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The role of sibling aggression during childhood in decision-making during adulthood

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Abstract
Research shows sibling relationships can influence cognitive development, specifically in terms of high-order processes involved in social functioning. These high-order processes take place in the human prefrontal cortex. While prefrontal connectivity can be influenced by factors experienced during developmental phases, it remains unclear how experiences of aggression towards a sibling in childhood can contribute to high-order processes in adulthood, specifically decision-making. Through two studies, we sought to establish a relationship between sibling aggression and decision-making styles reported in adulthood, as well as real-time risky decision-making. Study 1 examined the relationship between childhood experiences of sibling aggression and high-order function, specifically decision-making. Self-reports from 142 adult participants revealed that using sibling aggression to maintain dominance (ESAS; Harrison, Harrison, N. (2017). Sibling aggression: Associations with parenting styles, social dominance behaviour and co-occurring forms of family aggression (Doctoral thesis, University of Central Lancashire, UK). Retrieved from: https://clok.uclan.ac.uk/20917/) was linked to avoidant and spontaneous decision-making (GDMS; Scott & Bruce, Scott and Bruce, Educational and Psychological Measurement 55:818–831, 1995). The findings reported here indicate a possible role of sibling aggression in the development of avoidant and spontaneous decision-making styles. Study 2 investigated the relationship between childhood sibling aggression (ESAS; Harrison, Harrison, N. (2017). Sibling aggression: Associations with parenting styles, social dominance behaviour and co-occurring forms of family aggression (Doctoral thesis, University of Central Lancashire, UK). Retrieved from: https://clok.uclan.ac.uk/20917/) and performance in risky decision-making tasks (IOWA gambling task; Bechara et al., Bechara et al., Brain 123:2189–2202, 2000) among 75 adult participants. It revealed that experiences of sibling aggression did not predict risky decision-making. These findings indicate that the types of decisions made may be influenced by childhood sibling aggression, but not the level of risk involved in decisions made.

Keywords Cognitive development · Decision-making · Prefrontal cortex · Sibling aggression · Executive function

Decision-making development

Decision-making is a component of executive function, a complex cognitive action allowing for reasoning and emotional processing based on explicit or tacit assumptions (Kahneman & Tversky, 2000). As humans, we make countless decisions every day, affecting all aspects of life, and decision-making is arguably one of the most important human cognitive functions and an area of research prioritisation (Bechara, 2004; Clark, 2010; Clark et al., 2008). Developing a clear understanding of influences on decision-making development is vital to increasing our understanding of decision-making itself, high-order functions and ultimately the role of external factors in complex cognitive development.

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Role of stressors and traumatic experiences in decision-making development

Exposure to adverse childhood experiences (ACEs) during childhood can have a significant effect on a range of cognitive functions and their underlying physiological organisation in adulthood (Dannlowski et al., 2012; Hart & Rubia, 2012; Takiguchi et al., 2015). ACEs are said to have a lasting neurobiological effect, with research evidence (Anda et al, 2006; Pechtel & Pizzagali, 2011; McCrory et al., 2012; Wilson et al., 2011) consistently indicating that repeated adverse exposures can result in neurobiological abnormalities in cortical and subcortical regions that are associated with the mediation of anxiety and mood (hippocampus, amygdala, medial prefrontal cortex).

The prefrontal cortex (PFC) is known to be involved in a number of high-order, complex cognitive processes including decision-making, problem solving, forward planning and social inhibition (Alverez & Emory, 2006; Fuster, 2001; Kolb, 1984; Shoenbaum & Roesch, 2005). The PFC is also implicated in a range of neurological and psychological deficits, such as psychosis, depression and autism (Courchesne et al., 2011; Perlstein et al., 2001; Zhou et al., 2015). Given the research that has shown repeated stress and childhood trauma to have a long-lasting impact on cortical and subcortical regions of the brain, specifically those associated with anxiety and mood (e.g., hippocampus, amygdala and medial prefrontal cortex (mPFC); Anda et al., 2006), it could be possible that experiencing aggression in childhood also has a similar effect, thus influencing resultant behaviours involving structures including the hippocampus, amygdala and mPFC (e.g., anxious decision-making).

One common example of aggression in childhood occurs between siblings. Aggressive behaviours can take the form of play fighting, which is considered to be developmentally beneficial for children, cooperative, and enjoyable (Hart & Tannock, 2018), or sibling aggression, which is problematic aggressive behaviour, underpinned by different motivations to that of play, containing an intent to harm (e.g., Felson & Russo, 1988). However, there are difficulties in identifying the two different types of behaviour from the individual behaviours alone, as it is the intention of these that is different, rather than the outward expressions of aggression. This is problematic for those who experience sibling aggression, as not only do they struggle to receive help and intervention, but there are several negative long-term outcomes for those involved. Such outcomes include aggression in adulthood and mental health problems, such as increased levels of anxiety and depression (Mathis & Mueller, 2015), similar to the long term outcomes of repeated stress and childhood trauma. Given such similarities, it could be possible that aggression between siblings in childhood will also have an impact on executive functioning, including decision-making.

When exploring the link between sibling aggression and its impact on cortical development further, evidence has shown that the human PFC undergoes a period of prolonged development and is not fully developed until early adulthood, around the age of 25 (Casey et al., 2008; Sowell et al., 1999). This in turn means that complex functions associated with PFC, such as decision-making processes, undergo the same prolonged period of development. It has been established that the organisation of PFC connections is highly complex and differs in terms of specific structural components in comparison to other more understood cortical regions (Bedwell et al., 2014, 2015, 2017; Hoover & Vertes, 2011; Kondo & Witter, 2014). Such complexity in structure provides increased opportunity for multiple factors to influence development structurally, in turn affecting functional development. It is known that there are critical times throughout cognitive development, during which the formation of neural pathways can be changed by traumatic events (Perry, 2009). It remains unclear however, how common childhood experiences, such as sibling aggression, could contribute to the most complex human cognitive processes associated with the PFC, including decision-making.

The functional outcome of childhood stressors is thought to be largely dependent on developmental timing (Cook et al., 2005), likely due to the constant structural changes occurring in the developing cortex. Complex decision-making is particularly dependent on synaptic plasticity and prolonged development of PFC networks (Crews et al., 2007), meaning it is affected by the ability of synapses to vary in strength of connections over time. Decision-making style is understood as a habitual behavioural pattern with underpinning cognitive processes, which individuals follow in daily decision-making. Scott and Bruce (1995) describe decision-making style as a learned response in a specific decision-making context. It is understood that a variety of decision-making styles exist within the general population (Bruine de Bruin et al., 2007), and that there are many environmental and physiological factors that could contribute to the decision-making style an individual displays. For instance, early childhood stressors such as neglect can influence attachment and decision-making styles (Deniz, 2011). Similarly, decision-making style has been found to be associated with wellbeing and mental health (Cenkseven Önder & Çolakkadioğlu, 2013; Yilmaz et al., 2013), but there is limited evidence to support the role of trauma in decision-making style (Katwa & Bedwell, 2019). However, the psychological consequences of childhood stressors occurring as a result of other negative childhood experiences, such as sibling aggression, on decision-making in adulthood remains to be examined.

Sibling aggression

Aggression between siblings is one of the most common but widely accepted forms of family violence (Caspi, 2012). One of the reasons for its acceptance surrounds the difficulties around both the definitions of sibling aggression and the ability to distinguish the behaviours from play fighting, which is developmentally beneficial for children (DiCarlo et al., 2015). Many terms are used to describe aggressive behaviours between siblings, for instance, sibling violence, conflict, abuse and aggression (Phillips et al., 2009). We use the term 'sibling aggression' to include conflict, competition, violence and abuse among siblings (Caspi, 2012). Children who experience sibling aggression have been shown to develop traumatic symptoms in their childhood (Caffaro & Conn-Caffaro, 2006; Finkelhor et al., 2006), which can be long-lasting into adulthood (Dantchev et. al., 2018) and similar to those typically associated with events traditionally classed as traumatic in diagnostic criteria (APA, 2013). It is important to acknowledge that although sibling aggression has been associated with trauma, it is not necessarily a traumatic experience and is not generally considered as such. However, research into the impact of sibling aggression specifically is limited, and so it is important to examine the psychological consequences further.

Rates of sibling aggression have been shown to be as high as 90% for psychological aggression and 70% for physical assault (Relva et al., 2013), with much of this being mutual. Victimisation through sibling aggression has often been shown to be related to perpetration (Goodwin & Roscoe, 1990; Tippett & Wolke, 2015), where victims are often perpetrators and vice versa (e.g., Duncan, 1999). When exploring patterns in the prevalence of these behaviours, the frequency of aggression between siblings has been shown to decrease as children get older (e.g., Cole & Kerns, 2001; Tippett & Wolke, 2015). However, gender differences in sibling aggression remain unclear. Patterns have been found that show boys to be more aggressive than girls (e.g., Ostrov & Keating, 2004; Tippett & Wolke, 2015), girls to be more aggressive than boys (Tanrikulu & Campbell, 2015), and boys and girls using similar levels of both physical and verbal aggression with their sibling (Duncan, 1999; Goodwin & Roscoe, 1990). As the findings regarding these sex differences are mixed, it is important to consider that males and females can be both victims and perpetrators of sibling aggression.

Engagement in sibling aggression in childhood has been found to have several long-term effects on perpetrators when they reach adulthood. Not only is there an increased likelihood of people who have engaged in sibling aggression to use aggressive behaviours in future dating relationships, but there have also been links to increased levels of anxiety and lower levels of mental health in victims and perpetrators (Dantchev et al., 2018; Mathis & Mueller, 2015; Noland et al., 2004). Additionally, ACEs, which we consider to have similar psychological effects to sibling aggression, have been shown to have detrimental effects on numerous health outcomes in adulthood, including heart disease and cancer (Felitti et al., 1998). It is important to examine the long-term effects of sibling aggression further in order to gain a more in depth understanding around the psychological consequences of engaging in these behaviours on both victims and perpetrators in adulthood.

Development of aggressive behaviour

A vast amount of evidence in the field of sibling aggression draws on Social Learning Theory (Bandura, 1978) as an explanation of learned aggressive behaviour. Evidence suggests that children learn from observation of others that aggression is an appropriate method of conflict resolution, and can achieve a desirable outcome (Ingram et al., 2020). Similarly, research states that decisions are made, and decision-making networks strengthened, by assessments of future outcomes based on experience, often referred to as cost–benefit analysis (Bechara, 2004). Knowledge of likely desirable outcomes can come from past observations, such as using aggression to achieve a goal. When taken together, theoretical knowledge suggests similar learning processes play a role in aggressive behaviour and decision-making development.

Further support for a role of aggressive behaviour towards siblings in decision-making comes from observations of cortical activation in response to potential rewards and losses. Birn et al. (2017) revealed differences in activation, predicted by childhood stress exposure, but not by current adult stress exposure. When viewing stress responses to sibling aggression similarly to other traumatic childhood experiences, it stands to reason that the same processes underlying risky decision-making seen here will be influenced specifically by experience of childhood sibling aggression.

Aims and Hypotheses

The connection between childhood experiences of stress during critical developmental stages on cognitive function in adulthood has been widely studied. However, most studies have focused on the effect of parent-infant attachment on cognitive development. Here, we aim to establish the relationship between childhood experiences of sibling

aggression and high-order cognitive function, specifically complex decision-making, through two studies.

Study 1 was conducted to examine the relationship between childhood experiences of sibling aggression and high-order cognitive function, specifically complex decision-making. Two hypotheses were proposed; (1) the experience of sibling aggression will influence decision-making in adulthood, and (2) the way that people use aggression with a sibling will be associated with decision-making in adulthood.

Study 2 extended the findings of Study 1 to establish the relationship between childhood experiences of sibling aggression and performance in risky decision-making tasks. Two hypotheses were proposed: (1) the experience of sibling aggression will influence decision-making reaction time in a risky decision-making task; and (2) experience of sibling aggression will influence the risk level of decisions made in a risky decision-making task.

Study 1

Method

Participants and Procedure

A volunteer sample of 142 participants (41 males and 100 females[1]), who ranged in age between 25 and 70 years old ($M = 31.98$, SD = 9.66) were recruited via an online survey. Advertisements for the survey were placed on social media and survey participation websites. Participants were not provided with any incentives to take part. There were three eligibility criteria to take part in the study: (1) participants were required to be over the age of 25; (2) all participants were required to have grown up with at least one sibling whom they had engaged in fighting behaviours with in childhood; and (3) all participants were required to be fluent in English. Participants who reported a diagnosed neurological or psychological disorder, or a traumatic brain injury, were excluded from the analysis as these may impact performance in decision-making tasks.

Similar to McDonald and Martinez (2016), the definition of sibling aggression was not provided to participants beforehand due to inconsistencies and difficulties in distinguishing sibling aggression from play fighting. Participants were then assigned to one of four groups depending on their own reported definition of themselves as a victim or perpetrator of childhood sibling aggression (mutual victim and perpetrator, perpetrator only, victim only, and no aggression). Almost half (47.2%) of participants defined themselves as a mutual victim and perpetrator of sibling aggression, one-fifth (18.3%) defined themselves as a victim, and four (2.8%) had been perpetrators of sibling aggression. Forty-five (31.7%) participants defined themselves as having not been either a victim or a perpetrator of childhood sibling aggression, engaging in only play fighting with their sibling, and served as a comparison group.

On average, participants had 2.61 siblings, with a majority (70.4%) being related to their brother(s) and/or sister(s) biologically. In addition to this, 50.7% of participants were of American nationality and 21.8% were British. The remaining participants were made up from people of Nigerian (5.6%), Irish (4.2%) and other nationalities (17.7%).

Upon providing consent, all participants completed a series of three questionnaires in relation to the sibling that they had experienced the most conflict with in childhood. Prior to taking part in the study, all participants received a detailed on-screen information sheet and provided informed consent via an online form. All participants were given the right to withdraw at any point during the study, with a withdrawal option made available on every page. Upon completion of the study, participants were presented with a debrief screen, in which they were provided contact details for the researchers and directed towards appropriate support services should they have been affected by the content of the questionnaires. The study was approved by the University Ethics Committee and complied with the ethical guidelines of the British Psychological Society.

Measures

Study 1 employed a series of three separate questionnaires. Firstly, participants were asked to complete a demographics questionnaire, which asked participants to complete questions surrounding their age, gender, nationality, number of children, number of siblings and experience of sibling aggression.

Sibling aggression The Experiences of Sibling Aggression Scale (ESAS; Harrison, 2017) is a 24-item questionnaire, which asks participants to rate the extent to which they agree or disagree with a presented statement on a scale ranging from 1 (not at all) to 5 (a lot). The questionnaire contains four subscales for play fighting (e.g., I enjoyed physically play fighting with my sibling), sibling aggression (e.g., I only fought with my sibling when I was angry with them), normalisation (e.g., It is normal to fight with your sibling) and behaviours to maintain dominance (e.g., I did anything I could to get me sibling into trouble). High scores on any of the subscales are indicative of higher levels of

[1] There was no significant difference among participants between experience of sibling aggression (no aggression, victim only, perpetrator only, mutual victim and perpetrator) and gender ($\chi^2(6) = 4.53$, $p = .605$).

Table 1 Means (and standard deviations) of scores on the GDMS questionnaire by experience of childhood sibling aggression

Decision-Making Style	Experience of Sibling Aggression			
	No Aggression	Victim	Mutual	Total
Rational	3.99 (.58)	4.06 (.62)	3.93 (.62)	3.96 (.62)
Intuitive	3.79 (.67)	3.73 (.76)	3.57 (.79)	3.65 (.75)
Dependant	3.57 (.77)	3.34 (1.07)	3.64 (.81)	3.56 (.85)
Avoidant	2.74 (1.01)	2.26 (.87)	3.11 (1.14)	2.84 (1.09)
Spontaneous	2.89 (.74)	2.86 (.92)	2.85 (.91)	2.84 (.86)

the behaviours. The Cronbach's alpha scores for each of the subscales within this sample were; 0.77 for play fighting, 0.75 for sibling aggression, 0.62 for normalisation and 0.89 for behaviours to maintain dominance, demonstrating a good level of reliability for the scale.

Decision-making The General Decision-Making Style Questionnaire (GDMS; Scott & Bruce, 1995) consists of 24 items which ask participants to indicate the extent to which they agree with a presented statement on a scale ranging from 1 (strongly disagree) to 5 (strongly agree). There are five subscales relating to the five different decision-making styles; rational (e.g., I usually have a rational basis for making decisions), intuitive (e.g., When I make decisions I tend to rely on my intuition), avoidant (e.g., I generally make important decisions at the last minute), spontaneous (e.g., When making decisions I do what feels natural at the moment) and dependant (e.g., I rarely make important decisions without consulting other people). Higher scores on any of the subscales indicate a higher presence of that particular decision-making style. However, Scott and Bruce (1995) propose that individuals often have aspects of all five types. Cronbach's alpha scores have been reported between 0.77 and 0.85 for rational, 0.78 and 0.84 for intuitive, 0.68 and 0.86 for dependent, 0.93 and 0.94 for avoidant and 0.87 for spontaneous (Scott & Bruce, 1995). For the present sample, the Cronbach's alpha scores were 0.66 for rational, 0.81 for intuitive, 0.82 for dependent, 0.90 for avoidant, and 0.82 for spontaneous, demonstrating a good level of reliability.

Data analyses

The data were analysed in IBM SPSS 24. Hypothesis 1 predicted that experience of sibling aggression will have an effect on decision-making style in adulthood. As the number of participants who had been only perpetrators of sibling aggression in childhood was less than the number of dependent variables being tested, they were excluded from further analyses. Following this, a MANOVA was conducted on the data, with the dependent variables being the scores on each subscale of the GDMS (Scott & Bruce, 1995) and the independent variable being experience of sibling aggression (mutual, victim, or no aggression).

Hypothesis 2 predicted that the way that people use aggression with a sibling will be associated with decision-making in adulthood. Prior to analysis, Pearson's bivariate correlations were inspected to see if there were relationships between particular decision-making styles and the way siblings used aggression with one another. Significant relationships were then followed up with a multiple linear regression. This analysis determined whether childhood experiences of sibling aggression are likely to have a significant impact on decision-making, associated with the ongoing development of complex cortical networks. This led us to establish the effect on decision-making style exhibited in adulthood and the influence that varied experiences of childhood sibling aggression have on decisions made.

Results

Hypothesis 1: Experience of sibling aggression will have an effect on decision-making in adulthood

Table 1 shows the means and standard deviations of the scores on the GDMS (Scott & Bruce, 1995) as a function of the experience of sibling aggression.

To explore differences between participants' experiences of sibling aggression and their decision-making styles in adulthood, a MANOVA was conducted using the independent variable of aggression experience, which was measured on three levels: (1) mutual victim and perpetrator, (2) victim, and (3) no aggression. The dependent variables were the five subscales of the GDMS questionnaire. The MANOVA revealed a non-significant main effect of mutuality on decision-making style (Wilks $\lambda = 0.89$, F (10, 234) = 1.49, $p = 0.150$, $\eta^2 = 0.059$).

Hypothesis 2: The way that people use aggression with a sibling will be associated with decision-making in adulthood.

Two multiple linear regression analyses were conducted to assess whether participant's use of sibling aggression was associated with decision-making in adulthood. Prior to the analysis, Pearson's bivariate correlations were inspected

Table 2 Pearson's bivariate correlations between the subscales of the GDMS and the ESAS

	Play Fighting	Sibling Aggression	Normalisation	Behaviours to maintain dominance
Rational	.00	-.02	-.02	-.03
Intuitive	.05	-.01	.04	.01
Dependant	-.05	.02	.17	.11
Avoidant	.14	.19*	.19*	.31***
Spontaneous	.05	.04	.14	.17*

*$p < .05$, ***$p < .001$

Table 3 Multiple regression analysis for the sibling aggression, normalisation and behaviours to maintain dominance subscales of the ESAS to predict avoidant decision-making

Variables	B	SE B	β	Tolerance	VIF
Sibling aggression	-.00	.02	-.02	.75	1.33
Normalisation	.02	.02	.09	.81	1.24
Behaviours to maintain dominance	.04	.02	.26**	.77	1.30

**$p < .01$, $R^2 = .09$, Adj. $R^2 = .07$

to see preliminary relationships between the variables (see Table 2).

As seen in Table 2, there were significant positive correlations between avoidant decision-making style and the ESAS subscales of sibling aggression, normalisation, and behaviours to maintain dominance. There was also a significant positive correlational relationship between spontaneous decision-making styles of the ESAS subscale of behaviours to maintain dominance. For this reason, these variables were carried through to the two multiple regression analyses. In the first, the criterion variable was avoidant decision-making style and the predictor variables were the three ESAS subscales. In the second, the criterion variable was spontaneous decision-making style and the ESAS subscale of behaviours to maintain dominance. All variables entered the regression analysis simultaneously (see Table 3).

The results of regression analysis one (Table 3) showed that the full model significantly predicted avoidant decision-making [F (3, 126) = 4.17, $p = 0.007$, R^2 adj. = 0.07]. More specifically, using aggression with a sibling to maintain dominance in childhood (β = 0.26, $t = 2.71$, $p = 0.008$) significantly predicted a higher level of avoidant decision-making in adulthood. The predictor variables of normalisation and sibling aggression did not significantly predict avoidant decision-making ($p = 0.323$ and $p = 0.867$ respectively).

A second multiple regression analysis was conducted with the criterion variable of spontaneous decision-making scale and the ESAS subscale of behaviours to maintain dominance. A significant model emerged [F (1, 133) = 4.02, $p = 0.047$, R^2 adj. = 0.02]. Using aggression with a sibling to maintain dominance in childhood [β = 0.02, $t = 2.01$, $p = 0.047$] significantly predicted a higher level of spontaneous decision-making in adulthood.

Summary of Study 1

In Study 1, we sought to identify the relationship between experiences of sibling aggression during childhood and decision-making style reported in adulthood. We found a significant, positive association between the use of sibling aggression to maintain dominance during childhood and an avoidant decision-making style reported in adulthood, indicating a possible role of childhood sibling aggression in the development of decision-making processes.

Study 2

Aims and Hypotheses

Study 2 aimed to build upon the findings of Study 1 further, and examine the relationship between childhood sibling aggression and decision-making, through real time decision-making performance in adulthood. It was proposed that: (1) the experience of sibling aggression will influence decision-making reaction times in a risky decision-making task; and (2) the experience of sibling aggression will influence the risk level of decisions made in a risky decision-making task.

Method

Participants and Procedure

Sixty-five participants (39 female, 26 male) aged 18 to 50 years old ($M = 23.63$, $SD = 5.19$) were recruited via the university's Research Participant Scheme (RPS), social media, psychological study websites (e.g., call for participants) and word of mouth. All participants were over the age of 18, required to have at least one sibling, no previous diagnosis of neurological or psychological disorder, no diagnosed learning difficulty and have normal/corrected to normal vision. Of the 65 participants that took part, all had between one and six siblings ($M = 2.18$ siblings). Fifty participants (76.9%) had natural siblings, five (7.7%) had half-siblings and 10 (15.4%) had a combination of natural, half, step, adopted and fostered. Participants were allocated to one of four groups: (1) those who experienced sibling aggression during childhood as a perpetrator, (2) those who experienced sibling aggression during childhood as a victim, (3) those who experienced sibling aggression during childhood as both perpetrator

Table 4 Logistic regression analysis to investigate the effect of participant age, gender and number of siblings on status of sibling aggression (mutual or no aggression)

Variables	*B*	Wald χ^2	*p*	Exp (*B*)	95% Confidence Interval for Exp (*B*)	
					Lower	Upper
Age	-.00	.00	.960	1.00	.90	1.12
Gender	1.68	7.94	.005	5.36	1.68	17.22
Number of siblings	-.21	.90	.343	.81	.52	1.25

$R^2 = .14$ (Cox & Snell), .18 (Nagelkerke). Model χ^2 (3) = 8.94, p = .030

and victim, and (4) those who have siblings and reported no experiences of sibling aggression during childhood.

Participants attended the testing session at a mutually convenient time. Participants completed a demographics questionnaire followed by the ESA scale (Harrison, 2017) through an online survey. Following completion of the questionnaire element, participants were required to complete a gambling task. During this part of the study, participants were presented with five practice trials to familiarise with the task, before completing 100 test trials. The researcher left the room whilst the participant completed the study. Upon completion, participants were provided with a full debrief and given the opportunity for it to be emailed to them. Each testing session took approximately 30 min. All participants received a £5 shopping voucher for their participation.

Measures

Demographics Participants completed questions surrounding their age, gender, nationality, number of children, number of siblings, and experience of sibling aggression.

Iowa Gambling Task Participants completed a computer based decision-making task (IOWA gambling task, Bechara et al., 2000), presented through OpenSesame (Mathôt et al., 2012) on a desktop computer. All participants were task naïve. The task presented four decks of cards (A, B, C, & D). Participants were required to make a choice between the four decks. Each choice resulted in either a gain or loss of money. The goal of the task, as explained to participants, was to finish with as much money as possible. Each participant completed 100 trials. Within the IOWA gambling task, two decks are 'safe' (where little money is won and little is lost) and two decks are 'risky' (where large sums are won and large sums are lost). It is up to the participant to learn over the first few trials which decks are safe and which are risky. No real money was given in relation to task performance. Participants' choices and reaction times were recorded (in ms). The order of the four decks on the screen remained consistent between trials and was randomised between participants.

Data analyses

The data were analysed in IBM SPSS 24. Hypothesis 1 predicted that experience of sibling aggression would influence decision-making reaction times in a risky decision-making task. As the number of participants who had been only victims ($N = 1$) or only perpetrators ($N = 3$) of sibling aggression was low, they were excluded from further analyses. Following this, a multiple linear regression was conducted, with the predictor variables of gender and sibling aggression, and the outcome variable of decision-making time, as measured by the IOWA gambling task. Hypothesis 2 predicted that experiences of sibling aggression will influence the risk level of decisions made in a risky decision-making task.

Prior to analysis, Pearson's bivariate correlations were inspected to see if there were relationships between particular decision-making styles and the way siblings used aggression with one another. Significant relationships were then followed up with a multiple linear regression. This analysis determined if childhood experiences of sibling aggression are likely to have a significant impact on decision-making associated with the development of complex cortical networks, thus affecting decision-making style exhibited in adulthood and influencing the decisions made by individuals with varied experiences of childhood sibling aggression. A chi-square test was also conducted to assess for potential associations between experiences of sibling aggression and different decision-making styles.

Results

Logistic regression

A logistic regression was conducted (see Table 4) to investigate the effect of the independent variables; participant age, gender and number of siblings, on the nominal dependent variable of status of sibling aggression (mutual or no aggression).

Overall, the full model significantly predicted sibling aggression (χ^2 (3) = 8.94, $p = 0.030$). The model significantly classified 61.5% of participants who had experienced

Table 5 Multiple linear regression to investigate the effect of participant gender and sibling aggression status on decision-making time

Variables	B	SE	*B*	*t*	*p*
Gender	10.00	109.68	.01	.09	.928
Sibling aggression	35.07	109.07	.05	.32	.749
R^2	.003				
F	.076				
Adjusted R^2	-.032				

no aggression from a sibling in childhood and 74.3% of participants who reported being a mutual victim and perpetrator. This resulted in 68.9% accurate predictions. The only predictor variable to significantly predict status of sibling aggression was gender of participant ($p = 0.005$). All other predictor variables were non-significant. Being female was associated with an increase in the odds of being a mutual victim and perpetrator of sibling aggression by a factor of 5.36.

Hypothesis 1: Experience of sibling aggression will influence decision-making reaction times in a risky decision-making task

A multiple linear regression was conducted to investigate the effect of the independent variables, participant gender and sibling aggression status on the dependent variable, decision-making time (see Table 5). Overall, the full model did not significantly predict decision-making time (F (2, 58) = 0.08, $p = 0.927$, R^2 adj. = -0.03). Participant gender ($p = 0.928$) and status of sibling aggression ($p = 0.749$) did not make a statistically significant contribution to the predictive accuracy of the model.

Hypothesis 2: Experience of sibling aggression will influence the risk level of decisions made in a risky decision-making task.

A chi-squared test was conducted to explore whether there was a difference between experience of sibling aggression (mutual vs. no aggression) and types of decision-making (risky vs. safe). The test revealed a non-significant association between the two aforementioned variables (χ^2 (1, $N = 61$) = 0.03, $p = 0.856$, Cramer's V = 0.02).

Summary of Study 2

Study 2 explored the relationship between the experiences of sibling aggression during childhood and types of decision-making in adulthood. We found a non-significant relationship between experience of sibling aggression and risky/safe decision-making. However, we did find participant gender to be significantly related to experience of sibling aggression, in that females were more likely to have experience as a mutual victim and perpetrator compared to males.

General Discussion

The present study aimed to establish the relationship between childhood experiences of sibling aggression and high-order cognitive function, specifically complex decision-making, through two studies. We identified a significant association between specific experiences of childhood sibling aggression and decision-making styles reported in adulthood. Specifically, we have identified a link between using sibling aggression to maintain dominance during childhood and an avoidant decision-making style reported in adulthood. Individuals using aggression to gain control of resources or possessions were more likely to be avoidant in their decision-making style. The findings presented here provide an important basis on which to build further research into the impact of childhood experiences of sibling aggression on the underlying development of complex decision-making networks.

The relationship between the motivations for aggression with siblings and decision-making in adulthood

Experiencing sibling aggression has been linked to increased levels of anxiety and depression in adulthood (Mathis & Mueller, 2015; Wolke et al., 2015) and an increased likelihood of engaging in aggressive behaviours in later intimate relationships (Noland et al., 2004). The present study extends knowledge with regard to the psychological consequences of sibling aggression, finding that the motivation behind the use of aggression with a sibling influenced the decision-making styles reported. More specifically, using aggression to maintain dominance (i.e., gain control of resources) was linked to a higher likelihood of spontaneous and avoidant decision-making. This is a surprising result, given that avoidance is considered to be a personality trait common with inhibition, fear of criticism and social anxiety (APA, 2013). Avoidance is often associated with childhood emotional neglect and social rejection and thought to be a result of abusive childhood environments (Björn et al., 2005). One might naturally associate this with being a victim of sibling aggression over a perpetrator. However, research within this area often only looks at whether or not people have experienced aggressive behaviours from a sibling. By looking into the motivations behind those behaviours, we can see that it is not necessarily the role that individuals have in sibling aggression (i.e., perpetrator or victim), but their reasoning behind such acts which is associated with

decision-making styles. It is understood that there is a higher likelihood of neurobiological abnormalities in individuals of repeated childhood trauma (Anda et al., 2006; McCrory et al., 2012; Pechtel & Pizzagali, 2011; Wilson et al., 2011). When this is considered alongside our findings, we suggest that using aggression as a way to maintain dominance and control resources has an impact on prefrontal cortex development, and therefore on exhibited high-order processes such as decision-making. It is clear from our findings that experiences of sibling aggression affect decision-making style. However, exploring how the underlying neuroanatomical and neurophysiological development of network structures are influenced and contribute to these exhibited behaviours requires further investigation.

Role of sibling aggression in risky decision-making

Findings from Study 1 identified a role of sibling aggression in decision-making style reported in adulthood, therefore one may expect to find a similar role of sibling aggression in real time risky decision-making performance, however the findings presented here from Study 2 show this is not the case. Our findings indicate that sibling aggression does not predict risky decision-making in terms of reaction time or in terms of risk level in decisions made. Taken together with the findings from Study 1, this suggests that the types of decisions made (decision-making style) may be influenced by sibling aggression in developmental stages, but the 'riskiness' of decisions made are not. When considered alongside existing knowledge surrounding childhood trauma and cognitive development (Cook et al., 2005), and specifically decision-making (De Bellis et al., 2009; Guillaume et al., 2013; Katwa & Bedwell, 2019), these findings imply differences in the influence on neurophysiological and structural development.

The role of gender in the relationship between sibling aggression and decision-making

Interestingly, we identified gender as a significant predictor of sibling aggression, but not of risky decision-making. When exploring prevalence rates of sibling aggression, patterns around gender are mixed. Prevalence studies have found boys to be more aggressive than girls at all ages (Menesini et al., 2010; Tippett & Wolke, 2015; Tucker et al., 2013), whereas others have found no difference between males and females (Duncan, 1999). Interestingly however, Tanrikulu and Campbell (2015) found, similarly to our study, that girls were more aggressive towards their siblings than boys. More research is needed exploring this specific facet of sibling aggression, which uses consistently similar methods to measure prevalence statistics.

Limitations

The findings presented here provide a valuable insight into the role of childhood experiences in high order cognitive processes, specifically decision-making. However, it should be noted that participants were not provided with a definition of sibling aggression before taking part in the study. This means that they may have used different defining criteria to classify themselves as being a victim and/or perpetrator of sibling aggression. They may have also only considered particular types of aggression within their definition (e.g., psychological or physical). Consequently, this means that the study findings cannot distinguish between different types of aggression from siblings (i.e., physical, psychological). However, the definition of sibling aggression is often debated in the literature, with researchers using different terms for the same behaviours. Examples include 'sibling violence' (e.g., Elliott et al., 2019), 'sibling aggression' (e.g., Caspi, 2012), 'sibling conflict' (e.g., Tucker & Finkelhor, 2017), and 'sibling bullying' (e.g., Bowes et al., 2014). Similar to McDonald and Martinez (2016), we did not want to constrain participants to a prescribed definition of sibling aggression. Future research should try to explore definitions of sibling aggression in further detail, along with how different types of aggression (psychological and physical) among siblings impact on decision-making performance.

The study did not ask participants about the cultural practices and norms of participants that may have an impact upon the findings. Different cultural practices may influence participant perceptions of an aggressive sibling relationship. Research has shown that participants from a variety of different ethnic groups can identify specific behavioural acts that they consider to be abusive, with differences only in perceptions around the severity of the behaviours, i.e., those that they consider to be mild, moderate and extreme (Rapoza et al., 2010). However, there are cross-cultural differences in whether or not a sibling relationship is perceived as abusive. Some cultures (e.g., German, African) see sibling aggression as normal (Kiselica & Morrill-Richards, 2007). This study recruited participants from a wide variety of cultures, although proportions represented from outside North American and British cultures were very small. Future research should aim to explore cross-cultural differences in relation to sibling aggression in more depth.

Our findings demonstrate a relationship between childhood sibling aggression and decision-making in adulthood. We cannot exclude a possibility that those who show specific patterns of decision-making tend to engage in sibling aggression. However, it should be noted that sibling aggression being the causal factor in the way people make decisions, rather than the reverse, is far more plausible in this instance. The high-order cognitive process of decision-making is not

fully developed until early adulthood, therefore it is unlikely that complex decision-making processes can influence behaviour in childhood. Further investigation in child populations is needed to understand this relationship more clearly.

Practical implications and directions for future research.

The present study has provided a vital starting point for investigating the development of complex high-order functions in great detail, specifically in terms of their development and influence of early experiences. Given the high levels of sibling aggression within the family environment, it is important to explore the impact of these experiences further, particularly given the acceptance of the behaviours within families and the wider community (Elliott et al., 2019; Gelles, 1997; Mcdonald & Martinez, 2016). It is however important to note that the differences in decision-making we have identified in relation to experiences of sibling aggression do not denote a deficit as a result of sibling aggression. That is to say we have identified differences in the way people make decisions in relation to the sibling aggression they experienced as children, that is not to say any of these differences identified are a particular advantage or disadvantage. Indeed, evidence suggests that different approaches to decision-making are beneficial in different circumstances (Allwood and Salo, 2012). That being so, it is important to acknowledge that sibling aggression may have more of an impact than previously assumed. Reports of sibling aggression are sometimes minimised by parents, being classed as 'normal' sibling behaviour (Kramer et al., 1999). Looking at the role of parental intervention in the development of complex high-order functions would be a natural progression of this research.

By building on the knowledge gained here, future research will enable us to identify how different childhood experiences, both positive and negative, influence the development of high order cognitive processes, including decision-making. Ultimately, we will be able to have a greater level of insight into how decision-making networks develop and the influence of specific experiences on the properties of these functional networks. It is thought that disorders including autism and psychosis have underlying structural and network abnormalities in PFC, associated with high-order functioning (Courchesne et al., 2011; Goldman-Rakic, 1991; Perlstein et al., 2001). Given that childhood aggression with a sibling has been associated with psychosis (Dantchev et al., 2018; Liu et al., 2021), gaining a clearer understanding of how the development of these complex processes and their underlying network structure is influenced by childhood experiences will eventually enable a clearer understanding of abnormalities in development, leading to increased possibilities in management, treatment and prevention.

Conclusions

We have provided new evidence for differential decision-making styles amongst adults with varied childhood experiences of sibling aggression, which suggests that the underlying cognitive mechanisms of decision-making processes also differ. Further investigations into the underlying neurophysiological network structure and development will allow for further understanding of how childhood experiences of sibling aggression contribute to such development. The impact of sibling aggression on brain development, specifically in terms of high-order functioning, has not been widely studied, with emphasis often placed on influences of highly traumatic childhood experiences. We have demonstrated that sibling aggression, specifically from the often overlooked perspective of a mutual perpetrator and victim, may have a profound effect upon the development of high-order function, specifically decision-making, thus may be influenced by underlying prefrontal cortical pathways.

Data Availability The datasets generated during and analysed during the current study are available from the corresponding author on reasonable request.

Declarations

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