportion of trials where the participant selects the most likely box colour. *Deliberation time* is the mean time (in milliseconds) taken to make a response on box colour. It is the latency from the presentation of the coloured boxes to bet choice. *Risk adjustment* is the extent to which betting behaviour is moderated by probability, and reflects the tendency to stake higher bets on high-probability compared to low-probability trials. *Delay aversion* is the time participants are prepared to wait in order to place a higher or lower bet. *Overall proportion bet* is the mean proportion of points bet across all trials.

Compared to other instruments measuring decision-making, such as the widely used Iowa Gambling Task (IGT), the CGT makes the critical information for each decision (risk, potential gain and potential loss) explicit on each trial, and therefore there is no requirement for learning. Thus, a major advantage of the CGT is that it can experimentally quantify risky decision-making, betting behaviour, reaction time and adaptation to risk without the need for learning and thus the recruitment of other cognitive resources (Deakin et al., 2004; Rogers et al., 1999). It additionally separates out two key components of decision-making: 1) Probabilistic choice – whether participants choose a low or a high probability option; and 2)ʙ Betting – whether participants place a high or a low stake (Atkinson, 2015). The CGT is also considered to be ecologically valid. Disadvantageous CGT outcomes have been associated with mental health problems in childhood and adolescence suggesting adequate criterion validity. Importantly, they have been associated with mental disorders beyond the obvious cases of gambling and substance abuse disorders, for example, depression (Mannie et al., 2015; Rawal et al., 2013). Initial findings on CGT at age 11 in MCS showed cross-sectional relationships between the CGT risk-taking score and a range of antisocial or risky behaviours, most of which were however accounted for by background factors, but also that the sex gap in risk-taking on the CGT was larger than the sex difference in the risky behaviours examined (Brown & Sullivan, 2014). With respect to the role of demographic characteristics, at age 11 MCS boys showed faster deliberation times, more delay aversion and more risk-taking than girls. Parents with more education or income had children with better scores on risk adjustment, deliberation time and quality of decision-making, and lower scores on risk-taking. Among various ethnic differences not otherwise accounted for, black, and Pakistani or Bangladeshi children showed more risk-taking and poorer risk adjustment, when compared to white children (Brown & Sullivan, 2014). Other MCS studies on the CGT have found positive associations between cognitive ability and risk adjustment and quality of decision-making (Flouri et al., 2019), between bullying and risk-taking (Flouri & Papachristou, 2019), and, for girls only, between maternal psychological distress and risk-taking (Flouri et al., 2017).

The other main outcome was the *sex composition of the friendship group* at ages 11 and 14 years. At age 11 cohort members were asked 'Are your friends mostly boys, mostly girls or a mixture?' to which four response options were available: 'mostly boys', 'mostly girls', 'a mixture' or

'I have no friends'. Males who responded 'mostly boys' and females who responded 'mostly girls' were classified as having predominantly own-sex peers. At age 14 they were asked two questions: 'How many of your close friends are boys?' and 'How many of your close friends are girls?' and their response options were: 'all of them', 'most of them', 'some of them' and 'none of them'. Males who responded that 'all of them' or 'most of them' were boys were classified as having predominantly own-sex peers. Equivalently, females who responded that 'all of them' or 'most of them' were girls were classified as having predominantly own-sex peers. In the dichotomous variable we derived for ages 11 and 14 to use in the analysis (see under '*Analytic approach')*, having mixed or predominantly other-sex friends served as the reference category. The very few children who reported having no friends (n = 44 at age 11) were excluded from the analytic sample.

To minimize *confounding,* we adjusted for variables that were related to both sex of friends and decision-making (Boutwell et al., 2017; Flouri et al., 2019; Grard et al., 2018; F. Mata et al., 2013). At the age 11 sweep these included: exact *age* at the assessment, *maternal age, IQ, number of siblings* (0, 1, ≥2), *sex composition of sibship* (% male) and whether parents have *frequent arguments* with their children (usually mother-reported). IQ was assessed with the Verbal Similarities test of the BAS (Elliott et al., 1996): Children's age-adjusted scores were transformed into standardized IQ scores with a mean of 100 and a standard deviation of 15 (Hanscombe et al., 2012). We additionally adjusted for a history of *poverty* (number of sweeps, from age 3 until age 11, that family income was below 60% of the UK median household income) and child's *ethnic group* (White, Black, Indian, Pakistani/Bangladeshi, Mixed and Other). Covariates at the age 14 sweep included *sex composition of the school* attended (single- vs. mixed-sex) and involvement in *romantic relationships*.

Analytic approach

First, we examined sex differences in the covariates and the outcomes at both assessments. Next, we calculated Spearman's correlation coefficients for the bivariate associations of the outcome measures to establish that they are cross-sectionally and prospectively associated. In order to avoid multicollinearity, we excluded *the overall proportion bet* from the analyses and considered only the remaining five decision-making outcomes (the correlation between overall proportion bet and risk-taking was 0.96 and 0.97 at ages 11 and 14, respectively). Then, we ran a series of cross-lagged structural equation models to estimate the prospective

associations between decision-making outcomes and the sex composition of friendship groups in both directions. Cross-lagged models are path models which can be used to estimate the direction of the association between two or more variables assessed prospectively (cross-lagged paths), while also accounting for the individuals' relative standings on each variable over time (auto-regressive paths). All models were run separately for predominantly male and predominantly female friendship groups. We also stratified the analyses by the sex of the cohort member to allow for comparisons of the associations between boys and girls with predominantly own-sex friends or not. By using cross-lagged models we estimated simultaneously the associations between sex composition of friendship groups and decision-making over time as well as the stability of each measure across the two consecutive time-points. The paths of these models were tested for regression path equivalence and sex invariance against nested models with parameter constraints imposed. Constraints were imposed for the autoregressive paths, cross-lagged paths or both, successively. The nested models were tested against the baseline models with chi-square difference tests using the log-likelihood values and the scaling correction factors of the models (Tofighi & Enders, 2008). Upon identification of the best fitting-models, we ran two final cross-lagged models (one for each outcome) after adjusting the outcomes for all covariates.

Missing data on the variables included in the models were handled using full information maximum likelihood. Models were carried out using maximum likelihood estimation with robust standard errors (MLR) which can account for skewed distributions of data. We also applied attrition and stratification weights and cluster points to account for the disproportionately stratified and clustered design of MCS (Plewis et al., 2007). Analyses were performed in Stata/SE 14.2 (StataCorp, 2011) and Mplus 7.4 (Muthén & Muthén, 2009).

Results

Table 1 shows the differences and similarities at baseline (age 11) and follow-up (age 14) between sexes. Decision-making 'improves' between assessments in both sexes, as one might expect as the children mature. Compared to males, females scored significantly lower on delay aversion and risk-taking at both assessments. At age 14, males scored higher on risk adjustment but had longer deliberation time, compared to females.

Table 1. Unweighted baseline and follow-up characteristics at ages 11 and 14 years.

	Age 11 years			Age 14 years		
	Male (N = 6,338)	Female (N = 6,340)	p	Male (N = 5,372)	Female (N = 5,528)	p
Decision-making						
Delay aversion	0.31 (0.00)	0.26 (0.00)	<0.001	0.28 (0.00)	0.26 (0.00)	<0.001
Deliberation time	3260.56 (16.14)	3402.03 (17.94)	<0.001	2362.58 (13.35)	2312.97 (12.58)	0.01
Risk adjustment	0.66 (0.01)	0.63 (0.01)	0.11	1.09 (0.01)	0.90 (0.01)	<0.001
Risk taking	0.58 (0.00)	0.48 (0.00)	<0.001	0.56 (0.00)	0.48 (0.00)	<0.001
Quality of decision-making	0.80 (0.00)	0.80 (0.00)	0.08	0.88 (0.00)	0.88 (0.00)	0.96
Predominantly same-sex friends	3,091 (49%)	2,602 (41%)	–	4,543 (85%)	4,850 (88%)	–
Covariates						
Age at baseline	11.17 (0.00)	11.16 (0.00)	0.08	–	–	–
Number of siblings	758 (11%)	782 (12%)	0.30	–	–	–
0, n (%)	2,786	2,814				
1, n (%)	(41%)	(42%)				
≥2, n (%)	3,196	3,077				
	(47%)	(46%)				
% Siblings male	46.16 (0.52)	47.37 (0.53)	0.10	–	–	–
Maternal age	39.95 (0.08)	39.98 (0.08)	0.75	–	–	–
IQ	100.64 (0.19)	99.58 (0.18)	<0.001	–	–	–
Number of sweeps in poverty	1.02 (0.02)	1.06 (0.02)	0.10	–	–	–
Signs of puberty	2,215 (39%)	4,842 (84%)	<0.001	–	–	–
Frequent battles with parents	1,580 (28%)	1,626 (29%)	0.25	–	–	–
Ethnicity	5,382 (83%)	5,334 (83%)	0.59	–	–	–
White, n (%)	174 (3%)	190 (3%)				
Mixed, n (%)	173 (3%)	155 (2%)				
Indian, n (%)	443 (7%)	472 (7%)				
Pakistani/	215 (3%)	197 (3%)				
Bangladeshi, n (%)	92 (1%)	85 (1%)				
Black, n (%)						
Other, n (%)						
Attends single-sex school, n (%)	–	–	–	490 (10%)	713 (14%)	<0.001
Has romantic relationships, n (%)	–	–	–	935 (17%)	931 (17%)	0.48

Note. Values presented as M (SE) unless otherwise indicated

No sex differences were identified for quality of decision-making or risk adjustment at age 11. As expected, boys reported having predominantly male friends (49% at age 11 and 85% at age 14) and girls predominantly female friends (41% at age 11 and 88% at age 14). It was not a priori obvious that the cohort members' friendship groups would become more sex-segregated over these ages. Although this may be an artefact of the different wording of the questions at 14, there may also be social and structural reasons since the two MCS surveys at ages 11 and 14 years span

a transition from primary schools to larger secondary schools with larger pools of same-sex peers. Finally, most of the covariates considered showed little sex difference. Females, however, were more likely than males to show signs of puberty at age 11 years (84% vs. 39%) and to be attending single-sex schools at age 14 (14% vs. 10%).

Table 2 shows Spearman's correlation coefficients for the bivariate associations between the CGT indices and sex composition of the friendship group at both assessments and across sexes. With only few exceptions, the CGT scores correlated moderately yet significantly between them, ranging in (absolute) magnitude from 0.04 to 0.48, and were similar between the two sexes. The CGT scores also correlated cross-sectionally and prospectively with the sex composition of the friendship group. In males, having predominantly own-sex friends correlated positively with better quality of decision-making, greater risk adjustment, and shorter deliberation time. In females, not having predominantly female friends correlated positively with risk-taking at both assessments (11 and 14 years) and more delay aversion, longer deliberation time, lower risk adjustment and poorer quality of decision-making at age 14. Additionally, in males, not having predominantly male friends was associated positively with delay aversion, lower risk adjustment, more risk-taking and poorer quality of decision-making at age 14 only. Finally, in females, having predominantly own-sex friends was positively associated with quality of decision-making at both ages.

Cross-lagged models

The baseline (unadjusted) cross-lagged models were run on 12,678 (50% male) participating children with available data on at least one of the outcome measures. The fully adjusted models were run on the larger sample of 13,413 children with available data on at least one of the outcome measures or one of the covariates (the 'analytic sample') as missing data on the outcome measures were handled conditionally on the observed covariates using full information maximum likelihood. The children excluded from the analytic sample had a lower IQ (IQ score difference: 3.6 points) and they were more likely to be male (55%), to have spent more sweeps in poverty and to belong to an ethnic minority. However, the two groups did not differ in pubertal development at age 11, frequency of battles with their parents or romantic relationship status at age 14.

Table 2. Spearman correlation coefficients for the associations between outcome variables at MCS5 (age 11 years) and MCS6 (age 14 years).

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.
Male														
1. Delay aversion, MCS5	1.00													
2. Deliberation time, MCS5	−0.15**	1.00												
3. Risk adjustment, MCS5	−0.18**	−0.09**	1.00											
4. Risk taking, MCS5	0.03	−0.00	−0.25**	1.00										
5. Quality of decision-making, MCS5	−0.08**	−0.27**	0.30**	0.05**	1.00									
6. Delay aversion, MCS6	0.17**	−0.01	−0.11**	0.07**	−0.06**	1.00								
7. Deliberation time, MCS6	0.02	0.35**	−0.14**	0.01	−0.24**	−0.09**	1.00							
8. Risk adjustment, MCS6	−0.07**	−0.11**	0.27**	−0.07**	0.24**	−0.21**	−0.27**	1.00						
9. Risk taking, MCS6	0.00	0.02	−0.05**	0.29**	−0.01	0.15**	−0.02	−0.30**	1.00					
10. Quality of decision-making, MCS6	−0.09**	−0.13**	0.18**	−0.04	0.35**	−0.11**	−0.48**	0.41**	−0.03	1.00				
11. Predominantly male friends, MCS5	−0.03	−0.06**	0.06**	−0.03	0.09*	−0.04**	−0.06**	0.10**	0.02	0.09**	1.00			
12. Predominantly male friends, MCS6	−0.03	−0.02	0.04	−0.00	0.04	0.02	−0.06**	0.07**	−0.01	0.04**	0.13**	1.00		
13. Predominantly female friends, MCS5	−0.03	0.02	0.01	0.01	−0.03*	0.02	0.02	−0.01	−0.01	−0.03	–	−0.07**	1.00	
14. Predominantly female friends, MCS6	0.06**	0.01	−0.06**	0.00	−0.08**	0.05*	0.03	−0.11**	0.04**	−0.09**	−0.14**	–	0.10**	1.00
Female														
1. Delay aversion, MCS5	1.00													
2. Deliberation time, MCS5	−0.15**	1.00												
3. Risk adjustment, MCS5	−0.17**	−0.04**	1.00											
4. Risk taking, MCS5	0.33**	−0.04**	−0.21**	1.00										
5. Quality of decision-making, MCS5	−0.06**	−0.25**	0.28**	0.11**	1.00									
6. Delay aversion, MCS6	0.19**	−0.03*	−0.05**	0.14**	−0.05**	1.00								
7. Deliberation time, MCS6	0.01	0.32**	0.10**	0.02	−0.22**	−0.14**	1.00							
8. Risk adjustment, MCS6	−0.06**	−0.05**	0.26**	−0.05**	0.23**	−0.23**	−0.20**	1.00						
9. Risk taking, MCS6	0.10**	−0.05**	−0.04**	0.27**	0.05**	0.38**	−0.10**	−0.22**	1.00					
10. Quality of decision-making, MCS6	−0.07**	−0.10**	0.17**	−0.03	0.35**	−0.06**	−0.45**	0.39**	0.08**	1.00				
11. Predominantly male friends, MCS5	0.02	0.02	−0.02	0.04**	−0.04*	0.02	0.02	−0.01	0.00	−0.05**	1.00			
12. Predominantly male friends, MCS6	0.04**	0.02	−0.02	0.00	−0.04**	0.09**	0.04**	−0.06**	0.05**	−0.07**	0.09**	1.00		
13. Predominantly female friends, MCS5	−0.03	−0.03*	0.03*	0.03	0.08**	−0.05**	−0.04*	0.06**	−0.01	0.10**	–	−0.18**	1.00	
14. Predominantly female friends, MCS6	0.01	−0.01	−0.02	0.03	0.00	−0.01	−0.03*	0.03	0.00	0.05**	−0.07**	–	0.16**	1.00

*p < 0.05. **p < 0.01

Note: 'predominantly female' friends includes 'mixed' in boys at age 11; 'predominantly male' friends includes 'mixed' in girls at age 11.

Two fully adjusted cross-lagged models were run on the analytic sample estimating relationships between decision-making and sex composition of the friendship group, one for each dichotomization of the sex composition variable – predominantly male and predominantly female. These models were performed without any equality constraints imposed on the cross-lagged or autoregressive paths because these models provided an overall better fit to the data compared to the more restricted models (results in the Supplementary Material). The results of the models for the relationships between own-sex companionship and decision-making are illustrated in Figure 1 (Figures S1 and S2 in the Supplementary Material also show the relationships between decision-making and having other-sex friends). The estimates of the standardized autoregressive paths (not shown in the figure) for both models suggest that, of the five CGT measures, deliberation time showed the highest degree of stability during the study period (b = 0.30, SE = 0.03 in males; b = 0.28, SE = 0.03 in females) and delay aversion the least (b = 0.17, SE = 0.02 in males; b = 0.16, SE = 0.02 in females). Having mainly male friends was associated with improved risk adjustment in males (Figure 1). In addition, shorter deliberation times at age 11 were predictive of a predominantly male friendship group at age 14 in males. Results of the model using predominantly female friendship group as the outcome showed that girls who reported having predominantly female friends at age 11 showed better quality of decision-making and greater risk adjustment, and also shorter deliberation time and less delay aversion at age 14. The effects of the covariates on the outcomes in the adjusted cross-lagged models are shown in Tables S2 and S3 in the Supplementary Material. (The effects of the covariates on the CGT measures were almost identical for the two models; therefore, we show them only for the model using predominantly male friendship group as the outcome to avoid repetition.)

Bias analysis

We performed an additional bias analysis to examine whether the observed relationships between decision-making and sex composition of the friendship group differed after excluding from the analyses children who reported having mainly other-sex friends at either of the two

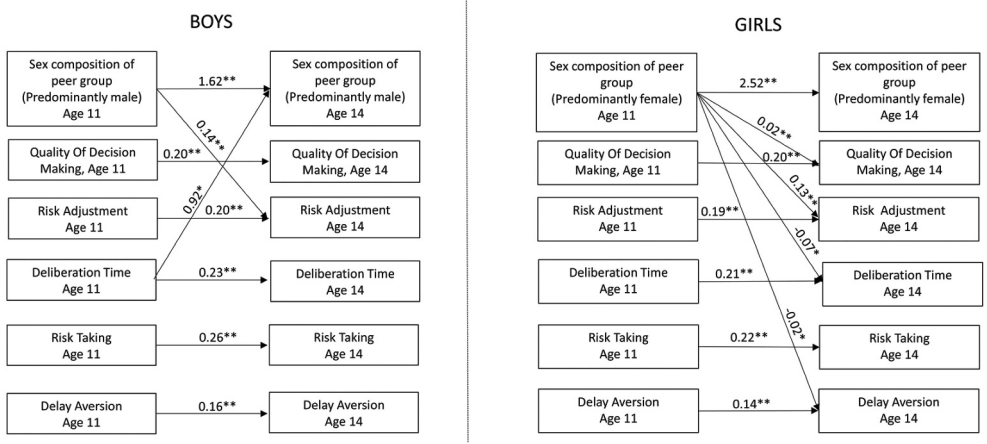

Figure 1. Fully adjusted cross-lagged model between having predominantly own-sex friends and decision-making. Paths leading to sex composition of the friendship group at age 14 are expressed in odds ratios. All others are unstandardized betas. *p < 0.05; **p < 0.01.

assessments (n = 1,667; 12% of the analytic sample). The results were comparable to those of the models run on the analytic sample and are presented in the Supplementary Material.

Discussion

Our analysis follows a large general-population cohort of UK adolescents from the end of primary school (age 11) to the mid-secondary school years (age 14). Over these three years, the adolescents' decision-making showed signs of maturing and the sex segregation of their friendship groups intensified. Our first research question was whether the sex composition of an 11-year-old's friendship group affects their decision-making at 14, even when we control for a battery of covariates and allow for influences in the other direction. The strongest link we found is for girls whose friends were mainly girls at 11, who showed advantageous performance on four out of the five CGT measures. Otherwise, the pathways from the sex of friends to decision-making, even when significant, were not strong. Risk-taking, the CGT outcome measure which shows the most difference between girls and boys, was not affected by the sex of friends.

This null finding is rather surprising. Research has demonstrated that girls have a stronger desire to conform to peers (Rose & Rudolph, 2006; Simons-Morton et al., 2001) – albeit there is also evidence that this desire is stronger in boys (Steinberg & Monahan, 2007) – and that other-sex peers have a significant impact on deviant behaviours in adolescence (Dick et al., 2007; Gaughan, 2006). Therefore, we expected that girls who belonged to mixed-sex friendship groups at age 11, compared to those who did not, would score higher in risk-taking at age 14 due to their interactions with boys. The boys in our cohort scored higher than girls in risk-taking at both assessments, as expected. In neither sex was risk-taking significantly associated with the sex composition of the friendship group. We, therefore, posit that the sex composition of the friendship group alone might not be a determining factor of future risk-taking. Rather, it is possible that sex of peers interacts with other qualitative characteristics of peer network dynamics associated with risk-taking, such as status among peers (Allen et al., 2005) or closeness to risk-taking friends (Deutsch et al., 2014), to further increase risk-taking. Since these characteristics have not been measured in the MCS, we could not examine them in our analyses.

Among girls, those with predominantly female friends were shown to be the best decision-makers in early adolescence with respect to delay

aversion, deliberation time, risk adjustment and quality of decision-making. In contrast, among boys, those with predominantly same-sex friends at age 11 showed better risk adjustment at age 14 but no other CGT difference. Our findings for girls chime with those of previous studies showing that any benefits of sex-segregation of contexts in adolescence tend to be seen in females. For example, Sullivan et al. (2010) using data from the 1958 British birth cohort, when the prevalence of single-sex schooling was about twice as high, showed that girls in single-sex schools were substantially more likely than their co-educated contemporaries to achieve high examination success at age 16. On the other hand, the boys in the 1958 British birth cohort did not differ in overall academic performance if attending single-sex schools, though here the boys in boys' schools showed overall better CGT scores than boys in mixed schools. Nonetheless, the evidence on the impact of the school's or classroom's sex composition on adolescent decision-making is mixed. Grard et al. (2018) showed that adolescent girls are best protected from substance use if they are in same-sex friendships but sex-balanced schools, while Dijkstra and Berger (2018) showed that sex-specific normative behaviours such as physical aggression in males and prosociality in females, which are key in friendship selection, are not influenced by the sex composition of classrooms.

Turning to the second research question, there were some significant associations between decision-making at 11 and the sex composition of the friendship group at 14, which varied by the sex of the cohort member. For boys, longer deliberation time at 11 mildly reduced the chances of being in a group predominantly of their own sex at 14, while better quality of decision-making at 11 reduced the chances of having mainly other-sex friendships at 14. For girls, delay aversion at 11 was associated with other-sex friendships at 14. These sex differences may be explained, in part, by the characteristics of boys' and girls' other-sex friendships. While the development of other-sex friendships is a normative process during adolescence, the timing and the pace at which other-sex friends are included in the friendship network, both of which differ by sex, likely determine the extent to which the transition to a mixed-sex friendship network is risky (Poulin et al., 2011). Girls seem to initiate the transition to a mixed-sex network earlier than boys and at a significantly faster pace throughout adolescence. Girls' other-sex friends also tend to be older than they are and from outside of school, characteristics that do not apply to boys' other-sex friends (Poulin & Pedersen, 2007). Although MCS did not include data on the timing of the

transition to other-sex friendships, the pace of acquisition of other-sex friends or the characteristics of other-sex friends, our findings clearly suggest that delay aversion in early adolescence may be an early indicator of risky behaviours in middle adolescence in girls.

Our findings carry some implications for practitioners and parents trying to understand and guide young people through the challenges of adolescence. Those of them who anticipate or must be prepared to mitigate adolescent risky behaviour – such as smoking, substance abuse or delinquency – may be interested that we did not find an association between risk-taking and keeping company with boys. Risk-taking, though higher in boys, was not associated with the sex of friends, in either boys or girls. However, other aspects of decision-making tended to be particularly favourable among girls who were already in mainly-girl friendship groups at 11. Educators may want to exploit the positive dynamics in girls' own-sex friendship groups and be sensitive to the needs of other girls and boys for support in the development of their decision-making.

Limitations

Our study used data from the Millennium Cohort Study (MCS) to test reciprocal relationships at ages 11 and 14 between decision-making, measured with the CGT, and sex composition of the friendship group. MCS, a multi-purpose resource, was not designed specifically to answer this question and has limited information about decision-making and social networks. Nevertheless, it allowed us to throw some light on relationships that might be further explored should more detailed data become available or be purposely collected. Furthermore, we cannot know whether the difference in the proportions of males and females with predominantly own-sex friends that we observed at ages 11 and 14 is due to the different questions asked at the two time-points. Importantly, we could not assess the quality of relationships, status among peers, number of friends or amount of time spent in their company. Nor could we determine to what extent friendship groups reflected the choices of adolescents, their parents (beyond controlling for type of schooling (single- or mixed-sex; Grover et al., 2007; Wong et al., 2018)), or other adolescents. It is also likely that peer influence may operate differently on behaviour when the peers are present, or observing, rather than when someone is doing an abstract computerized test such as the CGT in private. It is another limitation of the evidence that we must assume that

sex equals gender, and there are no specific questions about gender identity. We use the term 'gendered' to recognize different patterns of behaviour by boys and girls as social phenomena. Our findings must be interpreted with all these caveats in mind. Finally, there are the limitations of our main outcome measure, the CGT, especially regarding developmental or age differences. Performance on the CGT has been shown to differ significantly by age when comparing young to older adults (R. Mata et al., 2011). This may be due to older adults using simpler strategies that focus on the highest payoff and ignore probability magnitudes (older adults tend to struggle with the trade-off of choosing a low probability outcome that leads to a high reward (Brandstätter et al., 2006)). We believe however that the 3-year time interval between the two assessments in our study is short enough to avoid bias, especially given the age of the cohort. In fact, a study that used a child-friendly gambling task inspired by the CGT, the Cake Gambling task, found no difference in task performance among 8- to 30-year-old participants (Van Leijenhorst, Westenberg, & Crone, 2008), suggesting that the CGT should yield unbiased estimates when used with young participants.

Conclusion

It appears that flocking together with one's own sex may help to promote advantageous decision-making, but only for girls. It seemed to make little difference for boys' decision-making. In other words, 'exposure' to boys at age 11 had some mild disadvantage for girls, but 'exposure' to girls was not related to boys' decision-making. On the other hand, decision-making patterns, though gendered, were not strongly predictive of the sex composition of the friendship group, although there were a few links. As expected, we found a complex pattern of relationships involving other predictors of adolescents' decision-making and friendship group's sex composition – IQ, ethnicity, poverty, stage of pubertal development and school type. Perhaps the best message from our study is that risk-taking, as measured by the CGT, though more common among boys, appears not to be exacerbated (or cultivated) by associating with boys.

Declarations of interest

None

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