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Research highlights

- Aggressive behaviour serves many useful social functions, yet can have damaging consequences.
- We investigated dyadic determinants of hypothetical aggression toward peers in N=162 adolescents aged 11-17 using an experimental Hot Sauce Paradigm.
- Hot Sauce allocation varied depending on perceived relationship strength and self-reported mutual or unilateral real-world dyadic aggression. These relationships varied with cross-sectional age.
- Investigation at the dyadic level reveals how adolescents' aggression is moderated depending on who they are interacting with.

Abstract

Aggressive behaviour serves many useful social functions, yet can also have damaging consequences. In line with evidence showing adolescent development in social cognitive abilities, we hypothesised that the use of aggression would become more sophisticated with age. We investigated adolescent aggression toward peers using an experimental, hypothetical aggression paradigm, the Hot Sauce Paradigm, in a school-based social network setting. Participants (N=162 aged 11-17, 98 male) indicated which strength of imaginary hot sauce they would allocate to each of their classmates. A Social Network Questionnaire quantified participants' perceived dyadic social tie strength with each classmate, and the incidence of mutual or unilateral dyadic real-world aggression (e.g. teasing). Participants allocated weaker hot sauce to peers with whom they reported strong, positive social ties and an absence of self-reported unilateral real-world aggression. With increasing cross-sectional age, there was a decrease in the impact of social tie strength and an increase in the extent to which hot sauce allocation was predicted by self-reported mutual real-world aggression. This pattern of findings is consistent with young (vs. late) adolescent use of experimental, hypothetical Hot Sauce aggression to reflect real-world animosity, while late adolescents' behaviour is more subtle. These findings extend our understanding of the dyadic social context of adolescent aggressive behaviour using a novel experimental aggression paradigm.

Keywords: Social networks, social network analysis, Hot Sauce Paradigm, development, aggression, peer relationships

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Aggression is defined as behaviour intended to harm (Baron & Richardson, 1994). Human aggression can take many forms, ranging from direct physical and verbal aggression to more indirect and covert forms of aggression, such as damaging a target's social status through gossip (Heilbron & Prinstein, 2008). Aggression varies in the type and severity of intended harm, ranging from severe physical, social or emotional injury to the potentially more fleeting impact of a hostile facial display (McCarthy & Elson, 2018).

Across human development, aggression can be profoundly destructive. Bullying, defined as persistent aggression towards a lower-status individual (Olweus, 1993), is associated with a range of adverse outcomes for both victims and perpetrators, including mental illness, substance use, and poor educational attainment (Rothon, Head, Klineberg, & Stansfeld, 2011; Kaltiala-Heino, Rimpela, Rantanen, & Rimpela, 2000). However, viewed more broadly, aggressive behaviour serves a range of adaptive social functions, such as negotiating power and status hierarchies, safeguarding access to individual and group resources, and deterring attack from outsiders (Buss & Shackleford, 1997). Conceptualised in this way, aggression can be viewed as one of the many complex social behaviours in which an individual can acquire competence.

Throughout childhood and adolescence, individuals vary in their tendency to aggress (Huesmann et al. 1984). Individual differences in aggression influence friendship formation, with children and adolescents forming friendships based on similarity in aggression levels (Dijkstra et al. 2011; Rambaran et al. 2015). At the same time, there is evidence that aggression is subject to social influence, with aggressive friends and peer group norms serving to increase an individual's tendency to engage in aggressive, violent and delinquent behaviour (Allen et al. 2005; Dishion et al. 2010; Dishion & Tipsord, 2011; Sijtsema et al. 2009). Furthermore, for a given individual, at a given point in time, their level of aggression is moderated depending on who they are interacting with. In a study by Coie et al. (1999), the dyadic context (i.e. the particular pairing of individuals) accounted for more variance in children's reactive aggression than their individual traits, while Hubbard et al. (2001) further showed that these children's level of proactive aggression was influenced by both the individual and partner-level context. To date, there is little evidence on the dyadic context of aggression in adolescence. The current study investigated variation in adolescents' dyadic aggression depending on their perceived relationship strength with the target.

Across development, the incidence, form, and function of aggression changes. In general, aggressive behaviour becomes less reactive and more strategic throughout childhood and adolescence (Hawley, 2003). Superimposed upon this trajectory, some studies find a mid-adolescent peak in certain forms of aggression (e.g. physical, social), followed by decline (Aber, Brown & Jones, 2003; Björkqvist, Lagerspetz, & Kaukiainen, 1999; Farrell, Sullivan, Esposito, Meyer, & Valois, 2005; Karriker-Jaffe, Foshee, Ennett, & Suchindran, 2008). While early adolescent increases in physical aggression may be linked to increasing gonadal hormone levels (Spear, 2000), or a strategy for establishing status in secondary school (Pellegrini and Bartini 2001), the later adolescent decline has been attributed to cognitive factors, such as age-related increases in executive control, perspective-taking ability, and moral affective responding (Archer & Coyne, 2005; Laible, Panfile Murphy, & Augustine, 2014). Other studies report that social aggression remains high throughout adolescence, with individuals refining their use of aggression to be more proportionate, harder to detect, and with reduced likelihood of retaliation (Björkqvist, Österman, & Kaukiainen, 2000; Björkqvist, Österman & Lagerspetz, 1994; Card et al., 2008). More research is needed to clarify the developmental trajectory and determinants of aggressive behaviour in adolescence, particularly using more subtle measures of aggression. In the current study, we investigated cross sectional age differences in dyadic predictors of experimental aggression in participants aged 11-17.

During adolescence, individuals develop greater competence and understanding of subtle, complex social behaviours with multi-layered, context-dependent meaning (Blakemore & Mills, 2014; Brown & Larson, 2009; Burnett & Blakemore, 2009; Selman, 1980). Behaviour that could be classified as aggressive varies in meaning across different social contexts. For example, a physical or verbal challenge may be unambiguously negative when directed toward a disliked peer, but playful or even affectionate towards a friend. During adolescence, physically and socially aggressive behaviours such as teasing, pranking and 'creating drama' (instigating or facilitating social aggression) are perceived as playful and exciting for some individuals, while others find them stressful (Boyd, 2014). There is little research on such complex, often ambivalent, peer relationship constructs, and how these alter during development. In the current study, we investigated the incidence of experimental, hypothetical aggression based on whether the pre-existing dyadic relationship was characterised by self-reported mutual or unilateral real-world physical/social aggression.

Eliciting data on aggression in adolescent peer relationships presents a number of challenges. Particularly when data are collected in school, participants may be unwilling to report acts of aggression, due to social desirability or fear of repercussion. Experimental measures of aggression may circumvent some of these problems and provide a laboratory model to investigate aggressive behaviour across multiple participants. The Hot Sauce Paradigm (HSP) is an experimental measure of intent to physically aggress towards others (McGregor et al., 1998). In the HSP, participants decide how much painfully spicy sauce a fellow participant should drink. Prior studies show adult participants administered more hot sauce towards a confederate who had given them a noxious stimulus or violated their world views (Lieberman, Solomon, Greenberg, & McGregor, 1999; McGregor et al., 1998). In this study we adapted the HSP for multiple-recipient, hypothetical, questionnaire completion in a school setting.

We elicited experimental, hypothetical aggression in adolescents using the adapted HSP. Participants decided which strength of imaginary spicy sauce they would give to each of their classmates to drink. To characterise the social context of aggressive behaviour, we used a Social Network Questionnaire (SNQ; Burnett Heyes et al. 2015; Harrison, Sciberras, & James, 2011). The SNQ quantified dyadic relationship strength in each network, that is, the strength of social ties reported by each participant toward each of their classmates. This could range from antipathies characterised by distrust and dislike to strong friendships characterised by trust, liking, closeness and companionship. Participants reported whether the dyadic relationship was characterised by real-world social/physical aggression behaviour (teasing/pranking/creating drama), and whether this was perceived as mutual or unilateral.

The hypotheses were as follows. First, we predicted effects of social tie strength on aggression across the network, with participants being more willing to aggress toward peers with whom they reported a weaker or more negative social tie [H1]. Second, we predicted this effect would diminish with age, as late adolescents are less overtly aggressive [H2]. Third, we predicted a positive association between experimental and self-reported real-world dyadic aggression (teasing/pranking/creating drama; mutual vs. unilateral) [H3a], and tested whether this relationship varied by age [H3b]. Fourth, we predicted that males would allocate more hot sauce across the network [H4], in line with evidence that males show greater aggression in laboratory tasks (Denson, O'Dean, Blake & Beames, 2018).

Method

Participants

We included 162 participants across 11 classrooms from three state schools (two urban, one rural) in the Midlands and South East of England based on cohort year group (grade level) and classroom (see Table 1). One school was male-only in year (grade) 7-11. The remaining year groups and schools were mixed gender. We selected classrooms in consultation with a teacher such that each class spent time together each week as a group. We obtained parent/guardian consent for all participants. Participants additionally indicated assent or non-assent for each measure by marking one of two check boxes at the end of each measure (see Supporting Information 1). We collected data in spring 2016. The study was approved by the local research ethics committee and conducted in accordance with the WMA Declaration of Helsinki (2008).

Materials

Hot Sauce Paradigm. We adapted the Hot Sauce Paradigm (HSP), an experimental measure of intent to aggress (McGregor et al. 1998). In the original HSP, participants decided what volume of unpleasantly spicy sauce a confederate would drink, and were deceived into believing the confederate would drink it. We adapted the HSP for hypothetical, multiple-recipient, questionnaire completion in school. Therefore, the current HSP involved no deceit. We instructed participants to imagine, and then to indicate using pen and paper, which of four spicy sauce strengths (1=mildly spicy and enjoyable, to 4=extremely spicy, painful and damaging) they would give to each of their classmates to drink. For further details see Supporting Information 2.

Social Network Questionnaire. As in a prior study (Burnett Heyes et al., 2015), a Social Network Questionnaire instructed participants to respond to the following network questions for each classmate for whom parent/guardian consent had been obtained: a) presence of a familial tie (yes=1, no=0); b) duration of acquaintance (years); c) relationship classification (3=best friend, 2=good friend; 1=friend, 0=acquaintance; -1=negative relationship); d) time spent outside school (yes=1, no=0); e) conflict resolution (1=great effort to resolve; 0=small effort; -1=would not care); f) trust (1=more than; 0=the same as; -1=less than a random person from another school); g) academic collaboration (yes=1, no=0). The following items were added for the current study: h) 'tease', i.e. real-world dyadic physical/social aggression (e.g. teasing, pranking or creating drama) and its perceived direction ('ego-tease': ego [self] aggresses toward alter [other]; 'alter-tease': alter aggresses toward ego; neither). For further details see Supporting Information 2.

Familial tie (a) and duration of acquaintance (b) are control items. Since there were only two reciprocal family ties, we did not consider this variable further. Summing responses to relationship classification (c), time spent outside school (d), conflict resolution (e), trust (f) and academic collaboration (g) gives a composite measure of relationship strength (Burnett Heyes et al. 2015). The real-world dyadic aggression item (h) was included to test hypotheses relating mutual and unilateral real-world dyadic social/physical aggression to experimental aggression behaviour.

Family Affluence Scale-II. The Family Affluence Scale II (FAS-II) is a four-item measure of socioeconomic status suitable for completion by adolescents (Boyce, Torsheim, Currie, & Zambon, 2006). We included this measure to describe the sample and to justify pooling participants across schools.

Procedure

Experimental procedure. Participants in each group completed the measures in the order in which they appear above using pen and paper in large testing rooms that afforded privacy for each individual. The session took approximately 40 minutes.

Statistical procedure. First, we adopted a broadly descriptive approach to characterise the sample and identify variables to control for in analyses comparing across year group. We conducted a Chi squared test comparing the gender distribution across year groups, then univariate ANOVA (fixed factors: Gender, year group) to identify gender/year group differences in socioeconomic status (FAS-II score).

Second, we used network analysis methods to test hypotheses regarding predictors of experimental aggression at the network level. As a first step to investigate the role of social tie strength and self-reported dyadic real-world aggression on HSP allocation, we constructed a first regression model using multi-group multiple regression with quadratic assignment procedure (MRQAP) to predict dyadic hot sauce allocation with predictors SNQ strength, ego-tease, alter-tease, gender, and year group interactions. MRQAP is a form of multiple regression that takes into account statistical interdependency in network data (Dekker, Krackhardt, & Snijders, 2007). Multi-group MRQAP (MG-MRQAP) is a variation on this method that takes into account nesting of data in multiple discrete networks (Burnett Heyes et al., 2015). That is, this method tests the extent to which dyadic predictor variables account for variance in levels of aggression across all dyads in the network and across all networks. For an in-depth explanation of this method, see Burnett Heyes et al. (2015). After establishing an effect of these variables, a second regression

model further investigated whether the impact of self-reported dyadic real-world aggression differed depending on whether participants reported this as mutual or unilateral. Therefore, we conducted MG-MRQAP to predict dyadic hot sauce allocation with predictors SNQ strength, unilateral ego-tease, unilateral alter-tease, bilateral tease (i.e. ego reports teasing as bilateral), gender, and year group interactions. In both models we eliminated non-significant predictors in a backward manner and set the 2-tailed threshold for significance at $p<.05$. To further elucidate effects of interest we computed network descriptives and ran single-group regression models (reported in Supporting Information 3 and 4).

Results

Gender distribution

Gender differed significantly across year groups ($X^2(5)=30.8$, $p<.001$). Therefore, we included gender as a predictor variable in subsequent year group analyses.

Socioeconomic status

The sample was of medium to high affluence as indicated by mean classroom scores on the FAS-II (Boyce et al. 2006). There were no systematic year group or gender differences in mean scores on the FAS-II (year group: $F(5,106)=1.12$, $p=.355$; gender: $F(1,106)=.008$, $p=.928$; gender*year group: $F(4,106)=.970$, $p=.427$).

Hot Sauce allocation

We conducted MG-MRQAP predicting hypothetical aggression based on SNQ strength, ego-tease, alter-tease, gender and their interactions with year group. The final model shown in Table 2 (left) indicates hot sauce allocation is inversely predicted by ego-rated social tie strength, such that participants were less inclined to aggress toward peers with whom they reported a stronger positive social tie [H1]. This effect decreased modestly with age [H2]. Across age, participants allocated hotter sauce toward peers whom they reported teasing, and whom they reported being teased by [H3a]. There was no main effect of gender [H4]. Single group MRQAP models (Supporting Information 3) confirmed this general picture: Stronger social tie strength was associated with weaker hot sauce allocation, while either or both tease variables predicted stronger hot sauce allocation. For descriptives, see Supporting Information 4.

We conducted MG-MRQAP predicting hypothetical aggression based on SNQ strength, unilateral ego-tease, unilateral alter-tease, bilateral tease, gender and their interactions with year

group. The final model shown in Table 2 (right) indicates Hot Sauce allocation was predicted by unilateral ego-reported real-world aggression both by and of alters; ego-reported bilateral real-world aggression resulted in stronger hot sauce allocation in older (relative to younger) year groups; and ego-reported unilateral real-world aggression by alters resulted in stronger hot sauce allocation in younger (relative to older) year groups [H3b]. Social tie strength showed a similar main effect and year group interaction as in the first model. See Supporting Information 3 for single group regression models and Supporting Information 4 for descriptives.

Discussion

The current study investigated dyadic social network determinants of experimental, hypothetical aggression behaviour in adolescence using a Hot Sauce Paradigm (HSP). The sample included both urban and rural schools, and average classroom affluence was medium to high. Overall, participants (aged 11-17) allocated weaker hypothetical hot sauce to peers with whom they reported strong, positive social ties and an absence of self-reported unilateral real-world aggression. With increasing cross-sectional age, the impact of social tie strength diminished and hot sauce was allocated increasingly in the context of self-reportedly mutual real-world aggression.

Dyadic predictors of Hot Sauce allocation

Aggression can have negative consequences for both perpetrators and victims, yet can also be highly adaptive. Learning to use and respond appropriately to aggression is an important developmental goal (Bingham et al. 2011; Spear, 2000). However, the impact and meaning of aggression varies depending on its social context. We investigated dyadic predictors of adolescents' experimental, hypothetical aggression.

Multiple regression analysis showed that adolescent participants allocated stronger hypothetical hot sauce to peers with whom they reported a weak or more negative social tie (e.g. dislike, absence of friendship, lack of trust). This finding is consistent with participants' use of the adapted Hot Sauce task to reflect real-world animosity. Future research using this paradigm should differentiate between dislike versus weak or acquaintance relationships, as prior research indicates the former should be predictive of aggression (Erath et al. 2009).

With increasing age group, there was a decrease in the impact of dyadic social tie strength on hot sauce allocation. That is, whereas young adolescents allocated stronger hot sauce to classmates with whom they reported weak or negative social ties, late adolescents did not show this pattern.

Evidence from prior research suggests that across development, aggression becomes less frequent (Aber, Brown, & Jones, 2003; Bongers et al., 2003; Farrell, Sullivan et al., 2005; Karriker-Jaffe et al., 2008), or indeed less overt, less reactive and more strategic (Cairns et al., 1989; Card et al. 2008; Hawley, 2003; Heilbron & Prinstein, 2008; Xie et al., 2002). Potentially, the late adolescent pattern corresponds to a decline in aggression or in the use of hot sauce allocation to reflect real-world dyadic aggression or animosity. In relation to the second possibility, late adolescents may refrain from showing aggression in a context in which there is an observer, e.g., an experimenter (Card et al. 2008). Research should investigate additional real-world correlates of hot sauce allocation (e.g. observational and other-reported measures of aggression) at the individual and dyadic level, and the extent to which these vary during development.

Dyadic real-world aggression and Hot Sauce allocation

Consistent with the above suggestion, we observed relationships between hot sauce allocation and self-reported real-world aggression at the dyadic level ('teasing, pranking or creating drama'). In the first regression model, participants allocated hotter sauce to peers whom they reported aggressing towards, and from whom they reported receiving aggression.

A second regression model further examined the predictive value of real-world dyadic aggression as a function of whether it was reported by the participant as mutual or unilateral. Extending the first model, participants allocated hotter sauce to peers *toward* whom they reported unilateral real-world aggression, and *from* whom they reported receiving unilateral real-world aggression. In addition, this second analysis showed two opposite age effects. First, the impact of self-reported unilateral alter-to-ego real-world aggression on hot sauce allocation decreased with age. That is, in younger (relative to older) year groups, participants allocated stronger hot sauce to classmates from whom they reported receiving unilateral aggression. Taken into consideration with the age effect on the impact of relationship strength discussed above, this pattern of findings is consistent with young adolescents' use of the task to reflect real-world animosity, potentially in the context of dislike, antipathies and bully-victim relationships. Of course, further studies are required to evaluate this suggestion. Second, the impact of self-reported *mutual* real-world aggression on hot sauce allocation *increased* with increasing cross-sectional age. That is, in older (vs. younger) year groups, participants allocated stronger hot sauce to classmates with whom they reported mutual 'teasing, pranking and creating drama'. As a next step, it would be valuable to investigate the extent to which participants' evaluations of real-world aggression were reported as

reciprocally mutual. This could have implications for interpreting the late adolescent pattern of behaviour.

Hot Sauce allocation: Hypothetical aggression?

In prior research, adult participants allocated a greater volume of real spicy sauce to unknown confederates who held differing worldviews, or had nominated the participant to consume an unpleasant drink (Lieberman et al., 1989; McGregor et al. 1998). In the current study, younger adolescent participants in particular allocated stronger hypothetical hot sauce to classmates with whom they reported weak or negative social ties, and unilateral real-world aggression. This is consistent with young adolescents' use of the task to reflect real-world animosity, but does not necessarily correspond to real world, direct aggression. Indeed, the current paradigm offers participants the opportunity to aggress hypothetically, without fear of retaliation. Consistent with this suggestion, adolescents allocated stronger hot sauce not only to classmates toward whom they reported aggressing in the real world, but also to classmates whom they reported as targeting them to receive real-world aggression. This signposts the potential sensitivity of the adapted Hot Sauce Paradigm to distinct motivations for aggression across a range of dyadic relationship contexts.

Summary and conclusion

We investigated dyadic determinants of adolescents' hypothetical aggression toward peers using an experimental aggression paradigm, the Hot Sauce Paradigm (HSP), in a school-based social network setting. Participants (N=162, aged 11-17) allocated stronger hot sauce to peers with whom they reported a weaker or more negative social tie, and with whom they reported unilateral real-world aggression (e.g. teasing, pranking, creating drama). With increasing cross-sectional age, there was a reduction in the impact of social tie strength on Hot Sauce allocation. In addition, compared with their younger counterparts, older adolescents allocated hotter sauce in relationships characterised by self-reportedly mutual real-world aggression. These findings are novel, and require longitudinal replication before developmental conclusions can be drawn. The study extends our understanding of the dyadic context of adolescent social behaviour using a new experimental measure of hypothetical aggression. While many experimental aggression paradigms have been developed, most are unsuitable for adolescent completion in school due to ethical or practical considerations.

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Data Availability Statement

Data available on request from the authors.

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Table 1. Descriptive data for each classroom.

Demographical information	Cr01	Cr02	Cr03	Cr04	Cr05	Cr06	Cr07	Cr08	Cr9	Cr10	Cr11
School code	A	A	A	A	B	B	B	B	A	C	C
Year group/grade	8	10	12	12	7	8	11	9	8	9	12
Age range	12-13	14-15	16-17	16-17	11-12	12-13	15-16	13-14	12-13	13-14	16-17
N	20	9	16	20	16	14	13	16	16	13	9
N male	20	9	5	8	10	6	8	7	16	5	4
FAS-II: mean (SD)	5.94 (1.80)	5.61 (1.36)	6.57 (1.60)	5.85 (1.73)	6.92 (1.44)	6.17 (1.19)	6.00 (1.55)	6.18 (1.40)	7.07 (1.28)	7.00 (1.73)	7.88 (.641)

Abbreviations: Cr, classroom; FAS-II, Family Affluence Scale.

Table 2. Results of multiple regression analyses predicting Hot Sauce allocation.

Hot Sauce model 1	B	P	Sig.	Hot Sauce model 2	B	P	Sig.
Final model: R^2=.267, p<.001				Final model: R^2=.290, p<.001			
Strength	-.223	<.001	***	Strength	-.210	<.001	***
				Tease bilateral	.132	.745	
Ego tease	.320	.010	*	Ego tease unilateral	.554	.002	**
Alter tease	.371	.001	**	Alter tease unilateral	1.11	<.001	***
Gender (male)	.428	.069		Gender (male)	.364	.072	
Strength*year group	.045	<.001	***	Strength*year group	.040	<.001	***
				Tease bilat*year grp	.141	.019	*
				Alter tease unilat*year grp	-.151	.029	*
Gender*year group	-.118	.048	*	Gender*year group	-.102	.068	

Levels of significance and p-values: *** <.001, ** <.01, * <.05. Excluded predictor variables (in order) for model 1: Alter tease*year group (p=.516), ego tease*year group (p=.869). Excluded predictor variables (in order) for model 2: Ego tease unilateral*year group (p=.410). Intercepts for each classroom omitted. Gender variables retained to control for age differences in gender distribution. Non-significant main effects retained for which there is a significant interaction with year group.