



PAPER

Precursors to aggression are evident by 6 months of age

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Abstract

We tested the hypothesis that developmental precursors to aggression are apparent in infancy. Up to three informants rated 301 firstborn infants for early signs of anger, hitting and biting; 279 (93%) were assessed again as toddlers. Informants' ratings were validated by direct observation at both ages. The precursor behaviours were significantly associated with known risk factors for high levels of aggressiveness. Individual differences were stable from early infancy to the third year and predicted broader conduct problems. These findings suggest that some individuals set forth on the trajectory to high levels of aggression by 6 months of age. The findings have implications for developmental studies of aggression, clinical prevention and intervention strategies, and theoretical considerations regarding the detection of precursors in different domains of development.

Introduction

The aim of this paper is to illustrate a method for tackling a fundamental developmental question, determining when an early behaviour may be considered to be a precursor to a later outcome. The search for precursors may be undertaken in many different domains of development (for examples, see Hay & Angold, 1993). In this paper we illustrate our proposed method for identifying precursors with reference to the early development of aggression.

It is well established that developmental trajectories toward high levels of aggression emerge in very early childhood (Broidy, Nagin, Tremblay, Bates, Brame, Dodge, Fergusson, Horwood, Loeber, Laird, Lynam, Moffitt & Pettit, 2003; NICHD Early Child Care Research Network, 2004; Tremblay, Nagin, Séguin, Zoccolillo, Zelazo, Boivin, Pérusse & Japel, 2004). Individual differences in levels of aggressiveness are apparent by the second and third years of life, as reported by informants (e.g. Côté, Vaillancourt, LeBlanc, Nagin &

Tremblay, 2006) and as observed directly in toddlers' interactions with peers (Hay, Nash, Caplan, Pedersen, Ishikawa & Vespo, 2011c). In this paper we test the specific hypothesis that developmental precursors to high levels of aggression can already be detected in early infancy.

At least three criteria must be met when trying to identify precursors to later behaviours (Charman, Baron-Cohen, Swettenham, Baird, Cox & Drew, 2000; Hay & Angold, 1993). First, the concept of precursor, as opposed to the more general concept of risk factor, implies *resemblance* between the precursor and later developmental outcome. Thus we focus on infant behaviours that *resemble* angry aggressiveness in older children, their expressions of distress when confined or frustrated (a precursor to anger) and striking out with physical force (a precursor to physical aggression). We seek early precursors to angry aggressiveness, rather than unemotional proactive aggression, because angry protest is a well-known feature of young children's conflicts (e.g. Hay, Hurst, Waters & Chadwick, 2011a), and there is

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evidence that individual differences in emotionally dysregulated aggression appear by 2 years of age (Cummings, Iannotti & Zahn-Waxler, 1989).

However, resemblance alone does not prove that an early-occurring behaviour is related to a later outcome. Surface resemblance provides face validity but does not prove that the early behaviour matures into the later one. A second criterion for determining an infant's behaviour is a precursor to a later outcome is *association with well-established risk factors* for the later outcome. A number of familial risk factors are associated with the high aggressiveness trajectory, including family income, maternal education, early entry into parenthood and mothers' psychopathology and antisocial behaviour (Broidy *et al.*, 2003; Côté *et al.*, 2006; NICHD Early Child Care Research Network, 2004; Tremblay *et al.*, 2004). Prenatal risk factors, in particular maternal smoking and psychopathology in pregnancy, have also been found to predict aggression and related conduct problems. Recent evidence suggests that the impact of prenatal smoking is bound up with other genetic and environmental factors that predict antisocial outcomes (D'Onofrio, van Hulle, Waldman, Rodgers, Harden, Rathouz & Lahey, 2008; Rice, Harold, Boivin, Hay, van den Bree & Thapar, 2009). Maternal depression, anxiety and stress in pregnancy do predict aggressive outcomes in offspring (e.g. Hay, Pawlby, Waters, Perra & Sharp, 2010a; Maki, Veijula, Rasanen, Joulemaa, Valonen, Jokelainen & Isohanni, 2003; O'Connor, Heron, Golding, Beveridge & Glover, 2002), even when controlling for genetic factors. For example, mothers' reports of a stressful pregnancy are associated with conduct problems in offspring, even if, through egg or gamete donation, the mother is genetically unrelated to the foetus (Rice, Harold, Boivin, van den Bree, Hay & Thapar, 2010). If these sociodemographic and prenatal risk factors are similarly associated with infants' anger and use of force, there would be stronger evidence that the early behaviour is a true precursor to later aggressiveness.

Finally, an early behaviour can be deemed a precursor to the later outcome only if individual differences show *continuity over time*. In this paper we seek evidence for longitudinal continuities from early behaviours in infancy to aggression and related conduct problems in toddlerhood. This requires examination of continuity in the precise behaviours measured in infancy and also prediction to new forms of aggressive behaviour made possible when infants acquire more motor skills and begin to use instrumental aggression intentionally, to defend their possessions (Hay *et al.*, 2011a). By early childhood, aggressiveness may be accompanied by a broader range of conduct problems.

In sum, we hypothesize that 6-month-olds' early tendencies to express anger and use force against other people will meet the three criteria of *resemblance*, *association with risk factors*, and *continuity over time*. We further hypothesize that measurement of the infant precursor will convey added predictive power, beyond the contribution of familial risk factors and temperamental differences in self-regulation.

Method

Design

We tested these hypotheses in the 5-wave prospective longitudinal Cardiff Child Development Study (CCDS). First-time parents were interviewed during pregnancy. Infants were assessed at mean ages of 6, 12, 21 and 33 months post partum, in an alternating sequence of home visits and laboratory visits.

Participants

Three hundred and thirty-two primiparous women were recruited from prenatal clinics in two UK National Health Service (NHS) Trusts and a specialist NHS midwifery team designed to support pregnant women who were at high social risk (e.g. due to young age, homelessness, or experience of domestic violence). Parents were asked to provide contact details if they were interested in learning more about the study. Bookings for home visits were made in a follow-up telephone call. Written consent was obtained at the time of the prenatal interview and subsequently at the post partum assessment. The study was approved by the NHS Multi-Centre Research Ethics Committee for Wales.

The main reason given for not joining the study was lack of time to take part in a labour-intensive longitudinal study. Analysis of the postal codes of families who asked to learn more but decided not to participate in the study revealed that those who did not participate were representative of the entire range of socioeconomic categories associated with UK postal codes and thus there was no evidence of selective refusal. The sample is nationally representative. Comparison with families with firstborn infants in the UK Millennium Cohort Study revealed that the sample was not significantly different from this most recent national cohort sample on demographic characteristics (Kiernan, personal communication, April 2009).

Of the 332 families assessed in pregnancy, 316 (95.2%) were traced and assessed at least once after childbirth. The present analyses focus on 301 families who completed

questionnaires in infancy, whose demographic characteristics are presented in Table 1. They did not differ significantly from the overall sample on any demographic variable.

Procedure

Wave 1: Home visit in pregnancy

Mothers and 86% of their partners (94% of partners who were living with the mothers) were interviewed at home during the third trimester of pregnancy. In 99% of cases, the partner was the biological father (in other cases, the mother's same-sex partner). If the parents lived together, two interviewers went to the home, interviewing mothers and partners in different areas of the house or flat. Mothers and partners were then asked to complete questionnaires.

Wave 2: Early infancy home visit

A month before the infant reached the target age of 6 months, a research assistant rang the family and booked a time for a home visit, which incorporated another maternal interview and an observation of the infant. Infants were assessed at a mean age of 6.6 months (SD 0.9). For the purpose of this paper, we focus on one observational measure, the infant's vocal distress when being strapped into a car seat. Mothers, fathers and a third person who knew the infant well were asked to complete questionnaires. In 287 families, at least one informant completed the Wave 2 questionnaire (93% of those assessed at the 6-month home visit). Questionnaires were received from 279 mothers, 220 fathers and 206 third informants.

Table 1 Demographic characteristics

Variable	Infancy $N = 301$	Toddlerhood $N = 279$
Mother's age at birth (Mean)	28.53	28.76
Stable partnerships	90.7%	92.1%
Marital status (% married)	53.5%	54.8%
Ethnicity (% British or Irish)	92.7%	92.9%
Social class (% middle class)	53.5%	54.8%
Mother's education (% \geq basic qualifications)	80.4%	83.9%
Child's sex (% female)	43.9%	43.7%
Sociodemographic risk index (Mean)	1.36	1.28

Note: The sociodemographic risk index did not differ significantly between the 301 families assessed in infancy and the 279 families who were assessed at one or both toddler assessments.

Wave 3: Late infancy laboratory visit

Families participated in laboratory assessments at a mean age of 12.8 months (SD 1.2), with 291 families providing some information at this time point. The laboratory visit included direct observation of peer interaction in the context of a simulated birthday party. The primary caregiver (90% mothers) completed a questionnaire ($N = 280$, 96% of those participating at the wave).

Wave 4: Early toddler home visit

A second home visit was made at a mean age of 20.6 months (SD 2.3), with 279 families providing information at this time point. Questionnaires were completed by up to three informants in 258 families (253 mothers, 203 fathers and 206 third informants).

Wave 5: Late toddler laboratory visit

A second laboratory visit was scheduled at a mean age of 33.6 months (SD 2.5) with 272 families participating at this time point. Peer interaction was again observed during a simulated birthday party. Questionnaires were completed by at least one informant in 254 families (240 mothers, 179 fathers and 184 third informants). Of the 301 families who had reported on the infants' behaviour in infancy (at either Wave 2 or 3), 279 (93%) provided questionnaire reports at one or both toddler assessments.

Measures

Sociodemographic risk factors

Measures of sociodemographic risk, including the mother's age, educational attainments, occupation, and marital status, were ascertained from the Wave 1 interviews and questionnaires. Social class was determined using the Standard Occupational Classification 2000 (SOC2000; Elias, McKnight & Kinshott, 1999). A dichotomous variable, scored 1 or 0, was created that classified families as working or middle class. Information provided about mothers' education was also used to create a dichotomous variable, scored 1 or 0, indicating whether the mother had not attained the basic level of educational qualifications expected in the UK (at least 5 GCSE examinations passed at grades A* to C or the equivalent CSE or 'O' level grades). Because the vast majority of parents expecting their first child (94%) were in stable partnerships, marital status, scored 1 or 0, was dichotomized in terms of whether the mother was unmarried. The risk factors were themselves correlated.

To avoid problems of multicollinearity in subsequent regression analyses, a general sociodemographic risk index was computed based on the following variables: working-class social status, lack of basic educational qualifications, being a teenager at the time of the child's birth, being without a partner, and not being legally married. Because most of the parents were in stable partnerships, marital status was included in the risk index due to the well-established increased risk for separation in cohabiting couples and prior evidence for links between marital status and aggressive outcomes in offspring (Hay, Pawlby, Waters, Perra & Sharp, 2010a). The risk index showed an acceptable level of internal consistency ($\alpha = .74$).

Maternal depression. The Wave 1 prenatal interview incorporated the mood disorder and anxiety disorder sections of the Schedules for Clinical Assessment in Neuropsychiatry (SCAN; Wing, Babor, Brugha, Burke, Cooper, Giel, Jablenski, Regier & Sartorius, 1990), with an additional screen for psychotic symptomatology. Final decisions about clinical caseness were made in case conferences with two adult psychiatrists. There was significant agreement between two psychiatrists' diagnoses of prenatal disorder, $\kappa = .78$, $p < .001$, and past disorder, $\kappa = .76$, $p < .001$. In addition, a random sample of 20 cases in which researchers had not identified possible caseness was reviewed by the two psychiatrists, who agreed that disorder was not present. Dichotomous variables were created to measure presence of DSM-IV mood disorder (Major Depressive Disorder or Bipolar Disorder) in pregnancy or the past. At Wave 2, mothers were again interviewed using the SCAN, with all possible cases reviewed in case conferences with an adult psychiatrist. Diagnoses of post partum mood disorder were made with good agreement, $\kappa = .80$, $p < .001$.

Mothers' history of antisocial behaviour. Mothers reported on their history of arrest as part of the life events section of the Wave 1 questionnaire. The questionnaire battery at Wave 1 also included a section labelled 'What I Am Like', which included items from the screening questionnaire for the International Personality Disorder Examination (IPDE; Loranger, Sartorius, Andreoli, Berger, Buchheim, Channabasavanna, Coid, Dahl, Diekstra, Ferguson *et al.*, 1994). The screening questionnaire associated with the IPDE interview has been used in the UK and in community samples, including a large national sample in Australia (Lewin, Slade, Andrews, Carr & Hornebrook, 2005). For the present analyses, a subset of IPDE screening items that corresponded to the DSM-IV criteria for Antisocial Personality Disorder (ASPD) was identified.

Because a diagnosis of ASPD requires a history of juvenile conduct disorder, an additional set of items measuring DSM-IV symptoms of CD was included in the questionnaire. The conduct symptom items were incorporated into a section of the Wave 1 questionnaire entitled 'What I Was Like as a Child'. A composite variable created by summing the two individual scales showed an acceptable level of internal consistency, $\alpha = .79$, and was further validated by mothers' reports of their history of arrest, $r(323) = .56$, $p < .001$.

Mothers' cigarette smoking in pregnancy. Self-reported smoking was ascertained from the Lifestyle section of the Wave 1 questionnaire, which included questions about diet, exercise and leisure activities. The mean number of cigarettes per day across pregnancy was computed.

The Cardiff Infant Contentiousness Scale (CICS). A brief four-item scale, embedded into a checklist of normative developmental milestones, was devised to assess infants' explicit expressions of anger and use of force against their companions, i.e. manifesting a general tendency to be *contentious*, prone to conflict when interacting with other people (Hattwick, 1936). At this early age we do not assume that anger and use of force reflect intent to harm other people and so do not describe them as aggressive. Rather, we see them as possible precursors to later, intentional aggression. The other items on the milestones checklist pertained to age-appropriate motor and communication skills. Informants were asked to report whether each behaviour was often, sometimes, or not yet shown by the infants. The four items that comprise the CICS scale are *hits out at people*; *angry moods*; *bites*; and *has temper tantrums*.

The milestones checklist was first administered at Wave 2. The CICS scale had adequate internal consistency (median α across mothers, fathers and third informants being .69). Significant agreement was obtained between all possible pairs of informants, with high agreement between parents, $r(217) = .51$, $p < .001$. Our previous analyses have shown that the mean CICS score across possible informants was moderately stable from 6 to 12 months, $r(266) = .49$, $p < .001$, and significantly correlated with the infant's observed distress when confined, i.e. strapped into a car seat (for more details see Hay, Perra, Hudson, Waters, Mundy, Goodyer, Harold, Thapar & van Goozen, 2010b), and to the infants' observed tendencies to strike out at or grab toys from peers during the simulated birthday party (for more details see Hay, Mundy, Carta, Roberts, Perra, Waters, Perra, Jones, Jones, Goodyer, Harold, Thapar & Van Goozen, 2011b).

For the present analyses, Wave 2 CICS factor scores were derived through a measurement model whereby a latent dimensional construct was estimated using the maternal, paternal and third informant's assessments as indicators. These factor scores, analogous to standardized scores, were constrained to have a mean of 0 and $SD = 1$. Mplus 7 (Muthén & Muthén, 2012) was used to implement this measurement model and calculate factor scores. A Maximum Likelihood estimator with robust standard errors (MLR) was used to allow for non-normal distributions of the indicators. Mplus 7 uses Full-Information Maximum Likelihood methods (FIML), which makes use of all the information available; in cases when only one or two informants provided a rating, it was still possible to estimate a score based on the available information. Furthermore, to allow estimation of a dimensional score for the 14 additional cases in which families had not completed questionnaires at Wave 2 but did so at Wave 3, we regressed Wave 2 factor scores on Wave 3 scores, yielding a total $N = 301$ for the present analyses.

At Waves 4 and 5, the CICS items measured at 6 months were again embedded into a checklist of age-appropriate developmental milestones, suitable for the toddler years. Two new age-appropriate items measured instrumental aggression: *grabbing toys out of other children's hands* and *hitting or kicking to get toys*. With the inclusion of these instrumental items, the intentionality of the toddlers' behaviour becomes clearer (see Hay *et al.*, 2011a), and so we treat the six-item CICS scale administered at Waves 4 and 5 as a measure of toddlers' aggressiveness. Once again the informants' mean rating was significantly validated by the toddlers' observed tendencies to use physical aggression against their peers during the simulated birthday party at Wave 5, $r = .14, p < .05$.

Of the 301 families who completed the CICS in infancy, 277 (92%) provided milestones checklists at Wave 4 and/or Wave 5 from at least one informant (274 mothers, 219 fathers and 239 third informants). The six-item toddler CICS showed internal consistency, median α being .75. All informants' reports were significantly associated with those of all other informants at each wave of assessment. Inter-rater correlations for the six-item toddler CICS ranged from $r = .48, p < .001$ for mothers and fathers at Wave 4 to $r = .27, p < .001$ for fathers and other family members at Wave 5. Factor scores for Wave 4 and Wave 5 CICS were estimated separately at each time point by constructing separate measurement models: in each time point a latent dimensional construct was estimated using the available informants' ratings. The estimation of factor scores was conducted in the same way as in Wave 2 and yielded CICS factor scores constrained to have mean = 0 and $SD = 1$ at each time point. Finally, a mean CICS score for

the toddler assessments was constructed by averaging across factor scores estimated at Wave 4 and Wave 5 ($N = 286$), which was used in subsequent analyses as the summary measure of aggressiveness in toddlerhood.

The Infant Behaviour Questionnaire (IBQ). Infants' temperamental self-regulation in the face of restrictions on their activities was measured by the Distress to Limitations scale of the Infant Behavior Questionnaire (IBQ; Rothbart, 1981), administered at Wave 2. The items on the distress to limitations scale pertain to the infant's reactions to potentially frustrating situations, but do not explicitly measure physical aggression. The IBQ was completed by at least one informant in 265 families (250 mothers, 207 fathers and 206 other family members or friends who knew the infants well). Alpha coefficients ranged from .83 to .87 across informants (median $\alpha = .84$). Mothers' reports were significantly associated with fathers' reports, $r(202) = .56, p < .001$, and with the third informants, $r(193) = .49, p < .001$, with fathers' and third informants' reports also significantly correlated, $r(168) = .31, p < .001$. Mplus 7 was used to construct factors scores from the three informants' ratings, in a manner analogous to that used for the CICS scores.

The Child Behaviour Check List (CBCL) Aggressive Problems Scale. Of the 279 families who were assessed at least once as toddlers, 247 (88%) also reported on the child's clinically significant behavioural and emotional problems at Wave 5, using the 1½- to 5-year-old version of the Child Behaviour Check List (CBCL; Achenbach & Rescorla, 2000). The CBCL aggressive problems scale yields an age-appropriate continuous measure of young children's aggressiveness and associated behavioural problems. Mothers' ratings on the aggressive problems scale were significantly correlated with fathers' ratings, $r(168) = .46, p < .001$, and with ratings provided by the third informant, $r(172) = .48, p < .001$. Fathers' ratings were significantly associated with those made by the third informant, $r(150) = .39, p < .001$. In data analyses we used factor scores derived by a measurement model using Mplus 7, based on CBCL scales completed by all available informants, in a manner analogous to that used for the CICS and IBQ scores.

Results

Early manifestations of anger and use of physical force in infancy

Means and standard deviations for the four-item infant CICS and the six-item toddler CICS are presented in

Table 2. Previous analyses demonstrated that definite occurrences of the four key CICS items measuring infants' contentiousness (*angry moods, hits out at people, bites and temper tantrums*) had been reported for a minority of infants at 6 months of age (for details, see Hay *et al.*, 2010b). Even at the older ages, when more possible occurrences of anger and aggression are reported, definite occurrences were reported for fewer than 50% of toddlers. To illustrate, mothers' ratings of each behaviour as definitely present, possibly present, or not present in the Wave 5 age range are shown in Figure 1. Fathers and third informants reported slightly lower rates of these six behaviours (see Table 2). Thus individual differences in these behaviours were evident in infancy and toddlerhood.

Associations with known risk factors

As predicted, infants' CICS factor scores were significantly associated with male gender, $r(301) = .16, p < .01$; the sociodemographic risk index, $r(301) = .33, p < .001$; with mothers' symptoms of antisocial personality disorder, $r(301) = .29, p < .001$; with the mean daily number of cigarettes mothers smoked in pregnancy, $r(301) = .20, p < .001$; with the mother's diagnosis of depression during pregnancy, $r(301) = .27, p < .001$; and with her depression post partum, $r(295) = .17, p < .01$, but not with her depression prior to the child's conception. A subsequent regression analysis revealed that the association with post partum depression was no longer significant when the mother's depression during the pregnancy was taken into account.

When the five significant predictors (male gender, sociodemographic risk, prenatal smoking, prenatal

Table 2 Informants' Reports on the four- and six-item Cardiff Infant Contentiousness Scale (CICS) in infancy and toddlerhood

Informant	N	Mean	SD	Range
<i>Infant CICS (4 items)</i>				
Mother	279	2.12	1.86	0 to 8
Father ^a	220	2.10	1.69	0 to 8
Third informant	206	1.69	1.82	0 to 8
Mean ^b	301	2.12	1.57	0 to 8
<i>Toddler CICS (6 items)</i>				
Mother	274	4.40	2.28	0 to 11
Father ^a	219	3.97	2.09	0 to 11
Third informant	239	3.45	2.25	0 to 10
Mean	277	4.02	1.87	0 to 11

^aIf the mother were living in a same-sex partnership, her partner completed the 'father' questionnaire. ^bMean score includes 14 imputed scores; factor scores used in the analyses were constrained to a mean of 0 and a standard deviation of 1.

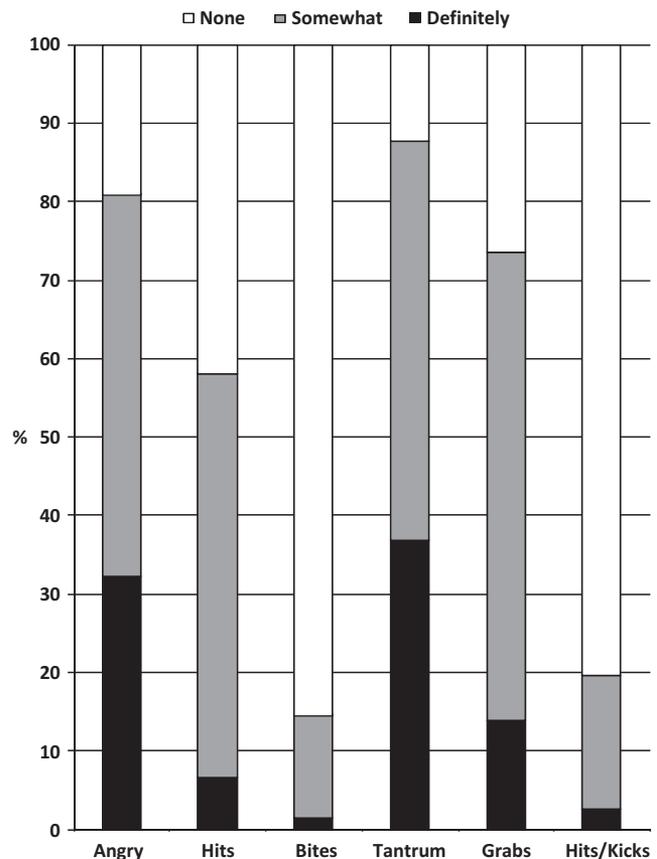


Figure 1 Definite and possible occurrences of each item in the six-item toddler CICS (*angry moods; hits out at people; bites; temper tantrums; grabs toys; hits or kicks to get toys*) as reported by the mother at Wave 5.

depression and mothers' antisocial symptoms) were entered together in a regression analysis, these well-known risk factors for later aggressiveness predicted infants' CICS scores, $F(5, 295) = 11.67, p < .001$, adjusted $R^2 = .15$. The risk index, the child's gender and the mother's prenatal depression remained significant, with the mothers' antisocial behaviour approaching significance (see Table 3).

Continuity over time and prediction to a broader set of conduct problems

There was evidence for moderate continuity over time. Infants' CICS scores at 6 months predicted toddlers' physical aggressiveness, as measured by the six-item CICS factor scores, $r(277) = .38, p < .001$. The 6-month-old CICS score also predicted a broader range of conduct problems in early childhood, as indicated by the CBCL aggressive problems scale, $r(247) = .27, p < .001$, which was itself significantly associated with the six-item toddler CICS score, $r(252) = .57, p < .001$.

Table 3 Prediction of Infant CICS score at 6 months from maternal risk factors: regression analysis

Predictor	CICS factor score in infancy	
	Adjusted R^2	β
Child's gender	.15***	.13*
Social risk index		.18*
Prenatal smoking		.03
Mother's antisocial symptoms		.12 ⁺
Mother's prenatal depression		.16**

Note: $N = 301$. ⁺ $p < .10$; * $p < .05$; ** $p < .01$; *** $p < .001$.

Information about the precursor adds predictive power

Prediction of physical aggressiveness in toddlerhood

A more stringent test of the hypothesis that an early behaviour is a precursor to a later outcome is made when the precursor adds predictive power, beyond the effects of the familial risk factors associated with both the precursor and the later outcome. The strongest predictors of infants' CICS scores (the sociodemographic risk index, the child's gender, prenatal depression and mothers' antisocial symptoms) were entered at the first step of a regression model where the six-item toddler CICS score (averaged across Waves 4 and 5) was the dependent variable. The infant CICS score was added at the second step (see Table 4).

The risk factors entered at the first step accounted for 8% of the variance in toddlers' aggressiveness, as measured by the six-item CICS scores, $F(4, 272) = 7.02$, $p < .001$, adjusted $R^2 = .08$ (Table 4). Mothers' antisocial symptoms and depression in pregnancy significantly predicted toddlers' CICS scores, but toddlers' aggressiveness was not significantly associated with male gender or the sociodemographic risk index. Inclusion of

the Wave 2 mean CICS score in the model explained an additional 10% of the variance, $\beta = .34$, $p < .001$, $F(5, 271) = 13.03$, $p < .001$, adjusted $R^2 = .18$.

Prediction to a broader set of conduct problems

An analogous regression analysis was undertaken, with the CBCL aggressive problems scale factor score as the dependent variable. The same risk factors were entered at the first step and the infant CICS factor score at the second step. At the univariate level, the CBCL aggression scale factor score was significantly associated with the sociodemographic risk index, $r(247) = .15$, $p < .05$, the mothers' antisocial symptoms, $r(247) = .19$, $p < .01$, and the mothers' depression in pregnancy, $r(247) = .18$, $p < .01$. However, when those risk factors were included in the model, the CICS factor score in infancy was the only significant predictor of the broader conduct problems measured by the later CBCL aggression scale, $\beta = .22$, $p < .01$, $F(5, 239) = 5.10$, $p < .001$, adjusted $R^2 = .08$ (Table 4).

Prediction with a control for early self-regulation

In a final analysis we tested whether the continuity between the precursor behaviours in infancy and aggressiveness in toddlerhood was explained by the infants' temperamental ability to regulate their behaviour in the face of potential frustration. A significant association was found between the CICS factor score in infancy and the factor score for the IBQ distress to limitations scale, $r(265) = .53$, $p < .001$. At the univariate level, the IBQ distress to limitations factor score in infancy was a significant predictor of the toddler CICS score, $r(248) = .24$, $p < .001$, and the CBCL aggressiveness scale, $r(222) = .22$, $p < .01$. However, those associations were no longer significant when the Wave 2 CICS score was

Table 4 Prediction of toddler aggression and related behavioural problems

Predictor	Dependent variable			
	Toddler 6-item CICS factor score $N = 277$		CBCL aggressive problems factor score $N = 245$	
	ΔR^2	β	ΔR^2	β
Step 1	.09***		.06*	
Male Gender		.04		.04
Social risk index		-.13*		.01
Mother's antisocial symptoms		.22**		.08
Mother's prenatal depression		.09		.10
Step 2	.10***		.04*	
Infant CICS Score		.34***		.21**

Note: The coefficients presented in the table are those obtained in the final models. $p < .10$; * $p < .05$; ** $p < .01$; *** $p < .001$.

included at the second step in a regression model (Table 5). Rather, the explicit measurement of the infant precursor to physical aggressiveness conveyed added predictive power. The Wave 2 CICS score was the sole predictor of the toddler CICS score, $F(2, 245) = 21.25$, $p < .001$, adjusted $R^2 = .14$, and the CBCL aggressive problems scale, $F(2, 219) = 14.27$, $p < .001$, adjusted $R^2 = .11$. This finding lends further support to our claim that infants' early contentious behaviour constitutes a true precursor to physical aggression in childhood, even when early self-regulatory ability is taken into account.

Discussion

Evidence for early contentiousness as a precursor to later aggression

Can it be said that early individual differences in infants' expressions of anger and use of force against other people constitute true precursors to later aggressiveness? A satisfactory answer to that question requires long-term follow-up of this and other samples. However, it was clear that infants' early expressions of anger and use of force met the theoretical criteria for determining that an infant behaviour is a precursor to a later outcome.

The first criterion we proposed was that of *resemblance*: it is necessary but not sufficient that the proposed precursor should resemble the later outcome. Without resemblance, the putative precursor is just another risk factor. We demonstrated resemblance in informants' interpretation of the same words to detect contentious behaviour at both time points. Mothers, fathers, and other family members or friends reliably reported on displays of anger and use of force in early infancy as well as toddlerhood. Furthermore, at both time points, the informants' reports were validated by the children's directly observed use of physical force in the context of peer interaction (an established operational definition of physical aggressiveness). Thus both the questionnaire

measurement and direct observations highlighted the resemblance between the early behaviour and later aggressiveness.

The second criterion we proposed was that the same *risk factors* would be associated with the proposed precursor and the later behaviour. Infants' early contentiousness was indeed linked to the same social and prenatal risk factors that predict high levels of aggression at older ages (Côté *et al.*, 2006; Hay *et al.*, 2010a; NICHD Early Child Care Research Network, 2004; Maki *et al.*, 2003; O'Connor *et al.*, 2002; Tremblay *et al.*, 2004; Tremblay & Nagin, 2005). In particular, the key risk factors for adolescent violence in a high risk community sample, mothers' antisocial behaviour and prenatal depression (Hay *et al.*, 2010a), were significantly associated with infants' contentiousness.

The third criterion we proposed was that there would be *continuity* in individual differences from the precursor to the later outcome. Indeed, young infants' reported anger and use of force predicted toddlers' anger and aggression, as well as the broader set of behavioural problems measured by the CBCL aggressiveness scale. Furthermore, the continuity in children's behaviour over time was not explained by the family risk factors exerting continued influence on the child at the later time point, nor by the dimension of infant temperament related to self-regulation in the face of frustration. Therefore the measure of infant contentiousness met all three criteria set beforehand (Hay & Angold, 1993), and so infant contentiousness qualifies as a developmental precursor to toddlers' physical aggression.

Limitations of the study

The present findings are limited by the fact that we relied primarily on informants' reports on a brief four-item scale to measure infants' early manifestations of anger and use of force against other people. This measurement strategy is not uncommon; studies of early trajectories toward aggression have also used parents' reports

Table 5 Prediction of toddler aggression controlling for infants' temperamental self-regulation

Predictor	Toddler six-item CICS score $N = 248$		CBCL aggressive problems scale $N = 222$	
	ΔR^2	β	ΔR^2	β
Step 1	.06*		.05*	
Infant IBQ distress to limitations Scale		.06		.06
Step 2	.09**		.07**	
Infant CICS score		.35**		.30**

Note: The coefficients presented in the table are those obtained in the final models. Because the IBQ was only administered at Wave 2, missing scores could not be imputed from Wave 3 data. * $p < .01$; ** $p < .001$.

(e.g. Alink, Mesman, van Zeijl, Stolk, Juffer, Koot, Bakermans-Kranenburg & van IJzendoorn, 2006; Côté *et al.*, 2006; NICHD Early Child Care Research Network, 2004; Tremblay *et al.*, 2004; Tremblay & Nagin, 2005). Our use of up to three informants to construct a factor score and our demonstrations that informants' reports were significantly related to directly observed distress in response to frustration and use of physical force against peers at both time points (Hay *et al.*, 2011b; Hay *et al.*, 2010b) address this limitation. We have also shown that a longer scale measuring infants' temperamental self-regulation is not a better predictor of later aggression than the four-item scale that explicitly asks parents to report infants' expression of anger and use of physical force.

Implications of the findings

Our findings suggest that young infants' expressions of anger and their tendencies to flail out at other people are not trivial, fleeting phenomena. Rather, stable and coherent individual differences were detected that predicted later aggression and a broader range of conduct problems. Our findings have implications for the study of aggression, for clinical practice and for broader developmental theory.

First, with respect to the literature on the development of aggression, the CCDS findings both corroborate and extend past research. Our findings are in line with earlier research in drawing attention to family risk factors, including sociodemographic characteristics and maternal mental health (e.g. Broidy *et al.*, 2003; Côté *et al.*, 2006; NICHD Early Child Care Research Network, 2004; Tremblay *et al.*, 2004).

As well as replicating earlier findings, our work extends the current literature by drawing attention to the emergence of individual differences at the point in infancy when the motor capacities for physical aggression are first emerging in the human repertoire. This suggests that risk factors underpinning the developmental trajectory toward high levels of aggression could be studied from the first months of life, in parallel with the study of infants' growing capacities for self-regulation of their emotions and actions. However, we have also shown that developmental continuities from the infant precursor to later outcomes cannot be explained entirely in terms of temperamental differences in self-regulation. In view of some developmental theorists' claims that aggressiveness in the preschool years can be socially adaptive (e.g. Hawley, 2002), the study of the social development of infants who were not contentious, in the context of poor or good self-regulation, would also be of considerable interest.

Our study of the earliest beginnings of physical aggression also has implications for clinical prevention and intervention studies. We have shown that a very brief report by parents and other family members of infants' early signs of anger and physical force reveals individual differences that can be detected within a short time in standardized laboratory observations. The CICS could be used as a brief screen for early behavioural problems. There are certainly serious reasons to avoid labelling young infants as aggressive. However, it is also possible that the precursor behaviours are already impacting negatively on parents and other carers, and that those families might need support. Using the CICS as a screening instrument to identify a high risk group of infants, who are then more extensively assessed on a variety of measures, might provide evidence that would eventually lead to more effectively targeted prevention studies.

Finally, and most importantly, our findings have implications for broader developmental theory. It is possible to extend the criteria for determining whether an early behaviour is a precursor to a later one to other domains of biological and psychological development. Tests of putative predictors have been made in the field of autism research (e.g. Charman *et al.*, 2000). Similar analyses might identify potential precursors of other childhood disorders, e.g. ADHD or emotional disorders, as well as infant precursors to later cognitive and social attainments. In these other domains, early precursors to children's later skills and problems may similarly be evident in the first months of life.

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