Patterns and Correlates of Prosocial Behaviour Development

Amélie Nantel-Vivier

Department of Psychology
McGill University, Montreal
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Abstract

Prosocial acts, such as providing comfort or help, as well as sharing and cooperating with others, are important domains of children’s early behavioural repertoire that set the stage for positive social interactions and response to others across the lifespan. While developmental research has provided evidence of associations of childhood prosocial behaviours with later prosociality and various aspects of psychosocial functioning, questions remain regarding patterns in prosocial behaviour development across developmental periods, associations with adjustment, and potential biological forces underlying prosocial responding. The present thesis therefore aimed to identify trends and individual differences in prosocial behaviour frequencies throughout childhood and adolescence, in addition to examining longitudinal patterns of association between prosocial behaviours and externalizing and internalizing problems. Neurochemical bases of prosocial behaviours, specifically serotonergic functioning, were also investigated. Three studies are presented.

Study 1 longitudinally described prosocial behaviour development from childhood to adolescence, using multiple informants within Canadian and Italian samples. Participants were boys from low SES areas of Montreal, Canada, as well as boys and girls in Genzano, Italy. Developmental trajectories were estimated based on yearly ratings by mothers and teachers (Montreal, ages 10 to 15) and children and teachers (Genzano, ages 10 to 14). Results revealed that the majority of children, across cultures and informants, followed trajectories characterized by stable or declining levels of prosocial behaviours over time. Low to moderate agreement was observed between informants.

Prosocial behaviour development must however be viewed within the broader context of children’s behavioural and affective functioning. Study 2 therefore focused on longitudinal associations between prosocial behaviour development and the development of externalizing and internalizing problems. Potential predictors of joint development were also investigated. Using a large, representative sample of Canadian children, prosocial behaviour, physical
aggression, anxiety, and depression developmental trajectories spanning ages 2 to 11 were modeled based ratings by the person most knowledgeable about the child. A negative association tended to operate between prosocial behaviour levels and levels of physical aggression and depression, while a more complex relationship emerged with anxiety. Child, mother, and family characteristics significantly contributed to the prediction of joint development, with evidence of maternal depression and low family income increasing the likelihood of displaying high levels of prosocial behaviours with high levels of externalizing and internalizing difficulties.

Study 3 focused on the neurochemical underpinnings of prosocial behaviours, specifically investigating the impact of acute tryptophan supplementation, and by extension increased serotonergic functioning, on children’s laboratory aggressive and prosocial behaviours. Boys with a history of relatively high levels of physical aggression were randomly assigned to a tryptophan supplementation or control condition following a double-blind procedure. Results revealed that boys in the tryptophan condition were more likely to sustain competition with a fictitious opponent during a computerized reaction time game. Boys in the tryptophan condition also showed greater perspective taking, as well as greater instrumental help.

Taken together, results of the present thesis provide evidence of both stability and change in prosocial behaviour frequencies during childhood and adolescence. Results also highlight the complex relationship of prosocial behaviours with adjustment, as well as potential contributions of the serotonergic system to the regulation of prosocial responding in children. The present thesis sets the stage for future studies investigating the interplay of psychosocial and biological forces in determining individual differences in prosocial behaviour and related aspects of functioning.
Résumé

Les comportements prosociaux, tels que le réconfort et l’aide, ainsi que le partage et la coopération, sont des domaines importants du répertoire comportemental des jeunes enfants, constituant la base des interactions sociales positives avec autrui tout au long du développement. Bien que la recherche ait démontré la présence d’associations entre les comportements prosociaux des enfants et leur prosocialité et adaptation psychosociale ultérieures, des questions demeurent quant aux patrons de développement au fil de différentes périodes développementales, l’association des patrons de développement avec l’adaptation, et les forces biologiques potentiellement sous-jacentes à la prosocialité. L’objectif de la présente thèse était donc d’identifier les patrons et les différences individuelles dans le développement des comportements prosociaux au cours de l’enfance et de l’adolescence, ainsi que d’examiner les associations longitudinales entre les comportements prosociaux et les problèmes extériorisés et intérieurisés. Les bases neurochimiques des comportements prosociaux, spécifiquement le fonctionnement sérotonergique, ont également été examinées. Trois études sont présentées.

La première étude décrit de façon longitudinale les comportements prosociaux au cours de l’enfance et l’adolescence, à l’aide de multiples informateurs et d’échantillons canadiens et italiens. Les participants étaient des garçons provenant de quartiers défavorisés de Montréal, Canada, et des garçons et des filles de la ville de Genzano, Italie. Des trajectoires développementales ont été estimées basé sur des évaluations annuelles faites par les mères et les enseignantes (Montréal, 10 à 15 ans) et par les enfants et les enseignantes (Genzano, 10 à 14 ans). Les résultats ont démontré que la majorité des enfants, au sein des deux cultures et pour tous les informateurs, suivait des trajectoires de comportements prosociaux aux niveaux stables ou déclinants au cours du temps. Un niveau faible à modéré d’accord était présent entre les différents informateurs.

Le développement des comportements prosociaux doit toutefois être observé dans le contexte général du fonctionnement comportemental et affectif.
des enfants. La deuxième étude a donc examiné les associations longitudinales entre le développement des comportements prosociaux et des problèmes extériorisés et intérieurisés. Les predicteurs potentiels du développement conjoint ont également été étudiés. Les trajectoires développementales (2 à 11 ans) de comportements prosociaux, agressivité physique, anxiété, et dépression ont été estimées à l’aide d’évaluations chez un large échantillon représentatif d’enfants canadiens. Une association négative tendait à être présente entre les niveaux de comportements prosociaux et les niveaux d’agressivité physique et dépression, tandis que des associations plus complexes étaient observées pour l’anxiété. Les caractéristiques de l’enfant, de la mère, et de la famille contribuaient significativement à la prédiction du développement conjoint, la dépression maternelle et un faible revenu familial augmentant la probabilité de démontrer conjointement un haut niveau de comportements prosociaux et de hauts niveaux de problèmes extériorisés et intérieurisés.

La troisième étude a examiné les bases neurochimiques des comportements prosociaux, évaluant spécifiquement l’effet de la supplémentation ponctuelle de tryptophan, ainsi donc de l’augmentation de la sérotonine, sur les comportements agressifs et prosociaux des enfants en laboratoire. Des garçons présentant un historique relativement élevé d’agressivité physique ont été assignés au hasard à la supplémentation de tryptophan ou à la condition contrôle, suivant un devis double aveugle. Les résultats ont démontré que les garçons du groupe tryptophan étaient plus enclins à soutenir la compétition avec un adversaire fictif lors d’un jeu compétitif de temps de réaction sur l’ordinateur. Les garçons du groupe tryptophan ont également démontré une plus grande prise de perspective ainsi que plus de comportements d’aide.

Globalement, les résultats démontrent la présence de stabilité et changements dans la fréquence des comportements prosociaux durant l’enfance et l’adolescence. Les résultats soulignent également la relation complexe entre les comportements sociaux et l’adaptation, ainsi que la contribution du système sérotonergique à la régulation de la prosocialité. La présente thèse invite les études futures portant sur l’interaction de facteurs psychosociaux et biologiques.
pouvant déterminer les différences individuelles en prosocialité et autres aspects du fonctionnement associés.
Statement of Original Contributions

Three original manuscripts constitute the present thesis, making unique contributions to our understanding of prosocial behaviour development, its association with children’s adjustment, and its potential biological underpinnings. Study 1 presents prosocial behaviour developmental trajectories spanning late childhood to early adolescence. Participants were boys from low SES areas in Montreal, Canada, as well as boys and girls from Genzano, Italy. Behaviour ratings were obtained from mothers and teachers in Montreal, and teachers and children themselves in Genzano. Never before have prosocial behaviour developmental trajectories been simultaneously examined in children of different sociodemographic and cultural backgrounds and viewed from the eyes of various informants. Existing mixed evidence concerning trends in prosocial behaviour development however require clarification from large-scale longitudinal investigations of diverse samples of children and informants. Study 1, by being the first cross-cultural, multi-informant investigation of children’s prosocial behaviour developmental trajectories, highlights individual differences and commonalities in prosocial development which were not available from previous investigations.

The significance of prosocial development patterns can however only be understood by investigating them in the context of potential correlates. This is why Study 2 investigated associations of prosocial behaviour development with physical aggression, anxiety, and depression. While past investigations of the relationship of prosocial behaviours with adjustment have generally investigated concurrent associations or associations at different points in time, Study 2 was able to truly look at longitudinal association by examining joint prosocial behaviour and problem behaviour trajectory membership. Spanning ages 2 to 11, the trajectories presented in Study include the youngest age cohort ever included in modeling of prosocial behaviour trajectories. This is particularly important considering previous findings of early prosocial behaviour emergence. In addition, Study 2 was the first to examine potential predictors of joint prosocial and problem behaviour development from early childhood to early adolescence.
This is crucial if we want to understand the factors predisposing different children to exhibit different combinations of prosocial behaviours and physical aggression, anxiety, and depression. Overall, Study 2 highlights the complex association of prosociality to adjustment, and suggests that certain environments may increase the likelihood of children experiencing joint elevated levels of prosocial and problem behaviours.

A complete understanding of factors predisposing children to various patterns of prosocial behaviour development could not however take place without investigations of potential biological underpinnings. The biological roots of prosocial behaviours in children has however been a neglected area of research, with only one very recent study (Dilalla et al., 2009) having investigated the contribution of dopaminergic functioning to young children’s prosocial and aggressive behaviours. Studies of serotonergic functioning in non-human primates and human adults have provided evidence of a contribution of the serotonergic system to the regulation of social behaviours and interactions. Study 3 was the first to employ a double blind, acute tryptophan supplementation procedure to investigate the contribution of serotonergic functioning to physically aggressive boys’ prosocial and aggressive laboratory behaviours. Study 3 is therefore one of only two studies having investigated neurochemical underpinnings of children’s prosocial behaviours. It makes important methodological innovations, showing that acute tryptophan supplementation is a valuable, useful, and efficient research technique in work with children. It also suggests a potential contribution of the serotonergic neurotransmitter system to prosocial responding in children.
Contributions of Authors

This thesis is comprised of three manuscripts, for which I am first author. Study 1, “Prosocial Development from Childhood to Adolescence: A Multi-Informant Perspective with Canadian and Italian Longitudinal Studies” is co-authored by myself, Dr. Katja Kokko, Dr. Gian Vittorio Caprara, Dr. Concetta Pastorelli, Dr. Maria Grazia Gerbino, Dr. Marinella Paciello, Dr. Sylvana Côté, Dr. Robert O. Pihl, Dr. Frank Vitaro, Dr. Richard E. Tremblay. I participated in the conceptualization of the study, in collaboration with Dr. Kokko, Dr. Tremblay, and Dr. Pihl. Support in completing the data analysis was provided by Dr. Alain Girard, Dr. Danielle Forest, and Dr. Abdeljelil Farhat, statisticians. Their contribution is noted in the acknowledgement section of the manuscript. I wrote the manuscript, and all co-authors provided editorial feedback. Dr. Tremblay and Dr. Caprara were the main investigators responsible for the longitudinal data banks from which data was derived.

Study 2, “Developmental Association of Prosocial Behaviours with Aggression, Anxiety and Depression from Infancy to Pre-Adolescence”, is co-authored by myself, Dr. Pihl, and Dr. Tremblay. I participated in the conceptualization of the study in collaboration with Dr. Pihl and Dr. Tremblay. I also participated in data analysis in collaboration with Dr. Alain Girard. Dr. Girard’s contribution is noted in the acknowledgement section of the manuscript. I wrote the manuscript. Dr. Pihl and Dr. Tremblay provided feedback on the analyses and writing.

Study 3, “Tryptophan Supplementation Effects on Boys’ Aggression and Prosociality”, is co-authored by myself, Dr. Pihl, Dr. Simon N. Young, Dr. Sophie Parent, Dr. Tremblay, and Dr. Jean R. Séguin. I participated in the conceptualization of the study in collaboration with all co-authors. I elaborated the research protocol with input from Dr. Séguin, Dr. Young, Dr. Pihl, and Dr. Parent. Dr. Stacey Bélanger, from the CHU Ste-Justine, acted as the medical officer for the study. Her contribution is noted in the acknowledgement section of
the study. I recruited and trained research assistants involved in the recruitment
and testing of the participants. I supervised data collection for each participant. I
completed the data analysis, with help from Dr. Séguin and Dr. Parent. Professor
Rhonda Amsel also provided feedback on the analyses. Her contribution is noted
in the acknowledgement section of the manuscript. I wrote the manuscript and
received editorial feedback from all co-authors. Dr. Jean Séguin was the primary
investigator responsible for the longitudinal investigation from which participants
were recruited.
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General Introduction

Reviews on the topic of prosocial behaviours in children and adolescents have concluded there is an intricate complexity to prosocial development and its significance to individuals’ functioning and adjustment (see Bar-Tal, 1982; Eisenberg, 2003; Eisenberg, Fabes, & Spinrad 2006; Radke-Yarrow, Zahn-Waxler, & Chapman, 1983; Zahn-Waxler & Smith, 1992). Despite great strides in understanding children and adolescents’ prosociality, important questions therefore persist regarding the development and correlates of prosocial behaviours in youth. The present review will offer a brief discussion of definitional issues, followed by a description of the literature on the developmental course of prosocial behaviours, the relationship of prosocial behaviours to children and adolescents’ psychosocial functioning, and possible biological contributions to prosocial behaviour development.

Definitions

Originally used to describe socially acceptable or institutionally sanctioned aggressive behaviours, the term prosocial paradoxically came to denote “positive forms of social behaviour”, generally considered opposite to aggression and other disruptive behaviours (Wispé, 1972). While current definitions vary, most authors broadly define prosocial behaviours as actions benefiting others and promoting positive interpersonal relationships (e.g., Eisenberg et al., 2006; Hay, 1994).

While the intention of benefiting others is often included as a definitional component of prosocial responding, the majority of authors agree that prosocial behaviours can follow a host of motives, which can be self-serving. As discussed by Eisenberg and colleagues (Eisenberg et al., 2006), this distinguishes prosocial behaviours from altruism, which is generally understood to represent benevolent actions free of self-interest. Prosocial behaviours are also distinct from empathy and sympathy, which constitute emotional states or reactions that may, but do not necessarily, give rise to prosocial gestures. In fact, studies of the relationship of prosocial affects and prosocial behaviours have provided evidence for a moderate positive relationship (e.g., Eisenberg & Miller, 1987), perhaps stronger for sympathy.
than empathy (Eisenberg et al., 2006), thereby simultaneously highlighting their association and distinctiveness.

The label of prosocial behaviour is thus a general one, encompassing a wide array of potential actions. The developmental literature has however by in large focused on four categories of behaviours: response to distress, helping, sharing, and cooperating. A discussion of developmental patterns pertaining to these behaviours follows.

**Emergence and development of prosocial behaviours**

Research on prosocial manifestations in infants, toddlers and preschoolers has shown that the first signs of prosociality appear early within young children’s behavioural repertoire (see Eisenberg et al, 2006; Hay & Cook, 2007; and Carpenter, 2009 for reviews).

Response to others’ distress has been observed in the youngest of babies. Newborns only a few hours-old respond to other infants’ distressed cries with cries, increased attentional focus, and facial expressions of distress. The same infants are significantly less reactive to recordings of their own cries, computer simulated cries, cries of older children, cries of non-human infants (e.g., chimpanzees), and white noise (Dondi, Simion, & Caltran, 1999; Martin & Clark, 1982; Sagi & Hoffman, 1975; Simner, 1971). This suggests that infant reactions to peer distress constitute a relatively specific response, which has been viewed and interpreted by many as a sign of nascent empathic responding (Hoffman, 2000). Children as young as 13 to 15 months can make rudimentary attempts to provide comfort following simulated or naturally occurring distress incidents, and by 18-24 months can show a wide range prosocial responses to others’ distress. This includes physical comfort, verbal comfort, seeking help from a third party to resolve the incident, as well as sharing with or distracting the distressed individual. Furthermore, these behaviours are observed in interactions with familiar individuals and strangers, both adults and children (e.g., Caplan & Hay, 1989; Demetriou & Hay, 2004; Denham, 1986; Farver & Branstetter, 1994; Howes & Farver, 1987; Johnson, 1982; Lamb, & Zakhireh, 1997; Phinney, Feschbach, & Farver, 1986; Zahn-Waxler, Radke-Yarrow, Wagner, & Chapman, 1992; Zahn-Waxler, Robinson, & Emde, 1992).
Early childhood prosocial behaviours are not limited to responses to emotional distress. Informal accounts of children’s prosocial behaviours indicated that children begin to display sharing behaviours before their first birthday, while laboratory studies have shown that virtually all toddlers display sharing behaviours, such as showing and giving objects to others (Hay, Castle, Davies, Demetriou, Stimson, 1999; Hay & Murray, 1982; Klein & Yarrow, 1980; Rheingold, Hay, & West, 1976). Furthermore, young children are able to use sharing behaviours as a means towards conflict resolution (Caplan, Vespo, Pedersen, & Hay, 1991). Instrumental helping (e.g., picking up an object for someone) has similarly been observed shortly after children’s first birthday and beyond (Rheingold, 1982; Warneken & Tomasello, 2006; Warneken & Tomasello, 2007), while cooperative behaviours (i.e., coordinating actions to attain a common goal) tend to emerge closer to children’s second birthday (e.g., Brownell, & Carriger, 1990; Eckerman, Davis, & Didow, 1989; Eckerman & Didow, 1996; Eckerman & Whitehead, 1999; Hay, 1979; Ross, 1982; Warneken & Tomasello, 2007).

It has therefore been shown that very young children can engage in behaviours that may be described as prosocial. The early emergence of prosocial gestures, particularly instrumental helping, has been observed cross-culturally and in some non-human primates (Tomasello, 2009), suggesting it may constitute a relatively universal stepping-stone of early behavioural development. The widespread early emergence of prosocial behaviours however quickly becomes the object of individual differences. Sex differences in prosocial responding have been noted in children, adolescents and adults. Meta-analyses have provided evidence of greater prosocial responding in males (Eagly & Crowley, 1986) and females (Eisenberg & Fabes, 1998), as sex differences may be partly dependent on the type of prosocial behaviours measured. Males may provide greater instrumental help, while women may provide more relational forms of support (Eagly, 2009). Early individual differences and the stability of such differences are also exemplified by studies finding significant correlations between preschool prosocial behaviours and prosocial manifestations in adulthood (Eisenberg, Guthrie, Cumberland, Murphy, Shepard, Zhou, et al., 2002. see also Eron & Huesman, 1984).
While agreement exists on the early emergence of prosocial behaviours, differing views and empirical evidence have been put forward concerning the developmental course of prosocial behaviours beyond their initial emergence. It has frequently been proposed that prosocial behaviours increase in frequency as children grow older. Developmental changes within the cognitive (e.g., self-other differentiation, theory of mind and perspective taking, moral development) and self-regulatory (e.g., delay of gratification, emotion regulation) spheres, in conjunction with socialization practices, are believed to underlie such an increase (see Eisenberg et al., 2006 for a review). Often cited in support of an increase in prosocial behaviour frequencies with age is a meta-analysis conducted by Eisenberg and Fabes (1998). Combining data from 125 studies on children and adolescents’ prosocial behaviours published between 1974 and 1994, the authors found that the weighted mean effect size of the relationship between age and prosocial behaviour frequencies was .26 (Cohen $d$). The authors reported that all age group comparisons yielded significant positive effects sizes, with the exception of comparisons of preschoolers with infants ($d = .15$), and comparisons of older adolescents with younger adolescents ($d = .06$). The strongest effect size was noted for comparisons of adolescents with preschoolers ($d = .68$), while small effect sizes emerged from studies comparing groups of infants ($d = .26$), groups of preschoolers ($d = .24$), school-age children (ages 7 to 12) with preschoolers ($d = .33$), groups of school-age children ($d = .30$) and adolescents with school-age children ($d = .13$). Eisenberg and Fabes (1998) concluded that, although the relationship between age and prosocial behaviour frequencies may be complex, their meta-analysis provided support for a general increase in prosocial behaviour frequencies as children grow older.

Others have however alternatively proposed that, rather than increasing in frequency throughout childhood and adolescence, prosocial behaviours become gradually regulated and nuanced over time (e.g., Caplan, 1993; Hay, 1994; Tomasello, 2009). From this perspective, developmental trends in prosocial responding are not only supported and governed by facilitative factors (e.g., developmental increases in perspective taking, empathy, and moral reasoning), but are subject to inhibitory forces as well. Potential inhibitory forces on prosocial responding include display rules and norms.
Preschoolers can clearly describe when they should or should not help distressed peers, for example stating that they are not the ones to help their peers when adult caregivers are present (Caplan & Hay, 1989). As well, preschoolers’ cooperative behaviours have been shown to be influenced by relationship closeness as well as reciprocity in cooperation (Olson & Spelke, 2008). Young children are not therefore indiscriminate in their prosocial gestures, and may quickly begin to balance prosocial inclinations with self-interest. Moreover, joint effects of inhibitory and facilitative forces on prosocial behaviour development may be subject to individual differences, with different children showing different frequencies and developmental patterns in prosocial behaviours over the years (Caplan, 1993). Heterogeneity in developmental patterns, rather than a general increase in prosocial behaviour frequencies, may thus exist.

Heterogeneity of empirical findings may not only be attributed to individual differences in prosocial behaviour development, but to methodological factors as well. The vast majority of studies included in the meta-analysis by Eisenberg and Fabes (1998) relied on cross-sectional designs comparing children from different age cohorts. Questions concerning prosocial behaviour development are however longitudinal in nature, and should ideally be investigated using longitudinal research designs. To date, very few longitudinal studies have specifically focused on the course of prosocial development over time. One exception is a longitudinal by Côté, Tremblay, Nagin, Zoccolillo, & Vitaro (2002a). The prosocial behaviours of 1,865 boys and girls were rated yearly by the children’s school teachers from kindergarten to grade six. A statistical group-based trajectory method was used, which allowed 1) the identification of subgroups of children following distinct developmental trajectories for prosocial behaviours, 2) the estimation of the proportion of children following each trajectory, and 3) the evaluation of the stability of each subgroup over time. This semi-parametric, group-based approach is quite advantageous in that, contrary to traditional correlational designs, it simultaneously takes into account all available data points, providing information on patterns of development over time (Nagin, 2005).
Côté and colleagues (2002a) identified three subgroups of children for both boys and girls: 1) children exhibiting high levels of prosocial behaviours, 2) children exhibiting moderate levels of prosocial behaviours and 3) children exhibiting low levels of prosocial behaviours. Results indicated that the three subgroups of children, for both boys and girls, were relatively stable in their levels of prosocial behaviours between the ages of 6 and 12, and that none of the subgroups demonstrated an increase in the frequency of prosocial behaviours over time. In fact, 50% of children exhibited a decrease in the frequency of their prosocial behaviours between the ages of 10 and 12 (Côté et al., 2002a). These findings, due to the large number of children studied, the power of the statistical method used, and the longitudinal nature of the investigation, shed doubt on the hypothesis that prosocial behaviours increase in frequency during childhood. Furthermore, results from Côté et al. (2002a) are consistent with more recent longitudinal investigations of prosocial behaviour development. Kokko, Tremblay, Lacourse, and Vitaro (2006), using the same group-based approach as Côté et al. (2002) identified two trajectory groups characterized by declining levels of prosocial behaviours from ages 6 to 12. As well, a study by Eisenberg, Cumberland, Guthrie, Murphy, and Shepard (2005) focused on patterns of prosocial development during the transition from adolescence (age 15-16) to adulthood (age 25-26). Results revealed that while certain sociocognitive aspects of prosocial responding (e.g., perspective taking, prosocial moral reasoning) increased over time, helping behaviours initially declined and subsequently increased during the observed time period. An investigation by Carlo, Crockett, Randall and Roesch (2007), also examining prosocial responding in adolescents, reported declining levels of prosocial behaviours during the high school years, followed by a slight increase in frequencies in Grade 12. The longitudinal studies described above, in contrast to cross-sectional studies included in the meta-analysis by Eisenberg and Fabes (1998), have not therefore provided strong evidence for an increase in prosocial behaviour frequencies over time.

The meta-analysis by Eisenberg and Fabes (1998) revealed that the magnitude of the relationship between age and the frequency of prosocial behaviours varied as a function of characteristics of the studies, including the informant used to rate children’s behaviours. Past investigations of
interinformant agreement on children’s behaviours have generally provided evidence for low to moderate concordance between parent and teacher ratings (Gagnon, Vitaro, & Tremblay, 1992; Offord, Boyle, Racine, Szatmari, Fleming, Sanford, et al., 1996; Sines, 1988; Touliatos & Lindholm, 1981; Verhulst, & Akkerhuis, 1989). In fact, a meta-analysis by Achenbach, McConaughy and Howell (1987) reported a mean correlation of .27 between teacher and parent ratings of children’s behaviours. However, the vast majority of studies investigating agreement between parents and teachers have focused on problem behaviours, such as aggression, hyperactivity, and conduct disorder (e.g., Baillargeon, Boulerice, Tremblay, Zoccolillo, Vitaro & Kohen, 2001; Gagnon, et al., 1992; Touliatos & Lindholm, 1981; Verhulst & Akkerhuis, 1989). Fewer studies have investigated the agreement of parents and teachers concerning children’s positive behaviours, but those that have reported correlations ranging from .01 to .34 (e.g., Pulkkinen, Kaprio & Rose, 1999; Sines, 1988; Vitaro, Gagnon & Tremblay, 1991). A recent investigation by Veenstra and colleagues (Veenstra, Lindenberg, Oldenhinkel, De Winter, Verhulst, & Ormel, 2008) indicated that parents and teachers’ ratings of children’s prosocial and antisocial behaviours were differentially affected by contextual factors, such as children’s academic performance and peer relationships. Interinformant agreement, particularly between parents and teachers, may thus be important to study in the context of prosocial development in order to provide a more complete and accurate picture of prosocial functioning in important life settings.

Prosocial behaviours and adjustment

The meaning and significance of children’s prosocial behaviour development, and potential individual differences in prosocial behaviour development, can only be derived by placing prosocial development within the broader context of children’s functioning. Research on the correlates of childhood prosocial behaviours has pointed to its many concurrent and longitudinal associations with markers of psychosocial adjustment. As noted in previous reviews (e.g., Eisenberg & Fabes, 1998), childhood prosocial behaviours are positively linked with cognitive and affective aspects of prosociality and prosocial responding, such as empathy and sympathy, as well as perspective taking and moral reasoning. Positive associations have also been
observed between children and adolescents’ prosocial behaviours and sociability, social competence, assertiveness, peer acceptance and popularity, academic achievement and self esteem (see Eisenberg et al., 2006 for a review).

A significant portion of the literature on prosocial behaviours and adjustment has focused on the link between prosocial behaviours and externalizing behaviour difficulties. Many such studies have provided evidence of a negative association, generally small or moderate in strength, of prosocial behaviours with aggression and other conduct problems (e.g., Eron & Huesmann, 1984; Caprara, Barbaranelli, Pastorelli, Bandura, & Zimbardo, 2000; Crick, 1996; Crick, Casas, & Mosher, 1997; Diener & Kim, 2004; Hämäläinen & Pulkinnen, 1996; Hughes, White, Sharpen, & Dunn, 2000; Keane & Calkins, 2004; Kokko & Pulkkinen; 2000; Nagin & Tremblay, 2001; Romano, Tremblay, Boulérice, & Swisher, 2005; Veenstra et al., 2008). However, the relative strength of the relationship between prosociality and aggression or conduct issues has sometimes been found to be gender-specific, with findings of stronger relationships for boys (e.g., Pursell, Laursen, Rubin, Booth-LaForce, & Rose-Krasnor, 2008) or for girls (e.g., Côté, Tremblay, Nagin, Zoccolillo, & Vitaro 2002b) depending on the investigation. Furthermore, despite the large number of studies having found a negative relationship between prosocial behaviours and externalizing problems, other studies have reported positive associations, particularly in the early years. Aggressive toddlers and preschoolers have at times been found to exhibit higher levels of prosocial responding than their less aggressive peers (e.g., Gill & Calkins, 2003; Radke-Yarrow, Zahn-Waxler, Barrett, Darby, King, Pickett, et al., 1976). A recent review (Lovett & Scheffield, 2007), focusing on the relationship between affective empathy and aggression, concluded that while results of studies with young children tend to be inconsistent, a negative association is generally observed between affective empathy and aggression in adolescence. Although the review by Lovett & Scheffield (2007) focused on affective components of prosocial responding and not on prosocial behaviours per se, the conclusions are similar to those of other authors suggesting that the negative association between prosociality and externalizing behaviour problems may consolidate with age (e.g., Eisenberg et al., 2006)
Nevertheless, children can exhibit both prosocial and aggressive interpersonal strategies (e.g., Hawley, 2003). In fact, past research has found that children who simultaneously present with high levels of prosocial behaviours and externalizing problem behaviours show lesser stability of problem behaviours over time (Hastings, Zahn-Waxler, Robinson, Usher, & Bridges, 2000). Furthermore, aggressive children who also show relatively high levels of prosocial behaviours tend to be less at risk of peer rejection (Bierman, Smoot, & Aumiller, 1993; Crick, 1996; Nangle & Foster, 1992; Volling, MacKinnon-Lewis, Rabiner, & Baradaran, 1993), and later show lower rates of criminality (Pulkkinen & Tremblay, 1992), and unemployment (Kokko & Pulkkinen, 2000).

Investigations focusing on associations between prosocial behaviours and the presence of internalizing problems (e.g., anxiety, depression) in children have painted a similar picture. A significant number of studies provided evidence of a negative association between children’s prosocial behaviours and internalizing symptoms (e.g., Bandura, Pastorelli, Barbaranelli & Caprara, 1999; Gagnon, Craig, Tremblay, Zhou & Vitaro, 1995; Haapasalo, Tremblay, Boulerice & Vitaro, 2000; Normandeau & Guay., 1998; Slee, 1995; Rydell, Thorell, & Bohlin, 2007; Wentzel, Filisetti, & Looney, 2007; Zimmer-Gembeck, Hunter & Pronk, 2007). These studies must however be considered in the context of other investigations having found no relationship (e.g., Rinaldi & Heath, 2006; Rudolph, Hammen & Burge, 2004) or a positive relationship (Bandura, Caprara, Barbaranelli, Gerbino & Pastorelli, 2003; Gjerde & Block, 1991; Hay & Pawlby, 2003; Perren, Stadelmann, von Wyl & von Klitzing, 2007) between children’s prosocial behaviours and internalizing symptoms.

Investigations of associations between prosocial behaviours and both externalizing and internalizing problems have therefore been somewhat inconclusive. While a good number of studies have pointed to a negative association between prosocial behaviours and externalizing and internalizing problems, such a negative relationship does not preclude that prosocial behaviours and externalizing/internalizing difficulties coexist within the same individuals, both concurrently and longitudinally. In fact, many authors have suggested that the small to moderate association between prosocial behaviours
and problem behaviours indicates that prosocial behaviours and problem
behaviours are not mutually exclusive, and should be studied within the same
individuals (Caprara, Barbaranelli, & Pastorelli, 2001; Eisenberg & Fabes,
1998). Studies using a person or profile based approached, investigating
children presenting with different combinations of prosocial behaviours and
problem behaviours, have shown that high levels of prosocial behaviours and
high levels of problem behaviours can in fact coexist (e.g., Haapasalo et al.,
2000; Lacourse, Nagin, Vitaro, Côté, Arseneault, & Tremblay, 2006;
Pulkkinen & Tremblay, 1992). To this day, the vast majority of cross-
sectional and longitudinal investigations of the relationship between prosocial
behaviours and adjustment have looked at concurrent or longitudinal
associations at differing numbers of points in time. Associations between
prosocial behaviours and adjustment are however likely to be dynamic,
evolving over time. Rarely have associations in longitudinal developmental
patterns been investigated. There are however a few exceptions. Côté et al.
(2002b) investigated the power of combined helpfulness, hyperactivity, and
fearfulness developmental trajectories, depicting children’s pattern of
behaviours over time (Nagin, 2005), in predicting conduct disorder. They
found that while high hyperactivity predicted conduct disorder in boys
regardless of fearfulness and helpfulness status, the combination of high
hyperactivity and low helpfulness developmental trajectories was necessary in
predicting conduct disorder in girls. Kokko and colleagues (2006), using the
same trajectory method as Côté and colleagues (2002b), found that while
levels of prosocial and physically aggressive behaviours tended to be
negatively related in a sample of boys ages 6 to 12, a small percentage of
participants (3.4%) jointly followed developmental trajectories characterized
by relatively high levels of prosocial behaviours and physical aggression. As
well, a study by Phelps and colleagues (Phelps, Balsano, Fay, Peltz,
Zimmerman, Lerner, & Lerner, 2007) presented joint developmental
trajectories of positive youth development, internalizing risk (depression), and
externalizing risk (substance use and delinquency) from middle childhood to
eyear adolescence. Positive youth development refers to a number of desirable
attributes, such as competence, confidence, character, connection, and caring
(Phelps et al., 2007). It is therefore broader than but relevant to prosocial
behaviour development. Joint trajectory analyses showed that negative associations tended to operate between levels of positive youth development trajectories and levels of internalizing and externalizing risk developmental trajectories. Heterogeneity in trajectory membership associations was however present.

The mechanisms underlying prosociality’s seemingly mixed association with children’s mental health have yet to be clarified. It has been proposed that prosociality may be associated with healthy development when appropriately regulated, but may be associated with significant adjustment problems when too low or too high (Caplan, 1993; Hay, 1994). Overly high prosociality may be associated with oversensitivity to or overconcern for others’ welfare, thereby correlating with internalizing forms of distress (e.g., Hay et al. 2003). A recent study by Perren and colleagues (Perren et al., 2007) found that above average levels of prosocial behaviours predicted above average levels of internalizing problems in children initially exhibiting above average levels of internalizing problems. This suggests that high prosocial behaviours may be problematic for certain subgroups of children. No study to date, to the best of our knowledge, has however longitudinally examined and predicted patterns of association of prosocial behaviour development with the development of aggression and internalizing problems in samples spanning the entire childhood period.

*Biological bases of prosocial development*

Relatively little is known about the biological underpinnings of prosocial responding. Evolutionary explanations of prosocial behaviours have naturally focused on the consequences and costs of these behaviours to survival. As reviewed by Penner and colleagues (Penner, Dovidio, Piliavin, & Schroeder, 2005), mechanisms such as kin selection, reciprocal altruism, and group selection have all been proposed in order to explain why prosocial behaviours have evolutionary success. Directing prosocial acts towards individuals to whom we are genetically related and/or individuals who are likely to reciprocate may increase the benefits of these acts. As well, by promoting positive social interactions, prosocial behaviours may not only benefit the individual, but the group, meaning that groups constituted of greater numbers of prosocial individuals may have greater evolutionary
success than groups with fewer prosocial individuals (Penner et al., 2005). The evolutionary advantage of prosocial behaviours thus lies within the promotion of positive relationships between individuals and within groups. It is however likely that in order for prosocial behaviours to be adaptive, self-regulation abilities must play a role in determining the context and circumstances where these behaviours are appropriate. Overly high or low levels of prosociality may thus pose an evolutionary disadvantage to individuals and groups.

A number of studies have investigated the heritability of prosocial behaviours and empathic responding in both children and adult twins. Adult studies have reported heritability rates as high as 72% (e.g., Gillespie, Cloninger, Heath, & Martin, 2003; Matthews, Batson, Horn, & Rosenman, 1981, Rushton, Fulker, Neale, Nias & Eysenck, 1986). Both cross-sectional and longitudinal studies of the heritability of prosocial behaviours in youth have provided evidence of moderate genetic contribution (rates varying between 30% and 78%: Gregory, Light-Häusermann, Rijsdijk, & Eley, 2009; Hur & Rushton, 2007; Knafo & Plomin, 2006; Knafo, Zahn-Waxler, Davidov, Van Hulle, Robinson, & Rhee, 2009; Knafo, Zahn-Waxler, Van Hulle, Robinson, & Rhee, 2008; Scourfield, John, Martin, & McGuffin, 2004; Stevenson,1997; Zahn-Waxler et al., 1992; Zahn-Waxler, Schiro, Robinson, Emde, & Schmitz, 2001) with higher rates often found with increasing age (Hur et al., 2007; Knafo et al., 2006; Knafo et al., 2008; Scourfield et al., 2004). It is important to note however that not all studies have found evidence for a genetic contribution to prosocial behaviours in children and adolescents (see Lemery and Goldsmith, 2003; Saudino, Carter, Purper-Ouakil, & Gorwood, 2008).

While a considerable literature has emerged on the neurobiological bases of empathy and prosocial action during economic games, this literature has been based on samples of adult participants (see Baschetti 2007; Seitz, Nickel, & Azari, 2006; Singer 2009 for reviews). Only a fraction of studies have focused on the brain correlates of empathy in children and adolescents (e.g., Decety, Michalska, Akitsuki, 2008; Decety, Michalska, Akitsuki, & Lahey, 2009; Light, Coan, Zahn-Waxler, Frye, Goldsmith, & Davidson, 2009) with no studies focusing on the neurobiological underpinnings of prosocial
behaviours per say. This is with the exception of a very recent study by Dilalla and colleagues (Dilalla, Elam, & Smolen, 2009) having observed decreased sharing behaviours in children with a specific polymorphisms of the DRD4 dopamine receptor gene.

Evidence has however been provided for a contribution of the serotonergic system to the regulation of social behaviours in human adults and non-human primates. Low serotonergic functioning has generally been associated with increased levels of impulsive aggression and risk taking behaviours (e.g., Brown, Ebert, Goyer, Jimerson, Klein, Bunney, et al., 1982; Fairbanks, Melega, Jorgensen, Kaplan, & McGuiere, 2001; Higley, Mehlman, Taub, Higley, & Suomi, 1992; Higley, Mehlman, Higley, Fernald, Vickers, Lindell, et al., 1996; Howell, Westergaard, Hoos, Chavane, Shaf, Cleveland, et al., 2007; Mehlman, Higley, Faucher, Lilly, Taub, Vickers, et al., 1994; Moore, Scarpa, & Raine, 2002; Tuinier, Verhoeven, & van Praag, 1995), while increased serotonergic functioning has been associated with affiliative behaviours and at times dominance (Chamberlain, Ervin, Pihl, & Young, 1987; Knutson, Wolkowitz, Cole, Chan, Moore, Johnson, et al., 1998; Mehlman, Highley, Faucher, Lilly, Taub, Vickers, et al., 1995; Raleigh, Brammer, McGuire, & Yuwiler, 1985; Raleigh, Brammer, Yuwiler, Flannery, McGuire, & Geller, 1980; Raleigh, McGuire, Brammer, Pollack, & Yuwiler, 1991; Tse & Bond, 2002; Westergaard, Suomi, Higley, & Mehlman, 1999). No studies to date have however investigated the contribution of serotonergic functioning to children’s prosocial behaviours. Such investigations would however be highly valuable, considering evidence that prosocial behaviours and individual differences in prosocial responding actually emerge in childhood.

**Key research questions**

Past research on the development of prosocial behaviours in children and adolescents has provided compelling evidence for the contribution of such behaviours to individuals’ functioning. Consistent evidence has been provided regarding the early emergence of prosocial behaviours. A number of very important questions however remain.

Firstly, patterns of development beyond early emergence remain unclear. Very few longitudinal investigations have specifically focused on the
developmental course of prosocial behaviours over time, particularly with regards to heterogeneity in developmental patterns within the population. Studies having investigated heterogeneity in developmental patterns have used samples of older children and adolescents. Because prosocial behaviours appear early within children’s behavioural repertoire, studies spanning early childhood are necessary. A first goal of the present thesis was therefore to longitudinally map and investigate heterogeneity in developmental patterns of prosocial behaviours in children and adolescents. Study 1, encompassing two related investigations, therefore presents prosocial behaviour developmental trajectories of children in Montreal, Canada, and Genzano, Italy, using a multi-informant framework. Study 2 presents prosocial behaviour trajectories spanning ages 2 to 11.

Secondly, mixed evidence has been provided with regards to the association between prosocial behaviours and externalizing and internalizing problems in children and adolescents. While negative correlations have often been observed, null or positive relationships have also been found. Furthermore, the presence of a general negative relationship does not eliminate the possibility that some subgroups of children may display high levels of both prosocial behaviours and externalizing/internalizing difficulties. As well, joint predictors of prosociality and externalizing/internalizing difficulties have rarely been investigated, particularly within a longitudinal design. Manuscript 2 of the present thesis therefore maps developmental associations between prosocial behaviours and physical aggression, anxiety, and depression, and predicts joint associations from important child, mother, and family characteristics.

Thirdly, the neurochemical bases of prosocial behaviours in youth have been a largely neglected area of research. Some evidence has been provided for a contribution of the serotonergic system to non-human primates and human adults positive social interactions. Never has the contribution of the serotonergic system to children’s prosocial behaviours been investigated. Manuscript 3 of the present thesis, using a double-blind acute tryptophan supplementation procedure, therefore investigates the contribution of the serotonergic functioning neurotransmitter system to physically aggressive boys’ prosocial and aggressive behaviours within a laboratory context.
Study 1

Prosocial Development from Childhood to Adolescence: A Multi-Informant Perspective with Canadian and Italian Longitudinal Studies


Amélie Nantel-Vivier ¹, Katja Kokko ², Gian Vittorio Caprara ³,
Concetta Pastorelli ³, Maria Grazia Gerbino ³, Marinella Paciello ³,
Sylvana Côté ⁴, Robert O. Pihl ¹, Frank Vitaro ⁴, Richard E. Tremblay ⁴

¹ McGill University, Canada
² University of Jyväskylä, Finland
³ La Sapienza University, Italy
⁴ University of Montreal, Canada
Abstract

Objectives: To longitudinally describe prosocial behaviour development from childhood to adolescence, using multiple informants within Canadian and Italian samples.

Method: Participants in Study 1 were 1037 boys from low SES areas in Montreal, Canada, for whom yearly teacher and mother reports were obtained between the ages of 10 and 15. Participants in Study 2 were 472 children (209 girls) from Genzano, Italy, for whom yearly self and teacher reports were obtained between the ages of 10 and 14. Developmental trajectories were estimated from ratings by each informant to identify subgroups of children following distinct courses of prosocial development.

Results: In Study 1, three trajectory groups (low/declining 53%, high/declining 16%, high/steep declining 31%) were identified from teacher ratings, while five trajectories (low/stable 7%, low/declining 19%, moderate/stable 41%, high/declining 24%, high/stable 9%) were identified from mother ratings. Small but significant associations were observed between mother and teacher ratings. In Study 2, three trajectory groups (low/stable 9%, moderate/stable 50%, high/stable 42%) were identified from self ratings, while four trajectory groups (low/stable 8%, moderate/declining 48%, high/declining 37%, increasing 7%) were identified from teacher ratings. Small but significant associations were observed between self and teacher ratings.

Conclusions: The present studies investigated levels of prosocial behaviours from childhood to adolescence, using a multi-informant, cross-cultural perspective. All but one of the developmental trajectories identified were characterised by stable or declining levels of prosocial behaviours. Further research longitudinally investigating prosociality across developmental periods is needed to clarify prosocial behaviour development over time.

Keywords: prosocial behaviours, longitudinal analysis.

Abbreviations: SES: socioeconomic status; SBQ: Social Behaviour Questionnaire; BIC: Bayesian Information Criterion
Introduction

A common statement within developmental psychology is that prosocial behaviours, including helping, sharing, comforting, and cooperating, increase in frequency as children grow older. Socialization processes, together with maturation within different developmental spheres, such as the affective (e.g., empathy) and socio-cognitive domains (e.g., moral reasoning), are believed to underlie this trend (Eisenberg, Fabes, & Spinrad, 2006). However, the investigation of age-related changes in prosocial behaviours has not been a simple endeavour, with prominent reviews concluding that the developmental course of prosocial behaviours is complex (see Bar-Tal, 1982, Eisenberg, 2003, Eisenberg & Fabes, 1998; Radke-Yarrow, Zahn-Waxler, & Chapman, 1983 and Zahn-Waxler & Smith, 1992).

Providing a quantitative summary of available empirical evidence, Eisenberg and Fabes (1998) performed a meta-analysis of 179 studies. A significant positive relationship emerged between frequencies of prosocial behaviours and age (mean weighted effect size (d) = .26). The magnitude of the relationship, however, varied as a function of methodological factors (e.g., focus age groups, informants). As well, only 13% of individual effect sizes presented (11/87) were above .5, a value generally thought to reflect a medium effect size (Cohen, 1992). Therefore, the meta-analysis by Eisenberg and Fabes (1998) highlighted the complexity of prosocial development, emphasising the importance of further qualifying the statement that prosocial behaviours increase in frequency throughout development.

Caplan (1993) and Hay (1994) suggested early childhood prosocial impulses become increasingly differentiated and individualized over time. From this perspective, maturation and socialization do not only promote children’s prosociality, but rather help them regulate their prosocial inclinations. With age, children acquire display rules that help them balance prosocial acts with self-interest, and exhibit prosocial actions that are gradually more relationship specific (Caplan, 1993). The interaction of facilitative (e.g., empathy) and inhibitory (e.g., self-interest) forces predicts that a general increase in prosocial behaviour frequency is unlikely.
Importantly, the interplay of inhibitory and facilitative factors is hypothesized to be subject to individual differences, with different children displaying different developmental trajectories (Caplan, 1993). Research on age-related changes in the frequency of prosocial behaviours should thus consider heterogeneity in developmental patterns.

Prosociality has at times been described as a double-edged sword, promoting healthy development when appropriately regulated, but creating difficulties if too low (e.g., antisocial behaviours) or too high (e.g., depression) (Hay, 1994). Côté, Tremblay, Nagin, Zoccolillo, and Vitaro (2002b) found that girls following an atypically low level trajectory of prosocial behaviours during the elementary school years were at high risk for conduct disorder in adolescence (16 years). This was not true, however, for boys. In addition, young girls with highest prosociality levels may be at an increased risk for internalizing forms of psychopathology (Gjerde & Block, 1991). Optimal development may therefore require flexible, regulated prosociality.

Few long-term longitudinal studies have focused on the course of prosocial development. An exception is work by Eisenberg and colleagues, prospectively following individuals from the preschool years to early adulthood (Eisenberg et al., 2002; Eisenberg, Miller, Shell, McNalley, & Shea, 1991; Eisenberg et al., 1987). This research program provided evidence for rank-order stability of individual differences in prosocial responding, with childhood prosociality indexes significantly correlating with adulthood indexes (Eisenberg et al., 2002). Analyses focusing on the transition from adolescence to early adulthood (Eisenberg, Cumberland, Guthrie, Murphy, & Shepard, 2005) found an increase in sociocognitive aspects of prosocial responding (e.g., perspective taking, prosocial moral reasoning), with no parallel increase in helping behaviours. Côté, Tremblay, Nagin, Zoccolillo, and Vitaro (2002a) investigated prosocial development from ages six through 12. The behaviours of 1,865 children were rated yearly by teachers from kindergarten to grade six. Using a group-based trajectory method (Nagin, 2005), three subgroups, respectively characterized by 1) high, 2) moderate, and 3) low frequencies of prosocial behaviours were identified, for both boys and girls. Frequencies were relatively stable for each subgroup, with no evidence of an increase in the frequency of prosocial behaviours over time.
Similarly, Carlo, Crockett, Randall and Roesch (2007) recently found evidence for a decline in levels of prosocial behaviours from the beginning to the end of high school, with a slight increase noted in Grade 12. This pattern was most notable for boys (Carlo et al., 2007). Overall, the above findings are consistent with the proposal that greater competence within the sociocognitive and affective spheres may not translate into greater behavioural performance.

Eisenberg et al. (1998) noted that the choice of informant influenced the magnitude of the relationship between prosocial behaviour frequencies and age, rendering multiple informants important when investigating prosocial development. The literature on interinformant agreement has described agreement between parents, teachers, and children concerning children’s behaviours as low to moderate (Gagnon, Vitaro, & Tremblay, 1992; Offord et al., 1996; Sines, 1988; Touliatos & Lindholm, 1981; Verhulst & Akkerhuis, 1989), with mean correlations ranging from .22 to .27 (Achenbach, McConaughy, & Howell, 1987). Studies that have explored interinformant agreement on children’s prosocial behaviours have reported correlations ranging from .01 to .34 (Pulkkinen, Kaprio, & Rose, 1999; Sines, 1988; Vitaro, Gagnon, & Tremblay, 1991).

The present two studies aimed to longitudinally map the frequency of prosocial behaviours during the transition from childhood to adolescence, focusing on reports from multiple informants. Using the same person-oriented approach that was used by Côté et al. (2002a), developmental trajectories were modelled to identify subgroups of children exhibiting distinct patterns of prosocial development. Children in the first study were boys from low SES backgrounds in Montreal, Canada, followed from ages 10 to 15. Children in the second study were boys and girls from a representative sample of children in Genzano, Italy, followed from ages 10 to 14. Separate trajectories were modelled from ratings by each informant. Mothers, teachers, and children were selected as informants as they are the main informants used in both research and clinical work on children’s adjustment (e.g., CBCL; Achenbach, 1994). It was believed that using reports from different informants and sampling behaviours of children from different cultural and socioeconomic backgrounds would offer a portrait of the variability in prosocial development.
STUDY 1

Methodology

Participants, Measurement and Procedures

One thousand and thirty-seven boys were recruited in 1984 by asking kindergarten teachers working in the lowest socioeconomic areas of Montreal, Canada, to rate the behaviours of all their male students. Only boys of biological parents born in Canada and whose mother tongue was French were included in the study. Informed consent was obtained for all participants (see Tremblay, Vitaro, Nagin, Pagani, & Séguin, 2003 and Kokko, Tremblay, Lacourse, Nagin, & Vitaro, 2006 for further sample description). Teachers and mothers provided yearly ratings using the Social Behaviour Questionnaire (SBQ; Tremblay et al., 1991) when the boys were between the ages of 10 and 15. Teachers and mothers rated the extent to which each statement described a given child (from 0 = never applies, to 2 = frequently applies). Prosocial behaviours items were: 1) shows sympathy; 2) praises others; 3) helps sick child; 4) helps hurt child; 5) helps child with a difficult task; 6) helps clean up mess; 7) invites bystanders to join in a game; 8) stops quarrels; 9) helps pick up objects; and 10) comforts upset child. Cronbach alphas ranged from .82 to .85 for mother ratings and .87 to .91 for teacher ratings.

Data Analysis

Prosocial behaviour trajectories were modelled using yearly scores obtained from teachers and mothers. Trajectories were derived from a general nonlinear Mixture of Curves (MOC) procedure in R programming (Boulerice, 2001). The method summarizes population heterogeneity in developmental patterns using polynomial functions, each constituting a developmental trajectory group (Nagin & Tremblay, 2005). As a first step, models with different numbers of trajectory groups were modelled and tested to find the model with the optimal number of trajectory groups. The Bayesian Information Criterion (BIC; Schwarz, 1978) is used to determine the optimal number of groups. Trajectory groups may differ in both their level and shape (i.e., linear, quadratic, cubic) over time.

Each trajectory group summarises the behaviours of subgroups of children that exhibit similar patterns over time. As summaries, trajectory
groups do not constitute literal descriptions of the behaviours of individual participants. Group membership is not absolute, and members of a trajectory group exhibit fluctuations around the group average trend. Uncertainty in group assignment is illustrated through one of the main outputs of the model, the posterior probabilities of group membership, consisting in the probability for each individual to belong to each trajectory estimated from the sample. The maximum probability rule is used to assign individuals to the trajectory to which they have the highest probability of belonging (see Nagin, 2005 for a complete discussion of developmental trajectory analyses).

Associations between mother and teacher ratings were assessed using different indicators. Mean differences in prosocial behaviours ratings were calculated, as were correlations between yearly reports. Longitudinal associations were investigated using continuous and categorical outputs of the trajectory models. Specifically, for each participant, the probability of belonging to each trajectory from one informant (i.e., posterior probability of belonging to Mother Group 1, 2, 3, etc) was multiplied by the probability of belonging to each trajectory from the other informant (i.e., posterior probability of belonging to Teacher Group 1, 2, 3, etc). The multiplied probabilities for each participant were then summed within each combination (i.e., M1T1, M1T2, M1T3, M2T1, M2T2, etc). Chi-square analyses were performed to investigate whether the distribution revealed significant associations (greater than expected N within a cell). Chi-square analyses were repeated using trajectory membership assignment by maximum probability rule, a categorical variable, to assess associations between category membership. Because trajectory groups are not determined a priori but are rather estimated from the data, models based on different informants are likely to generate different numbers and patterns of trajectory groups. Therefore, although originating from the same questionnaire items, trajectory models based on different informants may not map on directly to each other. This may restrict the strength of the associations observed.
Results

Prosocial development over time

Trajectory group assignment by maximum probability rule yielded mean assignment probabilities ranging from .69 to .87, indicating satisfactory model fit (Nagin, 1999, 2005).

Figure 1 presents estimated models based on yearly prosocial behaviour ratings from each informant. Three trajectories emerged from teacher ratings (Figure 1.A.): 1) 53% of boys initially exhibited relatively low levels of prosocial behaviours, which subsequently declined (low/declining group); 2) 31% of boys exhibited relatively high levels at age 10, followed by a notably steep decline (high/steep declining group); 3) 16% of boys exhibited initial levels identical to boys in group 2, with subsequent slower rates of decline over time (high/declining group). Five trajectories were modelled from mothers’ ratings (Figure 1.B.): 1) 7% of boys exhibited low and stable levels of prosocial behaviours (low/stable group); 2) 19% of boys initially exhibited low levels which subsequently declined (low/declining group); 3) 41% of boys demonstrated stable and moderate levels (moderate/stable group); 4) 24% of boys exhibited initially high levels which thereafter declined (high/declining group); 5) 9% of boys exhibited high, stable levels (high/stable group). Therefore, the five trajectories identified based on mother ratings and the three trajectories identified from teacher ratings were all characterised by stable or declining levels of prosocial behaviours over time.

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Figure 1

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Associations between mother and teacher ratings

As described in Figure 1, information provided by mothers and teachers differed in terms of the underlying subgroups that could be identified. Table 1 presents yearly mean scores, standard deviations, and correlations. Averaging across the six assessments, the mean rating given by teachers was 1.47, while the mean rating given by mothers was 2.01 ($t = -24.180$, $p = .000$). Significant correlations between the yearly sum scores for mother and teacher reports were of small magnitude, ranging from .08 to .15.
Analyses of the associations between trajectory models from mother and teacher ratings yielded positive, significant results, both for crossed posterior probabilities of group membership (Chi-Square: 699.83, \( p = .000 \)) and trajectory group assignment by maximum probability rule (Chi-Square: 24.16, \( p = .002 \)). Continuous and categorical indicators of group membership therefore pointed to significant associations between mother and teacher ratings. Table 2 presents the overlap in trajectory group assignment between the two trajectory models computed. Observed patterns of assignment suggest that boys assigned to low-level groups based on maternal ratings tended to also be assigned to low-level groups based on teacher ratings, with 76.6% of boys assigned to the low/stable mother group being assigned to the low/declining teacher group.

### Table 1

| Analyses of the associations between trajectory models from mother and teacher ratings yielded positive, significant results, both for crossed posterior probabilities of group membership (Chi-Square: 699.83, \( p = .000 \)) and trajectory group assignment by maximum probability rule (Chi-Square: 24.16, \( p = .002 \)). Continuous and categorical indicators of group membership therefore pointed to significant associations between mother and teacher ratings. Table 2 presents the overlap in trajectory group assignment between the two trajectory models computed. Observed patterns of assignment suggest that boys assigned to low-level groups based on maternal ratings tended to also be assigned to low-level groups based on teacher ratings, with 76.6% of boys assigned to the low/stable mother group being assigned to the low/declining teacher group. |

### Table 2

| STUDY 2 |

Methodology

*Participants, Measurement and Procedures*

Participants were 472 children (209 females) from a longitudinal research program focused on social adjustment in childhood and adolescence. All were drawn from schools in Genzano, located near Rome, Italy. The participants varied with regards to their socioeconomic background and the Genzano community represents a microcosm of the larger society. Informed consent was obtained for all participants (see Caprara, Barbaranelli, Pastorelli, & Cervone, 2004; Caprara, Barbaranelli, Pastorelli, Bandura, & Zimbardo, 2000; Caprara, Pastorelli, Regalia, Scabini, & Bandura, 2005 for further sample description). The project followed a staggered, multiple cohort design, with four cohorts assessed from ages 10 to 14, over a period of eight years. Yearly ratings were obtained from the children and their teachers using the Prosocial Behaviour Scale (Caprara & Pastorelli, 1993). The child version of the
Prosocial Behaviour Scale is made up of 15 items (answer format: often = 3; sometimes = 2; never = 1), with five control items which were not included in the present analyses. Items were: 1) I try to make sad people happier; 2) I spend time with my friends; 3) I try to help others; 4) I am gentle; 5) I share things I like with my friends; 6) I help others with their homework; 7) I let others use my toys; 8) I like to play with others; 9) I trust others; 10) I hug my friends. The teacher version of the Prosocial Behaviour Scale is made up of six items which overlap with six of the items in the child version of the scale: 1) tries to make sad people happier; 2) spends time with friends; 3) tries to help others; 4) shares things s/he likes with friends; 5) helps others with homework; 6) Lets others use toys. The Cronbach alphas at each year of assessment ranged from .75 to .82 for self ratings and .85 to .91 for teacher ratings.

Data Analysis

Prosocial development trajectories were modelled, using the five yearly prosocial behaviours scores obtained from self and teacher ratings. As in Study 1, trajectories were modelled using the MOC procedure in R programming. As well, associations between ratings by both informants were investigated through mean rating differences, yearly correlations, crossed posterior probability of group membership (Chi-square), and group assignment overlap (Chi-square).

Results

Prosocial Development Over time

Trajectory group assignment by maximum probability rule yielded mean assignment probabilities ranging from .76 to .91, indicating a satisfactory model fit (Nagin, 1999, 2005).

Three trajectories could be estimated from self ratings (Figure 1.C.): 1) 9% of children exhibited low, stable levels of prosocial behaviours (low/stable group) 2) 50% of children reported moderate, stable levels (moderate/stable group); 3) 42% of children exhibited high, stable levels (high/stable group). Four trajectories were estimated from teacher ratings (Figure 1.D.): 1) 8% of children exhibited low and stable levels of prosocial behaviours (low/stable group); 2) 48% of children initially exhibited moderate levels which thereafter declined (moderate/declining group); 3) 37% of children initially exhibited high levels which subsequently declined (high/declining group); 4) 7% of
children initially demonstrated moderate level followed by an increase (increasing group). Therefore, the three trajectories identified based on self ratings, and three of the trajectories identified based on teacher ratings could be described as stable or declining over time. Only for teachers was a subgroup of children with increasing levels of prosocial behaviours identified.

Boys and girls appeared to be non-randomly distributed across trajectory groups. In the model based on self ratings (Pearson Chi-Square 35.33, p = .000), the low/stable and moderate/stable groups were composed respectively of 81.6% and 64.1% of boys, while the high/stable group was composed of 59.4% girls. For teacher ratings (Pearson Chi-Square 11.89, p = .008), the low/stable and moderate/declining groups estimated were composed respectively of 65.4% and 62.4% boys, while the high/declining and increasing groups were composed respectively of 51.9% and 58.1% girls. Therefore, boys tended to belong to the groups with the lowest levels of prosocial behaviours, while girls tended to belong to the groups with the highest levels of prosocial behaviours. 

Associations between self and teacher ratings

As described in Figure 1, information provided by children and their teachers differed in terms of the underlying subgroups that could be identified. Table 3 presents yearly means, standard deviations, and correlations. Averaging across the five assessments, the mean rating given by the children themselves was 2.42, while the mean rating given by teachers was 2.27 (t = 7.356, p = .000). A significant difference thus exists between mean levels of prosocial behaviours as rated by children and teachers. All but one of the correlations between the yearly mean scores for children and teachers were significant, ranging from .12 to .38, with a mean correlation of .22.

-------------------------
Table 3
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Analyses of the association between trajectory models from self and teacher ratings yielded positive, significant results, both for crossed posterior probabilities of group membership (Chi-Square: 499.27, p = .000) and trajectory group assignment by maximum probability rule (Chi-Square: 41.72, p = .000). Continuous and categorical indicators of group membership
therefore pointed to significant associations between mother and teacher ratings. Table 4 presents the overlap in category membership for the two trajectory models computed. Close to 70% of children assigned to the low/stable trajectory group based on self ratings were assigned to the moderate/declining group based on teacher ratings. Slightly more than half of the children assigned to the moderate/stable group based on self ratings were assigned to the moderate/declining group based on teacher ratings. Similarly, close to half of the children assigned to the high/stable group based on self ratings were assigned to the high/declining group based on teacher ratings.

Table 4

Discussion

The present studies longitudinally investigated prosocial behaviours during the transition from childhood to adolescence, focusing on multiple informants. Results indicated that 1) the majority of trajectory groups were characterized by stable or declining prosocial behaviour levels over time, 2) associations between ratings by different informants could be characterised as low to moderate.

Findings from the present analyses do not support the frequently proposed increase in prosocial behaviour frequencies with age. Only for teacher reports in Study 2 was a trajectory characterized by increasing levels of prosocial behaviours observed. This trajectory, however, represented only 7% of children in the sample. All other trajectories, while differing in their relative levels, were characterised by stable or declining frequencies. The majority of children could therefore be described as exhibiting stable or declining levels of prosocial behaviours over time.

Findings from the present studies may be viewed as consistent with work by Hay (1994) and Caplan (1993). Past research has shown that maturational changes in the cognitive and affective spheres, as well as certain socialization practices, may promote prosocial responding (see Eisenberg, Fabes, & Spinrad, 2006 for a review). However, facilitative forces may not be associated with a general increase in the frequency of prosocial behaviours, as
children simultaneously learn to focus their prosocial responding and empathic abilities in more selective, differentiated ways with age. Findings of higher maternal prosociality ratings in Study 1 are consistent with the notion that children may exhibit more prosocial behaviours towards their affiliative groups (e.g., family, friends) as they age. Greater differentiation and individuality in prosocial behaviour patterns may render prosocial behaviours more private over time, emphasising the importance of self-reports and observations of prosocial behaviours towards different targets.

Children in the present two studies were purposely drawn from very different sociocultural environments in order to investigate variability within the complex process that is prosocial development. Children in Study 1 were boys from the lowest socioeconomic areas of a large city, Montreal, Canada. Children in Study 2 were boys and girls growing up in Genzano, Italy, a town located near Rome. Lower levels and steeper declines of prosocial behaviours were obtained from teacher ratings within the Montreal sample (Study 1). As our focus was on the transition from childhood to adolescence, children in both studies experienced a change in school environment during the longitudinal investigations. Children in Canada start middle school (or grade 7) at age 12, while children in Italy transition from elementary school to middle school (Scuole medie inferiori) at age 11. While the relationship between SES and levels of prosocial behaviours remains equivocal (Eisenberg et al., 1998), it is possible that transition to a low SES middle school context may have contributed to lower levels and greater declines of prosocial behaviours in the eyes of teachers for the Montreal boys. As well, it is possible that the smaller community context of the Genzano sample may have been associated with stronger reputations for children and consequently greater stability in teacher-reported prosocial levels. Furthermore, different measures were used for the two studies, perhaps contributing to observed differences in patterns for the two samples. However, it is important to note that teachers in Italy did describe a group with clearly non-stable prosocial behaviour levels (Increasers, 7%), suggesting some sensitivity on their part to changing levels of prosocial behaviours with age. Also important to note is the fact that in spite of varying sociocultural contexts, informants, and
measures, nowhere were increasing levels of prosocial behaviours considered normative.

The low to moderate associations found between informants in the two present studies were consistent with past research on interinformant agreement (Achenbach et al., 1987). Children may exhibit different patterns of prosocial behaviours at home and at school, and the differential patterns found in Study 1 between mother and teacher reports may reflect the context specificity of prosocial behaviours. It is also possible that teachers and parents perceive children’s prosocial behaviours differently. Teachers, generally able to compare a child to a large number of children, may have a better sense of normative development, while parents may hold a more individualised and specific view of a particular child’s behavioural development. Somewhat stronger associations were found between children and teacher reports in Study 2, which may be due to ratings of behaviours sampled from the same context (i.e., school). No correlation, however, was above 0.40. Different perspectives from different informants may yield very different depictions of children’s behaviours, emphasising the importance of considering numerous sources of information when investigating behavioural development. As well, consistent with past literature (Eisenberg et al., 2006), higher levels of prosocial behaviours tended to be observed in girls in Study 2. Expectancies regarding boys and girls’ social behaviours, and the impact of such expectancies on observed frequency patterns of prosocial behaviours should be considered.

In sum, the present two studies strongly suggest that the frequency of prosocial behaviours does not increase between the ages of 10 and 15 for the majority of children. The present studies were the first, to the best of our knowledge, to longitudinally map both individual differences in the frequency of prosocial behaviours during the transition from childhood to adolescence, using information from multiple informants. One trajectory, including 7% of children in Study 2, was characterized by increasing levels of prosociality over time, while all other trajectories presented stable or declining levels. Factors predisposing children to follow particular trajectories, as well as the predictive power of membership to a particular trajectory group for later psychosocial adjustment, should be further investigated.
Acknowledgements

This research has been supported by a graduate scholarship to Amélie Nantel-Vivier by the Fond Québécois de Recherche Société et Culture, grants from the Ministero dell’Istruzione dell'Università e della Ricerca (MIUR-COFIN 1998-00/2000-02) and from the University of Rome (Ateneo 2000, 2001, 2002) to Gian Vittorio Caprara, and research grants from the Academy of Finland (Nos. 54489 and 55289) to Katja Kokko. Grants from the Fonds pour la Formation de Chercheurs et l’Aide à la Recherche (FCAR-Centre), the Conseil Québécois de la Recherche Sociale (CQRS), the Fonds de la Recherche en Santé du Québec (FRSQ), the Social Sciences and Humanities Research Council of Canada (SSHRC), the Molson Foundation and the Canadian Institute of Advanced Research also supported the present research. We thank Alain Girard, Abdeljelil Farhat, and Danielle Forest for help with statistical analyses, Hélène Beauchesne for coordinating the data collection, Muriel Rorive for coordinating the data management, and Lyse Desmarais-Gervais for general coordination of the research activities.
References


Table 1. Yearly Means (SD) and Correlations of Mother and Teacher Ratings (Study 1)

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** significant at p<.01

* significant at p<.05
Table 2. Overlap (%) of Developmental Trajectory Membership by Mothers and Teachers (Study 1)

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Table 3. Yearly Means (SD) and Correlations of Self and Teacher Ratings (Study 2)

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** significant at p<.01

* significant at p<.05
Table 4. Overlap (%) of Developmental Trajectory Membership by Self and Teachers

(Study 2)

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Figure 1. Trajectories by Informants for Studies 1 and 2.

A
Study 1 - Teachers

B
Study 1 - Mothers

C
Study 2 - Children

D
Study 2 - Teachers
The results of Study 1 indicate that the vast majority of children followed prosocial behaviour developmental trajectories characterized by stable or declining levels of prosocial behaviours over time. This was true of boys from low SES neighborhoods in Montreal, Canada, as well as a representative sample of boys and girls in Genzano, Italy. Declining levels of prosocial behaviours over time were more apparent in teacher ratings (particularly in Montreal), while stable levels were characteristic of mother and self ratings. Overall, results do not support the frequently proposed increase in children’s prosocial behaviours with age (e.g., Eisenberg & Fabes, 1998) and are consistent with recent longitudinal investigations having specifically focused on prosocial behaviour developmental patterns (e.g., Côté et al., 2002a).

The development of prosocial behaviours does not however occur in isolation, but rather in the context of developments in other behavioural and affective spheres. Research on the association between prosocial behaviours and externalizing and internalizing problems has yielded mixed findings (see Eisenberg et al., 2006 for a review). However, rarely have longitudinal associations between prosocial behaviour trajectories and externalizing and internalizing difficulty trajectories been simultaneously examined, and never have potential joint predictors been investigated. Furthermore, studies having presented prosocial behaviour developmental trajectories focused on middle childhood and adolescence. No studies have therefore depicted prosocial behaviour developmental trajectories starting in early childhood, the crucial period when prosocial behaviours are known to emerge. Consequently, the goal of Study 2 is to investigate joint developmental trajectories of prosocial behaviours with physical aggression, anxiety, and depression trajectories, spanning ages 2 to 11. Potential joint child, mother, and family predictors are also investigated.
Study 2

Developmental Association of Prosocial Behaviours with Aggression, Anxiety and Depression from Infancy to Pre-Adolescence

Amélie Nantel-Vivier\textsuperscript{1}, Robert O. Pihl\textsuperscript{1}, and Richard E. Tremblay\textsuperscript{2}

\textsuperscript{1}McGill University, Canada
\textsuperscript{2}University of Montreal, Canada
Abstract

Objectives: To describe and predict the joint development of prosocial behaviours with physical aggression, anxiety, and depression from 2 to 11 years of age.

Method: Participants were 10 700 children from the National Longitudinal Survey of Children and Youth. Developmental trajectories, spanning ages 2 to 11, were modeled using an accelerated group-based design. Trajectories were based on biennial prosocial behaviour, physical aggression, anxiety, and depression ratings from the Person Most Knowledgeable about the child (PMK). Nominal regression was used to predict membership to joint prosocial behaviour/physical aggression, prosocial behaviour/anxiety, and prosocial behaviour/depression trajectories from child (sex), mother (education, depression), and family (income, parenting practices, family functioning) characteristics.

Results: Children following a high prosocial trajectory were more likely to follow a low physical aggression, and low depression trajectory. However, they were also more likely to follow a low or high anxiety trajectory. Boys were significantly more likely to follow a low prosocial behaviour trajectory, particularly in the context of high physical aggression or decreasing anxiety trajectory membership. Positive parenting was most strongly associated with prosocial behaviours, while hostile parenting was most predictive of physical aggression, anxiety, and depression development. Low family income and maternal depression increased the likelihood of jointly exhibiting high prosocial behaviours and high problem behaviours.

Conclusions: Individual differences exist in the association of prosocial behaviours with mental health. While high prosocial behaviour levels tend to develop in the context of low problem behaviours, high prosocial and problem behaviours can co-occur in subgroups of individuals. Child, mother, and family characteristics are predictive of individual differences in joint prosocial and problem behaviour development. Mechanisms underlying these associations warrant future investigations.
Introduction

A substantial literature exists on the association of prosocial behaviours with various markers of positive functioning, such as moral development (e.g., Carlo, Koller, Eisenberg, DaSilva, & Frolich, 1996), empathy (e.g., Eisenberg & Miller, 1987), social competence and peer acceptance (Warden & Mackinnon, 2003; Welsh, Parke, Widaman, & O’Neil, 2001), as well as academic and professional achievement (Caprara, Barbaranelli, Pastorelli, Bandura, & Zimbardo, 2000; Kokko & Pulkkinen, 2000; Normandeau & Guay, 1998). Research specifically investigating the link between children’s prosocial behaviours and mental health has however yielded mixed evidence (Caplan, 1993; Hay, 1994).

Studies reporting on the mental health correlates of prosocial behaviours have investigated associations with both the externalizing (e.g., aggression) and internalizing (e.g., depression) spheres of problem behaviours. Many such studies have found evidence of concurrent negative associations between prosocial behaviours and externalizing and internalizing problems in children and adolescents of various ages (e.g., Caprara et al., 2000 – children on average 8 years; Crick, Casas, & Mosher, 1997 – children 3 to 5 years; Hughes, White, Sharpen, & Dunn, 2000 – children on average 4 years; Normandeau & Guay, 1998 – kindergarten children; Romano, Tremblay, Boulerice, & Swisher, 2005 – children ages 2 to 11 years; Rydell, Thorell, & Bohlin, 2007 – 8-year-old children; Veenstra, Lindenberg, Oldehinkel, De Winter, Verhulst, & Ormel, 2008 – children on average 11 years; Wentzel, Filisetti, & Looney, 2007 – children 11 to 14 years; Zimmer-Gembeck, Hunter & Pronk, 2007 – children 9 to 13 years). These associations appear to hold over time, as longitudinal studies correlating levels of prosocial behaviours and externalizing/internalizing problems at different time points have also found evidence of negative relationships (e.g., Bandura, Pastorelli, Barbaranelli & Caprara, 1999 – follow-up from ages 11 to 13; Crick, 1996 – 1-year follow-up in children 9 to 12 years; Diener & Kim, 2004 – 5-month follow-up in children 2 to 4 years; Eron & Huesmann, 1984 – follow-up from ages 8 to 30; Hämäläinen & Pulkkinen, 1996 – follow-up from ages 8 to 32;
Kokko et al., 2000 – follow-up from ages 8 to 36). Negative correlations and associations reported between children and adolescents’ prosocial behaviours and externalizing/internalizing problems are however generally of small to moderate magnitude. In fact, a number of studies have also observed positive associations (e.g., Bandura, Caprara, Barbaranelli, Gerbino & Pastorelli, 2003 – 2-year follow-up in adolescents ages 14 to 19; Gill & Calkins, 2003 – children 2 years of age; Gjerde & Block, 1991 – follow-up from ages 11 to 18; Hay & Pawlby, 2003 – follow-up from ages 4 to 11; Perren, Stadelmann, von Wyl & von Klitzing, 2007 – follow-up from ages 5 to 6; Radke-Yarrow, Zahn-Waxler, Barrett, Darby, King, Pickett, et al., 1976 – children ages 3 to 7) or no associations (e.g., Rinaldi & Heath, 2006; children ages 8 to 13; Rudolph, Hammen & Burge, 2004; children ages 7 to 12) between different aspects of prosocial responding and externalizing/internalizing behaviour problems.

Mixed empirical evidence may be partly attributed to methodological factors. Many studies have examined the association between prosocial behaviours and composite indexes of externalizing or internalizing difficulties. Such indexes combine together different problem behaviours, such as various forms of aggression, hyperactivity, opposition, and general disruptiveness (e.g., Hughes et al., 2000; Pursell, Laursen, Rubin, Booth-Laforce, & Rose-Krasner, 2008; Veenstra et al., 2008). A recent meta-analysis by Card, Stucky, Sawalani, & Little (2008) however revealed that prosocial behaviours were differentially associated with specific forms of aggression, correlating negatively with overt aggression but in some circumstances positively with indirect aggression. This emphasizes the importance of differentiating between specific forms of problem behaviours when investigating associations with prosocial behaviours. Furthermore, as reviewed by Eisenberg, Fabes, and Spinrad (2006), associations between prosocial behaviours and aggression in particular may be subject to age effects. Specifically, negative associations between prosocial and aggressive responding may consolidate over time, with positive association being more typical of younger cohorts. A recent review by Lovett & Scheffield, 2007, focusing on affective empathy, concluded that while a negative association tends to operate between affective empathy and aggression in adolescence, associations in younger children tend to be more inconsistent. Although the review by Lovett Scheffield (2007) focuses on
empathy and not prosocial behaviours per say, their conclusions do speak to a consolidation of negative associations with age (Eisenberg et al., 2006).

Mixed empirical evidence may also be attributed to heterogeneity in patterns of association. Negative correlations between prosocial behaviours and externalizing/internalizing problems do not preclude that subgroups of children may exhibit high levels of both prosocial and problem behaviours. Studies having used a person or profile based approach to children’s behaviours indicate that prosocial and problem behaviours can and do coexist within individuals (e.g., Haapasalo, Tremblay, Boulerice, & Vitaro, 2000; Lacourse, Nagin, Vitaro, Côté, Arseneault, & Tremblay, 2006; Pulkkinen & Tremblay, 1992). The presence of prosocial behaviours in children with externalizing behaviour difficulties has been found to decrease the stability of aggression and other problem behaviours over time (Lacourse et al., 2006; Hastings, Zahn-Waxler, Robinson, Usher, & Bridges, 2000; Tremblay, Pihl, Vitaro, & Dobkin, 1994) and to decrease the risk of peer rejection (Bierman, Smoot, & Aumiller, 1993; Crick, 1996; Nangle & Foster, 1992; Volling, MacKinnon-Lewis, Rabiner, & Baradaran, 1993), criminality (Pulkkinen & Tremblay, 1992), and long-term unemployment (Kokko & Pulkkinen, 2000) in aggressive individuals. Conversely, high levels of prosocial behaviours have been shown to at times be associated with high levels of internalizing problems (e.g., Hay & Pawlby, 2003), perhaps most importantly in children presenting above average levels of both prosocial behaviours and internalizing symptoms (Perren et al., 2007). Findings of both potential protection and risk associated with high prosocial behaviours are consistent with proposals by Caplan (1993) and Hay (1994), who suggested prosocial behaviours may contribute positively to adjustment when optimally regulated, but may also increase the risk of psychopathology when overly low or high.

Understanding the interplay of prosocial and problem behaviours requires that associations, as well as heterogeneity in associations, be investigated within a developmental framework. Most of the longitudinal studies described above have correlated information at discrete points in time. Recent studies have used developmental trajectory analyses (Nagin & Tremblay, 1999; Nagin, 2005) to provide a better understanding of intra-individual development over long periods of time, the association of these
developmental trajectories across different behavioural dimensions, and their link to later mental health conditions. For example, Côté, Tremblay, Nagin, Zoccolillo and Vitaro (2002b), predicted the likelihood of adolescent conduct disorder (age 15) from various combinations of helpfulness, hyperactivity, and fearfulness developmental trajectories in childhood (ages 6 to 12). Results indicated that membership to a high hyperactivity trajectory increased the likelihood of conduct disorder in boys, irrespective of fearfulness and helpfulness trajectory membership status. Membership to the high hyperactivity trajectory however only increased the likelihood of conduct disorder in adolescent girls when combined with membership to a low helpfulness developmental trajectory. As well, Kokko and colleagues (Kokko, Tremblay, Lacourse, and Vitaro, 2006) described joint prosocial behaviour and physical aggression developmental trajectories in boys (ages 6 to 12). They found that levels of prosocial behaviours and physical aggression tended to be negatively associated. A small proportion of boys (3.4%) nevertheless followed a joint trajectory characterized by high physical aggression and elevated prosocial behaviours. Physical aggression trajectory membership, but not prosocial behaviour trajectory membership, was predictive of later physical violence and school dropout (age 17). Finally, Phelps and colleagues (Phelps, Balsano, Fay, Peltz, Zimmerman, Lerner & Lerner, 2007) presented joint developmental trajectories of positive youth development, internalizing risk (depression), and externalizing risk (substance use and delinquency) from Grades 5 to 8. Positive youth development, including measures of competence, confidence, character, connection, and caring (Phelps et al., 2007.), is broader than but relevant to prosocial behaviour development. Results revealed that children assigned to the highest level positive youth development trajectory were most likely to be assigned to the low internalizing and externalizing trajectories. However, as noted by Kokko et al. (2006), variability in trajectory membership associations was observed.

Results by Kokko et al. (2006) and Phelps et al. (2007) point to the complexity of developmental associations between prosocial behaviours and problem behaviours. The meaning of such variability can only be derived by placing joint development in context. Firstly, the joint prosocial and problem behaviour trajectories described above spanned middle childhood to early...
adolescence. Past research has however clearly established that prosocial behaviours emerge within the first years of life, and that individual differences in prosocial responding begin to consolidate before school entry (e.g., Eisenberg, Guthrie, Cumberland, Murphy, Shepard, Zhou, et al., 2002). Joint developmental trajectories including younger age cohorts are therefore needed to provide a complete picture of associations. Secondly, while a number of child, parent, and family characteristics have been used to predict prosocial behaviours in children (see Eisenberg, et al., 2006 for a review), no investigation, to the best of our knowledge, has focused on predictors of joint prosocial and problem behaviour developmental trajectories. Prediction of joint associations is however important in clarifying the factors which may predispose children to exhibit different combinations of prosocial and problem behaviours over time.

The first goal of the present study was therefore to model the joint developmental trajectories of prosocial behaviours with physical aggression, anxiety and depression as early as possible, i.e. from early childhood to pre-adolescence (ages 2 to 11). We expected children following a high level prosocial behaviour trajectory to be more likely to follow a low level physical aggression, anxiety, and depression trajectory. We however also expected heterogeneity in associations, so that subgroups of children exhibiting joint elevated prosocial behaviour, physical aggression, anxiety, and depression trajectories would also emerge. Secondly, we examined the extent to which developmental associations between prosocial behaviour, aggression, and anxiety from early childhood to pre-adolescence were predicted by the sex of the child, mothers’ characteristics (education, depression) and family characteristics (income, parenting practices, family functioning) assessed early in life.

Methodology

Sample and Procedure

Participants for the present study were part of the National Longitudinal Survey of Children and Youth (NLSCY) (Statistics Canada, 2007). 15,579 Canadian households with at least one child aged 0 to 11 years were randomly selected by Statistics Canada in 1994 to take part in a
longitudinal investigation of children’s development. 86.3% of families responded, providing a sample of 13,439 children. These children represent 12 age cohorts (approximately 1000 children per cohort) at the first (1994) assessment point (Cycle 1) (Cohort 1: 0-11 months; Cohort 2: 12-23 months; Cohort 3: 24-35 months; Cohort 4: 36-47 months; Cohort 5: 48-59 months; Cohort 6: 60-71 months; Cohort 7: 72-83 months; Cohort 8: 84-95 months; Cohort 9: 96-107 months; Cohort 10: 108-119 months; Cohort 11: 120-131 months; Cohort 12: 132-143 months). Biennial data collections were done through home interviews with the Person Most Knowledgeable about the child (PMK), who was the mother in the vast majority of cases (see Statistics Canada, 2007 for further details). Analyses for the present study focused on children initially ages 0 to 9 at Cycle 1 (N = 10,700), using data collected at Cycles 1 through 4 (1994, 1996, 1998, 2000). Table 1 presents sample characteristics.

Measures

Child behaviours. The PMK was asked by the trained interviewer to rate the frequency of specific child behaviours, for children age 2 and older, using a three-point scale (0 = never to 2 = often). Prosocial behaviours were measured using five items: “will help someone who has been hurt”, “offers to help other children with task”, “comforts a child who is crying or upset”, “helps other children who are feeling sick”, and “praises the work of less able children”. Cronbach alphas ranged from .80 to .83 for measurements at ages 2 to 11. Physical aggression was measured with the following three items: “gets into many fights”, “reacts with anger and fighting” and “kick, bites, hits other children”. Cronbach alphas ranged from .61 to .66 for measurements at ages 2 to 11. Anxiety was measured using three items: “too fearful, anxious”, “worried” and “nervous, high-strung, tense”. Cronbach alphas ranged from .50 to .71 for measurements at ages 2 to 11. Finally, depression was measured using four items: “seems to be unhappy, sad or depressed,” “is not as happy as other children,” “cries a lot,” and “has trouble enjoying him/herself”. Cronbach alphas ranged from .41 to .67 for measurements at ages 2 to 11.
Predictors of joint behavioural development. Mother and family characteristics at Cycle 1 were included as potential predictors of the joint development of prosocial behaviours with physical aggression, anxiety, and depression. Dichotomous coding ($1 = \text{presence}, 0 = \text{absence}$) was used to represent mother having completed high school, low family income, and intact family status (i.e., both parents living with the child). A 12-item scale from the Center for Epidemiological Studies of Depression (Radloff, 1977) was used to measure past-week maternal depressive symptoms (e.g., mood, appetite, and sleep issues). As well, three parenting scales were included to predict joint behavioural development: positive parenting, consistent parenting, and hostile parenting. Past studies using these parenting scales have demonstrated their reliability (e.g. Côté, Vaillancourt, Leblanc, Nagin, & Tremblay, 2006). Parenting behaviours were rated on a scale ranging from never to many times each day. The positive parenting scale assessed the extent to which the parent engaged in pleasant activities and shared positive emotions with their child (e.g., How often do you praise your child? How often do you and your child laugh together?), while the consistent parenting scale assessed the extent to which the parent follows through when making a request of their child (e.g., When you give your child a command or order to do something, what proportion of the time do you make sure he/she does it? How often does your child get away with things that you feel should have been punished?). The hostile/ineffective parenting scale assessed parent disapproval of the child and negative emotions towards the child (e.g., Of all the times that you talk to your child about his/her behaviour, what proportion is disapproval? How often do you get angry when you punish your child?). Finally, a family functioning scale, comprised of 12 items, was used to assess communication, problem solving, behaviour management, and sharing of affection within the family (Boyle, Offord, Hofmann, Catlin, Byles, Cadman, et al., 1987).

Analyses

Joint developmental trajectories. Developmental trajectories, spanning ages 2 to 11, were modeled using an accelerated group-based design, based on biennial behavioural ratings by the PMK. The accelerated design combines trajectories from each of the 10 age cohorts (ages 0 to 9 at Cycle 1) into a
summary model describing prosocial behaviour, physical aggression, anxiety, and depression developmental trajectories from ages 2 to 11 (Nagin, 2005). Children contributed to a minimum of three and a maximum of four time points, depending on their age at Cycle 1. Table 2 describes the contribution of each age cohort to the accelerated developmental trajectory models.

As a first step, prosocial behaviour, physical aggression, anxiety, and depression trajectories were modeled separately. Trajectories were derived from a general nonlinear Mixture of Curves (MOC) procedure in R programming (Boulerice, 2001). The method allows for a summary of population developmental heterogeneity using polynomials, each constituting a developmental trajectory group (Nagin, 2005). Models with different numbers of groups are tested to find the optimal number and shape of trajectories, using the Bayesian Information Criterion (BIC; Schwarz, 1978). Group membership in trajectory models is not absolute, as represented by the posterior probabilities of group membership, consisting in the probability for each individual of belonging to each trajectory estimated from the sample. The maximum probability rule is used to assign individuals to the trajectory to which they have the highest probability of belonging (see Nagin, 2005 for a complete discussion of developmental trajectory analyses).

As a second analytical step, joint trajectory models of prosocial behaviours with physical aggression, anxiety and depression were estimated to describe their longitudinal overlap. Joint trajectory analyses generate joint probabilities as one of their outputs (Côté, Vaillancourt, Leblanc, Nagin, & Tremblay, 2007; Nagin, 2005; Nagin & Tremblay, 2001), consisting in the distribution of children across each combination of prosocial behaviour trajectories with physical aggression, anxiety, and depression trajectories. Joint probabilities are estimated from the posterior probabilities calculated for each trajectory. Chi-square analyses were performed on the distribution of children assigned to each combination of prosocial behaviour trajectories with physical aggression, anxiety, and depression trajectories to assess their interrelationships.

Prediction of joint trajectories. Nominal regression was used to predict joint trajectory membership from child (sex), mother (education,
depression), and family (income, parenting practices, family functioning) characteristics. Odds of membership to a specific joint trajectory group were calculated relative to the odds of belonging to the normative (i.e., largest) joint trajectory group in the model.

All analyzes performed for the present study were weighted to account for the sampling and stratification strategies used for the NLSCY.

Results

Developmental trajectories

Figure 1 presents estimated trajectory models based on prosocial behaviour, physical aggression, anxiety, and depression ratings by the PMK. Three trajectories emerged for prosocial behaviours (Figure 1a): 1 - Low (28%); 2 - Moderate (51%); 3 - High (22%). Four physical aggression trajectories emerged (Figure 1b): 1 - Extremely Low (12%); 2 - Low (45%); 3 - Moderate (39%); 4 - High (4%). Furthermore, four-trajectory models were also found to best describe anxiety development (Figure 1c) (1 - Extremely Low (6%); 2 - Low (46%); 3 - High Decreasing (12%); 4 - High Increasing (36%)) and depression development (Figure 1d) (1 - Extremely Low (8%); 2 - Low (55%); 3 - Moderate (34%); 4 - High (3%)). The majority of children could therefore be described as following a moderate prosocial behaviour trajectory, while low levels were generally normative of physical aggression, anxiety, and depression.

Joint developmental trajectories

Tables 3 to 5 present the joint probabilities of membership to the physical aggression, anxiety, and depression trajectories. As expected from the distribution of subjects across the trajectories for each behavioural dimension, joint probabilities indicated that the largest joint trajectory groups consisted of moderate prosociality with low or moderate physical aggression, low anxiety, and low or moderate depression. A considerable proportion of
children (17%) however followed a joint moderate prosocial and high increasing anxiety developmental trajectory.

Chi-square analyses (p = .000) revealed, as hypothesized, that joint membership to the high prosocial behaviour trajectory with the a) extremely low/low physical aggression trajectories, b) extremely low depression trajectory, and c) extremely low anxiety trajectory was more likely than expected by chance. Interestingly, joint membership to the high prosocial and high/increasing anxiety developmental trajectories was also more likely than expected by chance. Patterns of association were therefore different for anxiety and depression.

Chi-square analyses further revealed that joint membership to the low prosocial behaviour trajectory with the a) moderate or high physical aggression trajectories, b) extremely low or high depression trajectories, and c) low anxiety trajectory was also more likely than expected by chance.

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<td>Insert Table 4 here</td>
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Predicting joint development

Tables 6 to 8 present the nominal regression results predicting the joint development of prosocial behaviours with physical aggression, anxiety, and depression. The extremely low and low physical aggression, anxiety, and depression trajectories were combined for the regression analyses to allow for a more parsimonious model. Odd ratios represent risk relative to the normative (largest) group for each joint model, namely the moderate prosocial/combined low physical aggression, moderate prosocial/combined low anxiety, and moderate prosocial/combined low depression joint trajectories.
Prosocial behaviours and physical aggression. All of the 9 variables included in the regression model significantly contributed to the prediction of joint prosocial behaviours and physical aggression. Most noteworthy were findings for sex of the child, low family income, maternal education, maternal depression, positive parenting, and hostile parenting. Boys were more likely to follow a low prosocial behaviour trajectory, particularly in the context of high physical aggression (OR = 7.90), and less likely to follow a high prosocial behaviour trajectory. Low family income generally increased the likelihood of children following a low prosocial behaviour trajectory. It also increased the likelihood of children exhibiting moderate physical aggression in the context of moderate prosocial behaviours (OR = 1.41) and moderate (OR = 1.78) or high (OR = 2.23) physical aggression in the context of high prosocial behaviours. Mothers who had completed high school were significantly less likely to have children exhibiting high physical aggression in the context of low (OR = 0.49) or high prosocial behaviours (OR = 0.37). Maternal depression increased the likelihood of children following a joint moderate prosocial/low aggression trajectory rather than a low prosocial/low aggression trajectory. It also increased the likelihood of children exhibiting moderate aggression in the context of moderate (OR = 1.02) or high (OR = 1.05) prosocial behaviours. Positive parenting increased the likelihood of belonging to the high prosocial behaviour trajectory and decreased the likelihood of belonging to the low prosocial behaviour trajectory, irrespective of physical aggression levels. Hostile parenting increased the likelihood of belonging to the moderate or high physical aggression trajectories, and decreased the likelihood of belonging to the low physical aggression trajectory, irrespective of prosocial behaviour levels.

Prosocial behaviours and anxiety. All of the 9 variables included in the regression model significantly contributed to the prediction of joint prosocial behaviours and anxiety. A general, negative relationship was again observed between being a boy and levels of prosocial behaviours. Low family income tended to be associated with membership to the low prosocial behaviour trajectory, and with high increasing levels of anxiety in the context of moderate prosociality (OR = 1.26). Having a mother who completed high school increased by five-fold the likelihood of children following a joint low
prosocial/high decreasing anxiety trajectory. Maternal depression and hostile parenting tended to be generally associated with membership to the higher level anxiety trajectories, while positive and consistent parenting increased the likelihood of membership to the high prosocial behaviour trajectory and decreased the likelihood of membership to the low prosocial behaviour trajectory.

Prosocial behaviours and depression. All of the 9 variables included in the regression model significantly contributed to the prediction of joint prosocial behaviours and depression. A general, negative relationship was again observed between being a boy and levels of prosocial behaviours. Interestingly, low family income decreased the likelihood of exhibiting high depression in the context of moderate prosocial behaviours (OR = 0.52), but significantly increased the likelihood of exhibiting high depression in the context of high prosocial behaviours (OR = 3.19). Maternal depression and hostile parenting increased the likelihood of membership to the moderate and high depression trajectories, irrespective of prosocial behaviour trajectory membership, while positive parenting and consistent parenting were found to increase the likelihood of membership to the high prosocial behaviour trajectory and to decrease the likelihood of membership to the low prosocial behaviour trajectory.

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Discussion

The present study investigated associations between developmental trajectories of prosocial behaviours and physical aggression, anxiety, and depression. Results revealed heterogeneity in patterns of association, as well
as the power of child, mother, and family characteristics in predicting joint development.

Children following a low prosocial behaviour trajectory were more likely to follow a high physical aggression or high depression trajectory. Conversely, children following a high prosocial behaviour trajectory were significantly more likely to follow an extremely low or low physical aggression trajectory or an extremely low depression trajectory. This is in line with past literature having found a negative relationship between prosociality and disruptive behaviours (e.g., Caprara et al.; 2000, Côté et al., 2002; Crick, 1996) as well as between prosociality and internalizing forms of distress (e.g., Bandura et al., 1999, Wentzel et al., 2007). However, a more complex relationship emerged between prosociality and anxiety. Specifically, membership to the high prosocial behaviour trajectory was significantly, positively associated with membership to the low anxiety and high/increasing anxiety trajectory. Therefore, while levels of prosocial behaviours were generally negatively associated with physical aggression and depression, they were associated with low anxiety for some children while being significantly associated with high/increasing levels of anxiety for others. This suggests that population heterogeneity exists not only in terms of levels of prosocial behaviours and externalizing and internalizing difficulties, but also in terms of the developmental interplay between prosocial behaviours and behavioural/emotional difficulties. Also, although membership to the high prosocial behaviour trajectory was associated with membership to low level physical aggression, depression, and anxiety trajectories, subgroups of children simultaneously exhibiting high levels of prosociality with physical aggression, depression, or anxiety were observed. This emphasizes that a general negative relationship between the development of prosocial behaviours and adjustment difficulties does not preclude that subgroups of children exhibit high prosocial behaviour development in the context of potentially significant behavioural and emotional disturbances.

Findings from the present study may be viewed as consistent with past research depicting prosociality as a double-edged sword, promoting healthy development when appropriately regulated, but creating difficulties if too low (e.g., antisocial behaviours) or too high (e.g., depression) (Hay, 1994). Past
studies have shown a positive relationship between prosocial behaviours and moral development (e.g., Carlo, Koller, Eisenberg, DaSilva & Frolich, 1996) and empathy (e.g., Eisenberg & Miller, 1987), attributes that are generally judged to be important to individuals’ interpersonal relationships and functioning within society. However the development of high prosocial behaviours may be accompanied by an over concern for others, emotion regulation difficulties, and elevated levels of internalizing forms of distress, particularly anxiety (Hay & Pawlby, 2003). Alternatively, highly anxious individuals may be more likely to use prosocial behaviours as a way of navigating their social environments (Culotta & Goldstein, 2008). Our study did not assess causal links, but emphasizes the importance of placing prosocial behaviours within the broader context of individuals’ functioning and environment.

Our analyses further investigated early predictors of the joint development of prosocial behaviours with physical aggression, anxiety, and depression. Child, mother, and family characteristics were found to significantly predict the joint trajectory models. Many of our predictors appeared to be more sensitive to prosocial behaviours or physical aggression, anxiety, and depression rather than to their interplay. For example, positive parenting significantly increased the likelihood of membership to the high prosocial behaviour trajectory and decreased the likelihood of membership to the low prosocial behaviour trajectory, regardless of accompanying levels of physical aggression, anxiety, and depression. Conversely, hostile parenting contributed to higher levels of physical aggression, anxiety, and depression at all prosocial behaviour levels. Such findings suggest that positive parenting can increase children’s prosocial behaviour levels, regardless of whether they are simultaneously experiencing internalizing or externalizing behavioural problems. However, it also suggests that the development of high prosocial behaviour does not protect children from the behavioural problems associated with hostile parenting, or that hostile parenting may lead to the development of behaviour problems even in the presence of high prosocial behaviour development.

Furthermore, a number of predictors appeared to be associated with the interplay of prosocial behaviour development with physical aggression,
anxiety and depression development. In line with past literature (e.g., Côté, Tremblay, Nagin, Zoccolillo, & Vitaro, 2002a), being a boy was a very strong predictor of membership to the low prosocial behaviour trajectory. This was particularly true when low prosocial behaviour development was accompanied by high physical aggression development or high/decreasing anxiety development. Children of depressed mothers were more likely to exhibit a low aggression developmental trajectory in the context of a moderate prosocial behaviour developmental trajectory rather than a low prosocial trajectory. Maternal depression also increased the likelihood of a moderate trajectory of physical aggression in the context of a moderate or high prosocial behaviour trajectory. As well, low family income decreased the likelihood of exhibiting a high depression trajectory in the context of a moderate prosocial trajectory, but increased the likelihood of showing a high depression trajectory in the context of a high prosocial trajectory. It is therefore possible that certain family environments, perhaps characterized by greater hardship and greater likelihood of sensitivity to others’s distress, may be particularly predictive of higher levels of prosocial development accompanied by higher trajectories of externalizing and internalizing distress. These hypotheses call for empirical verification.

The present study was the first to map the associations between the development of prosocial behaviour with the development of aggression, anxiety, and depression from the preschool years to preadolescence. Using a large, representative sample of Canadian children, we painted a broad picture of patterns of association over time. However, because our children were selected from a general rather than clinical sample, the extent to which children following a high physical aggression, anxiety, and depression developmental trajectory were exhibiting clinical levels of problem behaviours and affect is unknown. Measures of low family income, maternal depression, and hostile parenting did significantly predict membership to the high physical aggression, anxiety, and depression trajectories. This speaks to the face validity of our behavioural measures. Future research investigating associations of prosocial behaviour and aggression, anxiety and depression development within clinical samples will however be informative. Furthermore, while we may speculate regarding the potential risk and
protection afforded by varying levels of prosocial behaviour development, this study cannot identify the direction of the relationships observed or the mechanisms underlying such relationships. Experimental evidence is needed from preventive randomized controlled trials. Further investigation is also needed to better describe the characteristics and adjustment of children following various joint prosocial behaviour and problem behaviour developmental trajectories. Finally, the present study used a composite prosocial behaviour measure. Evidence of stronger associations between specific forms of prosocial responding and mental health has however recently been provided (Champion, Jaser, Reeslund, Simmons, Potts, Shears, et al., 2009). Future investigations will therefore benefit from disentangling the specific associations at play between subcomponents of prosocial responding and mental health.

The present study provides evidence for the complex relationship between prosocial behaviours and physical aggression, anxiety, and depression development during childhood within the general population. Future research, further investigating the links between prosocial behaviour development and various markers of mental health development, will be important in further differentiating contexts where prosociality can be helpful to children’s development from contexts where prosociality may be associated with significant externalizing and internalizing problems.
Acknowledgements

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References


Figure 1. Developmental Trajectories

a) Prosocial Behaviour Trajectories

b) Physical Aggression Trajectories

c) Anxiety Trajectories

d) Depression Trajectories
Table 1. Sample characteristics at cycle 1 (1994)

<table>
<thead>
<tr>
<th>Characteristics</th>
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<tr>
<td><strong>Sex of Child</strong> <em>(N = 10 700)</em></td>
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<tr>
<td>Male</td>
<td>51.2</td>
</tr>
<tr>
<td>Female</td>
<td>48.8</td>
</tr>
<tr>
<td><strong>Mother Graduated from High School</strong> <em>(N = 10 659)</em></td>
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<tr>
<td>Yes</td>
<td>78.9</td>
</tr>
<tr>
<td>No</td>
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</tr>
<tr>
<td><strong>Father Graduated from High School</strong> <em>(N = 8 901)</em></td>
<td></td>
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<tr>
<td>Yes</td>
<td>76.5</td>
</tr>
<tr>
<td>No</td>
<td>23.5</td>
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<tr>
<td><strong>Mother Employed Outside the Home</strong> <em>(N = 10 638)</em></td>
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<tr>
<td>Yes</td>
<td>70.5</td>
</tr>
<tr>
<td>No</td>
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<tr>
<td><strong>Father Employed Outside the Home</strong> <em>(N = 8 868)</em></td>
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<td>95.2</td>
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<td><strong>Family Status</strong> <em>(N = 10 700)</em></td>
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<td>One parent</td>
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<td><strong>Family Income</strong> <em>(N = 9 132)</em></td>
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<td>60 000$ and above</td>
<td>38.0</td>
</tr>
</tbody>
</table>
Table 2. Contribution of each age cohort to the accelerated developmental trajectory models (ages 2 to 11)

<table>
<thead>
<tr>
<th>Age at Cycle 1</th>
<th>Cycle 1</th>
<th>Cycle 2</th>
<th>Cycle 3</th>
<th>Cycle 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 to 11 months (N = 975)</td>
<td>-</td>
<td>2</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>Age 1 (N = 1063)</td>
<td>-</td>
<td>3</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>Age 2 (N = 1040)</td>
<td>2</td>
<td>4</td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td>Age 3 (N = 1145)</td>
<td>3</td>
<td>5</td>
<td>7</td>
<td>9</td>
</tr>
<tr>
<td>Age 4 (N = 1122)</td>
<td>4</td>
<td>6</td>
<td>8</td>
<td>10</td>
</tr>
<tr>
<td>Age 5 (N = 1114)</td>
<td>5</td>
<td>7</td>
<td>9</td>
<td>11</td>
</tr>
<tr>
<td>Age 6 (N = 1076)</td>
<td>6</td>
<td>8</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Age 7 (N = 1056)</td>
<td>7</td>
<td>9</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>Age 8 (N = 1014)</td>
<td>8</td>
<td>10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age 9 (N = 1095)</td>
<td>9</td>
<td>11</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 3. Joint probabilities of prosociality and physical aggression.

<table>
<thead>
<tr>
<th>Prosociality</th>
<th>Physical Aggression</th>
<th>Low</th>
<th>Moderate</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>0.03</td>
<td>0.08</td>
<td>0.11</td>
<td>0.02</td>
</tr>
<tr>
<td>Moderate</td>
<td>0.05</td>
<td>0.24</td>
<td>0.22</td>
<td>0.01</td>
</tr>
<tr>
<td>High</td>
<td>0.04</td>
<td>0.12</td>
<td>0.07</td>
<td>0.01</td>
</tr>
</tbody>
</table>

Table 4. Joint and conditional probabilities of prosociality and anxiety.

<table>
<thead>
<tr>
<th>Prosociality</th>
<th>Anxiety</th>
<th>Extremely Low</th>
<th>Low</th>
<th>High Decreasing</th>
<th>High Increasing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>0.02</td>
<td>0.14</td>
<td>0.02</td>
<td>0.10</td>
<td></td>
</tr>
<tr>
<td>Moderate</td>
<td>0.03</td>
<td>0.22</td>
<td>0.09</td>
<td>0.17</td>
<td></td>
</tr>
<tr>
<td>High</td>
<td>0.02</td>
<td>0.10</td>
<td>0.01</td>
<td>0.09</td>
<td></td>
</tr>
</tbody>
</table>

Table 5. Joint and conditional probabilities of prosociality and depression.

<table>
<thead>
<tr>
<th>Prosociality</th>
<th>Depression</th>
<th>Extremely Low</th>
<th>Low</th>
<th>Moderate</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>0.03</td>
<td>0.13</td>
<td>0.13</td>
<td>0.02</td>
<td></td>
</tr>
<tr>
<td>Moderate</td>
<td>0.00</td>
<td>0.26</td>
<td>0.19</td>
<td>0.02</td>
<td></td>
</tr>
<tr>
<td>High</td>
<td>0.02</td>
<td>0.10</td>
<td>0.09</td>
<td>0.01</td>
<td></td>
</tr>
</tbody>
</table>
Table 6. Prediction of joint prosocial behaviour (P) and physical aggression (PA) trajectories.

<table>
<thead>
<tr>
<th>Predictors</th>
<th>Joint Trajectory Groups [ OR (95%CI)]</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low P/ Low PA</td>
<td>Low P/ Moderate PA</td>
<td>Low P/ High PA</td>
<td>Moderate P/ Moderate PA</td>
<td>Moderate P/ High PA</td>
<td>High P/ Low PA</td>
<td>High P/ Moderate PA</td>
<td>High P/ High PA</td>
</tr>
<tr>
<td>Boy</td>
<td>1.42*** (1.18-1.70)</td>
<td>2.65*** (2.22-3.18)</td>
<td>7.90*** (4.73-13.21)</td>
<td>1.05 (1.01-1.085)</td>
<td>3.31* (0.39-0.54)</td>
<td>0.46*** (0.39-0.54)</td>
<td>0.71** (0.58-0.89)</td>
<td>0.63 (0.35-1.14)</td>
</tr>
<tr>
<td>Low income</td>
<td>1.30** (1.06-1.59)</td>
<td>1.27* (1.05-1.54)</td>
<td>1.91*** (1.32-2.78)</td>
<td>1.41*** (1.21-1.63)</td>
<td>2.40 (0.88-6.58)</td>
<td>0.81* (0.67-0.70)</td>
<td>1.78*** (1.42-2.24)</td>
<td>2.23** (1.23-4.05)</td>
</tr>
<tr>
<td>Intact family</td>
<td>1.43 (0.92-2.20)</td>
<td>0.84 (0.60-1.17)</td>
<td>1.30 (0.63-2.68)</td>
<td>0.97 (0.73-1.28)</td>
<td>6.06 (0.11-342.79)</td>
<td>0.67** (0.49-0.91)</td>
<td>1.158 (0.69-1.90)</td>
<td>2.96 (0.50-17.49)</td>
</tr>
<tr>
<td>Maternal education</td>
<td>0.73** (0.58-0.93)</td>
<td>0.82 (0.66-1.03)</td>
<td>0.49*** (0.33-0.73)</td>
<td>0.85 (0.71-1.02)</td>
<td>0.40 (0.13-1.19)</td>
<td>0.86 (0.69-1.07)</td>
<td>1.45* (1.06-2.00)</td>
<td>0.37** (0.19-0.73)</td>
</tr>
<tr>
<td>Maternal depression</td>
<td>0.96*** (0.93-0.98)</td>
<td>1.00 (0.98-1.02)</td>
<td>1.02 (0.98-1.05)</td>
<td>1.02*** (1.01-1.04)</td>
<td>1.03 (0.94-1.12)</td>
<td>1.01 (1.00-1.03)</td>
<td>1.05*** (1.03-1.07)</td>
<td>1.05 (0.99-1.10)</td>
</tr>
<tr>
<td>Positive parenting</td>
<td>0.98 (0.96-1.01)</td>
<td>0.90*** (0.90-0.95)</td>
<td>0.89*** (0.85-0.94)</td>
<td>1.04*** (1.02-1.06)</td>
<td>1.14 (0.97-1.33)</td>
<td>1.16*** (1.13-1.19)</td>
<td>1.19*** (1.15-1.23)</td>
<td>1.27*** (1.15-1.40)</td>
</tr>
<tr>
<td>Hostile parenting</td>
<td>0.97* (0.94-1.00)</td>
<td>1.15*** (1.13-1.18)</td>
<td>1.37*** (1.31-1.43)</td>
<td>1.18*** (1.15-1.20)</td>
<td>1.54*** (1.36-1.75)</td>
<td>0.96*** (0.94-0.98)</td>
<td>1.16*** (1.13-1.20)</td>
<td>1.30*** (1.21-1.41)</td>
</tr>
<tr>
<td>Consistent parenting</td>
<td>0.98 (0.95-1.01)</td>
<td>0.98 (0.95-1.10)</td>
<td>1.03 (0.98-1.09)</td>
<td>1.03** (1.01-1.05)</td>
<td>1.16 (0.99-1.34)</td>
<td>1.05*** (1.03-1.08)</td>
<td>1.01 (0.98-1.04)</td>
<td>1.12* (1.02-1.22)</td>
</tr>
<tr>
<td>Family functioning</td>
<td>0.97 (0.93-1.01)</td>
<td>1.04* (1.00-1.09)</td>
<td>0.95 (0.87-1.03)</td>
<td>1.04 (0.97-1.04)</td>
<td>0.93 (0.74-1.16)</td>
<td>0.96-1.04 (0.87-0.96)</td>
<td>1.00 (1.12-1.52)</td>
<td>1.31*** (1.12-1.52)</td>
</tr>
</tbody>
</table>

Comparison group: Moderate prosocial/Low physical aggression joint trajectory. * p < .05; ** p < .01; *** p < .001. N = 6988
Table 7. Prediction of joint prosocial behaviour (P) and anxiety (A) trajectories.

<table>
<thead>
<tr>
<th>Predictors</th>
<th>Joint Trajectory Groups [ OR (95%CI)]</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low P/High ↓ A</td>
<td>Low P/High ↑ A</td>
<td>Low P/High ↓ A</td>
<td>Moderate P/High ↓ A</td>
<td>Moderate P/High ↑ A</td>
<td>High P/High ↓ A</td>
<td>High P/High ↑ A</td>
<td>High P/High ↑ A</td>
</tr>
<tr>
<td>Boy</td>
<td>2.11***</td>
<td></td>
<td>2.39***</td>
<td>1.22*</td>
<td>1.07</td>
<td>0.61***</td>
<td></td>
<td>0.57***</td>
</tr>
<tr>
<td></td>
<td>(1.82-2.45)</td>
<td>(1.97-2.90)</td>
<td>(1.02-1.47)</td>
<td>(0.92-1.24)</td>
<td>(0.51-0.72)</td>
<td>(0.46-0.69)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low income</td>
<td>1.30**</td>
<td>1.45</td>
<td>1.31**</td>
<td>0.97</td>
<td>1.26**</td>
<td>1.03</td>
<td></td>
<td>1.22</td>
</tr>
<tr>
<td></td>
<td>(1.10-1.53)</td>
<td>(0.63-3.31)</td>
<td>(1.07-1.61)</td>
<td>(0.78-1.21)</td>
<td>(1.07-1.49)</td>
<td>(0.85-1.25)</td>
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<td>(0.99-1.51)</td>
</tr>
<tr>
<td>Intact family</td>
<td>0.98</td>
<td>1.31</td>
<td>0.78</td>
<td>0.64*</td>
<td>0.73*</td>
<td>0.65*</td>
<td></td>
<td>0.66*</td>
</tr>
<tr>
<td></td>
<td>(0.71-1.36)</td>
<td>(0.235-7.291)</td>
<td>(0.53-1.14)</td>
<td>(0.44-0.94)</td>
<td>(0.54-1.00)</td>
<td>(0.46-0.93)</td>
<td></td>
<td>(0.44-0.99)</td>
</tr>
<tr>
<td>Maternal education</td>
<td>0.80*</td>
<td>5.28**</td>
<td>1.06</td>
<td>1.42*</td>
<td>0.84</td>
<td>0.90</td>
<td></td>
<td>1.31</td>
</tr>
<tr>
<td></td>
<td>(0.66-0.97)</td>
<td>(1.49-18.69)</td>
<td>(1.06-1.89)</td>
<td>(1.06-1.89)</td>
<td>(0.69-1.02)</td>
<td>(0.71-1.13)</td>
<td></td>
<td>(0.99-1.73)</td>
</tr>
<tr>
<td>Maternal depression</td>
<td>0.97***</td>
<td>1.15***</td>
<td>1.05***</td>
<td>0.98</td>
<td>1.05***</td>
<td>1.01</td>
<td></td>
<td>1.06***</td>
</tr>
<tr>
<td></td>
<td>(0.95-0.99)</td>
<td>(1.10-1.21)</td>
<td>(1.03-1.06)</td>
<td>(0.96-1.00)</td>
<td>(1.04-1.07)</td>
<td>(0.99-1.03)</td>
<td></td>
<td>(1.04-1.08)</td>
</tr>
<tr>
<td>Positive parenting</td>
<td>0.93***</td>
<td>0.84**</td>
<td>0.94***</td>
<td>0.98</td>
<td>1.01</td>
<td>1.17***</td>
<td></td>
<td>1.14***</td>
</tr>
<tr>
<td></td>
<td>(0.91-0.95)</td>
<td>(0.75-0.93)</td>
<td>(0.91-0.96)</td>
<td>(0.95-1.00)</td>
<td>(0.98-1.03)</td>
<td>(1.14-1.21)</td>
<td></td>
<td>(1.10-1.18)</td>
</tr>
<tr>
<td>Hostile parenting</td>
<td>0.98</td>
<td>1.30***</td>
<td>1.07***</td>
<td>1.00</td>
<td>1.06***</td>
<td>0.93***</td>
<td></td>
<td>1.07***</td>
</tr>
<tr>
<td></td>
<td>(0.96-1.00)</td>
<td>(1.19-1.43)</td>
<td>(1.04-1.10)</td>
<td>(0.97-1.03)</td>
<td>(1.04-1.08)</td>
<td>(0.91-0.96)</td>
<td></td>
<td>(1.04-1.10)</td>
</tr>
<tr>
<td>Consistent</td>
<td>0.96***</td>
<td>0.89**</td>
<td>0.94***</td>
<td>1.00</td>
<td>0.99</td>
<td>1.04**</td>
<td></td>
<td>1.00</td>
</tr>
<tr>
<td>parenting</td>
<td>(0.94-0.98)</td>
<td>(0.81-0.97)</td>
<td>(0.92-0.97)</td>
<td>(0.97-1.02)</td>
<td>(1.01-1.07)</td>
<td>(0.97-1.03)</td>
<td></td>
<td>(0.97-1.03)</td>
</tr>
<tr>
<td>Family functioning</td>
<td>1.00</td>
<td>0.98</td>
<td>1.04</td>
<td>0.97</td>
<td>0.96*</td>
<td>0.97</td>
<td></td>
<td>1.00</td>
</tr>
<tr>
<td></td>
<td>(0.97-1.04)</td>
<td>(0.82-1.17)</td>
<td>(0.92-1.01)</td>
<td>(0.93-1.00)</td>
<td>(0.93-1.01)</td>
<td>(0.95-1.05)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Comparison group: Moderate prosocial/Low anxiety joint trajectory. * p < .05; ** p < .01; *** p < .001. N = 6983.

The number of children (n = 7) for the joint High P/High↓A trajectory did not allow inclusion in formal analyses.
Table 8. Prediction of joint prosocial behaviour (P) and depression (D) trajectories.

<table>
<thead>
<tr>
<th>Predictors</th>
<th>Joint Trajectory Groups [ OR (95%CI)]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low P/ Moderate D</td>
</tr>
<tr>
<td>Boy</td>
<td>1.81*** (1.56-2.12)</td>
</tr>
<tr>
<td>Low income</td>
<td>1.21* (1.02-1.43)</td>
</tr>
<tr>
<td>Intact family</td>
<td>1.23</td>
</tr>
<tr>
<td>Maternal education</td>
<td>0.87 (0.71-1.06)</td>
</tr>
<tr>
<td>Maternal depression</td>
<td>1.01</td>
</tr>
<tr>
<td>Positive parenting</td>
<td>0.92***</td>
</tr>
<tr>
<td>Hostile parenting</td>
<td>0.97**</td>
</tr>
<tr>
<td>Consistent parenting</td>
<td>0.95***</td>
</tr>
<tr>
<td>Family functioning</td>
<td>1.02</td>
</tr>
<tr>
<td></td>
<td>(0.98-1.06)</td>
</tr>
</tbody>
</table>

Comparison group: Moderate prosocial/Low depression joint trajectory. * p < .05; ** p < .01; *** p < .001. N = 6988.
Connecting Text – Study 2 to Study 3

Study 2 provides evidence of developmental associations between prosocial behaviours and physical aggression, anxiety and depression. A negative association tended to be observed between prosocial behaviours and physical aggression and depression, while a more complex relationship emerged with anxiety. Furthermore, while parenting predictors tended to be associated with prosocial behaviours or externalizing/internalizing difficulties, predictors such as maternal depression and low family income showed some sensitivity to the interplay of prosocial behaviours with externalizing and internalizing problems.

Aggression, anxiety, and depression have been linked with serotonergic functioning (see Gringrich, Ansorge, Merker, Weisstaub, & Zhou, 2003 for a review). Associations of prosocial behaviours with aggression, anxiety, and depression raise the question of possible serotonergic contributions to prosocial responding as well. Research with non-human primates and human adults has provided evidence of a positive association between serotonin and agreeableness, affiliative behaviours, and assertive/dominant behaviours (see Krakowski, 2003; Young & Leyton, 2002, for reviews). Never has serotonin been investigated in relations to children’s prosocial behaviours. Consequently, investigations of the link between aggression and serotonin in children have never simultaneously considered positive and negative aspects of functioning. Study 3 therefore investigated the impact of a double-blind, acute tryptophan supplementation on physically aggressive boys’ laboratory aggressive and prosocial behaviours.
Study 3

Tryptophan Supplementation Effects on Boys’ Aggressive and Prosocial Behaviours

Amélie Nantel-Vivier¹, Robert O. Pihl¹, Simon N. Young¹, Sophie Parent², Richard E. Tremblay², Jean R. Séguin²

¹ McGill University, Canada
² University of Montreal, Canada
Abstract

Objectives: To investigate the impact of a double-blind, acute tryptophan supplementation procedure on physically aggressive boys’ laboratory aggressive and prosocial behaviours.

Method: Participants were 23 boys with a history of elevated physical aggression, recruited from a larger community sample. Approximately half of the children (11 boys) were given a chocolate milkshake supplemented with tryptophan (500 mg), while the rest of the sample (12 boys) received a chocolate milkshake with no tryptophan added. A series of experimental tasks followed. These included a competitive reaction time game, tapping into boys’ aggressive behaviours, impulsivity, perspective taking, and sharing behaviours towards a fictitious opponent. Impulsivity was further assessed through a Go/No-Go paradigm. Finally, a computerized emotion recognition task and a staged instrumental help incident were administered.

Results: Boys in the tryptophan condition showed greater stability in their retaliation against the fictitious opponent during the competitive reaction time game. They also showed greater perspective taking and tended to be less impulsive. Boys in the tryptophan condition tended to better distinguish facial expressions of fear and happiness, and provided greater instrumental help to the experimenter during the staged incident.

Conclusions: The present study was the first to employ a double-blind, acute tryptophan supplementation procedure with children. While further investigations are necessary, evidence is provided that tryptophan supplementation may have increased the situational appropriateness of boys’ behaviours. Our findings globally point to a contribution of the serotonergic neurotransmitter system to children’s aggressive and prosocial behaviours.
Introduction

The contribution of the serotonergic neurotransmitter system to social functioning, particularly aggressive and affiliative behaviours, has been the object of numerous empirical investigations. A negative association between serotonergic functioning and aggressive behaviours has been observed in both nonhuman primates and humans (Krakowski, 2003). In monkeys, low cerebrospinal fluid (CSF) levels of the 5-HIAA serotonin metabolite concurrently and longitudinally predict high levels of unrestrained and violent aggression, as well as impulsivity, risk taking behaviours, and premature violent death (Fairbanks, Melega, Jorgensen, Kaplan, & McGuire, 2001; Higley, Mehlman, Taub, Higley, & Suomi, 1992; Higley, Mehlman, Higley, Fernald, Vickers, Lindell, et al., 1996a; Howell, Westergaard, Hoos, Chavane, Shoaf, Cleveland, et al., 2007; Mehlman, Higley, Faucher, Lilly, Taub, Vickers, et al., 1994). In humans, low serotonergic functioning is associated with antisociality, impulsivity, and hostile aggression towards both the self and others (Brown, Ebert, Goyer, Jimerson, Klein, Bunney, et al., 1982; Moore, Scarpa, & Raine, 2002; Tuinier, Verhoeven, & van Praag, 1995). Interestingly, deficits in serotonergic functioning appear to be specific to impulsive and violent forms of aggression, as they do not predict overall rates of aggression or instrumental aggression and competition used to increase dominance and status (Olivier, 2004). Conversely, high levels of CSF serotonin metabolites have been associated with high dominance, as well as sociability and affiliative behaviours (Mehlman, Higley, Faucher, Lilly, Taub, Vickers, et al., 1995; Westergaard, Suomi, Higley, & Mehlman, 1999). The nature of associations between dominance and serotonin may however vary between species of monkeys (e.g., Riddick, Czoty, Gage, Kaplan, Nader, Icenhower, et al., 2009; Yodyingyuad, de la Riva, Abbott, Herbert, & Keverne, 1985). Studies manipulating serotonin levels in humans and monkeys have provided evidence consistent with results of correlational studies, with decreased serotonergic functioning causing an increase in aggressive behaviours and impulsivity (Bjork, Dougherty, Moeller, Cherek & Swann, 1999; Chamberlain, Ervin, Pihl, & Young,
of all methods available to study serotonergic functioning, experimental approaches present the advantage of allowing for assignment of research participants to experimental groups. Experimental manipulation of tryptophan, a dietary component and precursor to serotonin which has few side effects and is acceptable for use in humans, has provided great insight into the contribution of serotonergic functioning to behaviours and mood. Tryptophan, and by extension serotonin, may be acutely depleted and augmented in experimental participants through ingestion of amino acid mixtures devoid of or supplemented with tryptophan (Young & Leyton, 2002).

Studies of human adult participants have found that acute tryptophan depletion can increase levels of both observed and self-reported aggression within the laboratory context (Bjork et al., 1999; Bjork, Dougherty, Moeller, & Swann, 2000; Moeller, Dougherty, Swann, Collins, Davis, & Cherek, 1996; Pihl, Young, Harden, Plotnick, Chamberlain, & Ervin, 1995), with stronger effects often found in individuals with a pre-existing vulnerability (e.g., high hostility/aggression trait) (Cleare & Bond, 1995; Dougherty, Bjork, Marsh, & Moeller, 1999, Finn, Young, Pihl, Ervin, 1998). Interestingly, tryptophan depletion increased the proportion of rejected unfair offers, but not fair offers, during an ultimatum game (Crockett, Clark, Tabibnia, Lieberman, & Robbins, 2008). Conversely, tryptophan supplementation in human adults has been associated with decreased aggression levels in laboratory tests (Bjork et al., 2000; Pihl et al., 1995). In pathologically aggressive patients, tryptophan supplementation decreased uncontrolled behaviours (Morand, Young, & Ervin, 1983). In healthy adults it decreased quarrelsomeness in social interactions, while increasing dominance
Furthermore, in high trait quarrelsome individuals, it decreased quarrelsomeness and increased agreeableness. Only for high trait quarrelsome males did tryptophan supplementation decrease dominance (aan het Rot, Moskowitz, Pinard, & Young, 2006).

A study by Attenburrow and colleagues (Attenburrow, Williams, Odontiadis, Reed, Powell, Cowen, et al., 2003) found that tryptophan supplementation can also increase emotional processing and recognition in human adults. Similar results have been obtained with acute use of citalopram, a serotonin reuptake inhibitor (Bhagwagar, Cowen, Goodwin, & Harmer, 2004; Browning, Reid, Cowen, Goodwin, & Harmer, 2007; Harmer, Bhagwager, Perrett, Voellm, Cowen, & Goodwin, 2003a). While tryptophan depletion studies have found evidence of decreased emotion recognition, the relationships observed have been found to vary according to gender (Harmer, Rogers, Tunbridge, Cowen, & Goodwin, 2003b), serotonergic polymorphism (Marsh, Finger, Buzas, Soliman, Richell, Vythilingam, et al., 2006), depression history (Hayward, Goodwin, Cowen, & Harmer, 2005), and contextual factors (aan het Rot, Coupland, Boivin, Benkelfat, & Young, in press).

The literature on experimental manipulations of tryptophan levels in human adults, as well as animals, therefore highlights a contribution of serotonergic functioning to the regulation of aggression and positive social interactions, as well as emotional processing. However, retrospective and prospective longitudinal investigations have clearly established that the behaviours and self-regulatory processes known to be influenced by tryptophan manipulations in adults emerge in childhood. Contrary to the popular belief that physical aggression and violence are problems most frequent during adolescence, large surveys of representative samples of young children have shown that physical aggression is most frequent in early years (Tremblay, in press; Tremblay, Nagin, Séguin, Zoccolillo, Zelazo, Boivin, et al., 2004; see also Holden, 2000). Prosocial behaviours, such as helping and sharing, have also been observed to emerge in early years (e.g., Brownell & Carriger, 1990; Hay, Castle, Davies,
Demetriou, Stimson, 1999, Nantel-Vivier, Pihl, & Tremblay, in preparation; Romano, Tremblay, Boulerice, & Swisher, 2005). As well, childhood manifestations of both aggressive and prosocial behaviours appear to be predictive of future behavioural tendencies. For example, preschool prosocial behaviours have been shown to prospectively predict prosocial and antisocial behaviours measured in early adolescence and adulthood (Eisenberg, Guthrie, Cumberland, Murphy, Shepard, Zhou, et al., 2002; Tremblay, Pihl, Vitaro, & Dobkin, 1994). Furthermore, a subgroup consisting of approximately 5 to 10% of children, mainly boys, exhibits chronically high levels of physical aggression throughout childhood and adolescence (Bongers, Koot, van der Ende, & Verhulst, 2004; Brame, Nagin & Tremblay, 2001; Broidy, Nagin, Tremblay, Bates, Brame, Dodge, et al., 2003; Côté, Vaillancourt, Leblanc, Nagin, & Tremblay, 2006; Nagin & Tremblay, 1999; NICHD, 2004), and are at greatest risk for physical violence and other difficulties during adolescence and beyond (Broidy et al., 2003).

Developmental research has therefore pointed to the significance of early aggressive and affiliative behaviours, particularly the risk posed by high levels of childhood physical aggression. It thus follows that the relationship of serotonergic functioning to aggressive and affiliative behaviours in childhood would be an important empirical question. However, few tryptophan manipulation studies have focused on child samples. Studies having investigated the impact of tryptophan manipulation on children’s behaviours have generally focused on children with a diagnosis of Attention Deficit Hyperactivity disorder (ADHD), finding some evidence of symptom relief with tryptophan supplementation (Ghose, 1983; Nemzer, Arnold, Votolato, & McConnell, 1986; Hoyse, 1982). A recent series of investigations demonstrated that acute tryptophan depletion can impact ADHD children’s laboratory aggression, defined as points taken away from a fictitious opponent following provocation during a competitive reaction time game (Stadler, Zepf, Demisch, Schmitt, Landgraf, & Poustka, 2007), as well as reaction times (Zepf, Wöckel, Poustka, & Holtmann, 2008) and behavioural inhibition (Zepf, Holtmann, Stadler, Demisch, Schmitt, Wockel, & Poustka, 2008).
In sum, the experimental manipulation of tryptophan levels, an amino acid precursor to serotonin, has proven to be a useful and informative tool in understanding mechanisms of behaviour self-regulation. Developmental research has clearly established that self-regulation of social interactions emerges during the first years of life, specifically with regards to physically aggressive and prosocial behaviours. While experimental manipulation of tryptophan levels has previously been used with samples of children, never has tryptophan supplementation been employed to experimentally investigate the contribution of serotonergic functioning to physically aggressive children’s behaviours. Physically aggressive boys are however research participants of particular interest, as they are at highest risk of exhibiting significant violence at later life stages (Broidy et al., 2003; Nagin & Tremblay, 1999).

The goal of the present study was therefore to investigate the impact of acute tryptophan supplementation on physically aggressive boys’ aggressive and prosocial behaviours. We hypothesized that boys within a tryptophan supplementation group would show lesser aggression than boys in the control condition in response to provocation by a fictitious opponent during a competitive reaction time game. Reactivity to provocation was measured as change in points taken away from the fictitious opponent at varying levels of provocation, relative to a no provocation baseline. We expected group differences in aggression to be more salient during periods of low provocation, as retaliation to high provocation has been suggested to be normative of both healthy controls and behaviourally disordered children (Waschbusch, Pelham, Jennings, Greiner, Tarter, & Moss, 2002). Furthermore, we also expected boys in the tryptophan condition to show lesser impulsivity than boys in the control condition. Finally we hypothesized that boys in the tryptophan condition would show greater prosocial behaviours than boys in the control condition, as evidenced by greater sharing and helpfulness. We also expected boys in the tryptophan condition to exhibit greater perspective taking and emotion recognition.
Methods

Participants

Participants for the present study were boys from a community sample of 572 children who have been followed yearly since they were 5 months old (Jetté, Desrosiers, Tremblay, 1997). Physical aggression developmental trajectories (Côté, Boivin, Nagin, Japel, Xu, Zoccolillo, et al., 2007; Nagin, 2005), spanning ages 17 to 84 months, were modeled based on mother ratings for 512 children of the original community sample. This was done to identify boys with a relatively history of high physical aggression (Figure 1). 103 boys exhibited a probability greater than 75% of following the high physical aggression trajectory. Of the 103 families, 57 were currently active participants in the greater longitudinal research program and currently lived within the greater Montreal region, and could thus be contacted. Exclusion criteria were the presence of a serious medical illness, history of head injury, and current use of prescription medications, with the exception of Ritalin, Ritalin SR, Concerta, Adderall XR, and Dexedrine. Participants taking one of the exception prescription drugs had to be on the same dosage regimen for at least a month to be included in the study, and were asked not to take their medication on the day of testing. Two boys were excluded from participation based on the medication criteria. Agreement to participate was obtained from the parents of 23 of the 55 remaining boys. Mean age at the time of the study was 123.17 months (SD = 2.8 months). The research protocol was approved by Health Canada, the Ste-Justine Hospital Research Center Ethics Committee, and the McGill University Institutional Review Board (IRB) of the Faculty of Medicine. Participants were treated according to the American Psychological Association principles (American Psychological Association 2002).

Procedure

Informed verbal and written consent was obtained from parents and assent was obtained from participants upon their arrival at the laboratory. The present study followed a randomized, double-blind design. All boys were given a chocolate milkshake which, for 11 randomly selected boys, contained a 500 mg tryptophan (Tryptan™) tablet that had been previously ground into a fine powder.
The remaining 12 participants received a chocolate milkshake with no added tryptophan. Only the onsite research supervisor, who did not interact with families and participants, knew of the group assignment. Therefore, the research assistants interacting with participants and their parents, as well as parents and the boys themselves were blind to the group assignment. Although the milkshakes were not identical in taste they were both palatable and the blind was maintained because the participants tasted only one milkshake. Experimental tasks tapping into children’s laboratory aggression and prosociality were administered 45 minutes following milkshake ingestion. This was done in order for enough serotonin to be synthesized from tryptophan to have an effect on brain function; indeed, plasma tryptophan level increases several folds within half and hour and peaks around two hours after its ingestion (Yuwiler, Brammer, Morley, Raleigh, Flannery, & Geller, 1981). The sequence of task presentation was the same for all participants. The testing session was filmed in its entirety to allow subsequent coding.

**Measures**

*Competitive reaction time game.* A modified version of the Taylor-Buss paradigm used by Pelham and colleagues (Pelham, Milich, Cummings, Murphy, Schaugency, & Greiner, 1991) was administered. Boys were informed they would play a competitive reaction-time game with another boy over the Internet, when in fact the opponent was fictitious and boys were playing the computer. A video of the fictitious opponent, a child confederate previously filmed, was presented to participants before the game began. Participants were told that what they saw on the monitor was a real-time view of their opponent getting ready to play against them.

The game consisted of pressing the space bar and releasing it as quickly as possible when the computer gave a signal. Boys were instructed that the player with the faster reaction time on any given trial would be awarded 50 points. Additionally, the winner of the trial would be allowed to remove 0, 10, 20, 30, 40, 50, 60, 70, 80, 90 or 100 points from their opponent. These points would not go to the trial winner taking the points away, but to a point “bank” common to both players. This was done to remove immediate instrumental gains from taking
points away, thereby tapping more into aggressive responding. Participants were told that the competitor who won the most trials and therefore accumulated the most points would be able to exchange their points for a toy at the end of the game.

The sequences of wins and losses, as well as the number of points the computer took away from the boys on each loss trial was predetermined. There were a total of 40 trials, divided into quarters of ten trials, which varied in provocation level. There were no pauses between the quarters. The first quarter was a “no provocation” baseline, where the computer did not remove points from participants when they lost. The second quarter consisted of a “high provocation” period, where the computer removed either 80 or 90 points when boys lost. The third period was a “low provocation” period, where the computer removed either 10 or 20 points when boys lost. Finally, the last quarter was again a “no provocation” period, where the computer did not remove any points when boys lost. Final earnings for all participants were 900 points.

Boys’ aggression was operationalized as the amount of points they took away from their opponent. Reactivity was operationalized as the change in points taken away, decision time and reaction time during varying levels of provocation relative to the no provocation baseline. Impulsivity was defined as the number of times the boys released the spacebar before the signal was given by the computer.

In addition, we extended Pelham et al.’s (1991) original protocol to include measures of perspective taking and sharing. Perspective taking was assessed by asking boys to indicate how they thought their opponent was feeling upon losing the game, using an array of schematic faces presented on the computer (neutral, happy, sad or angry). Next, sharing was assessed in a manner consistent with previous investigations of anonymous donations to a third party (Eisenberg-Berg & Geisheker, 1979; Koenig, Cicchetti, Rogosch, 2004; Stewart & McBride-Chang, 2000). The research assistant showed the boys a video of the fictitious opponent looking sad and disappointed he had lost. The research assistant then 1) congratulated the boys for winning; 2) pointed out that the opponent appeared disappointed to have not done as well; 3) informed them that,
as the winner, they could divide the points from the bank as they wished between themselves and their opponent. The experimenter emphasized that the decision would be anonymous. Boys were then left alone to divide the points, using and analog scale on the computer.

*Go/No-Go.* The basic Go/No-Go paradigm measures inhibitory control (Nigg, 2001). Participants were instructed that the letter ‘X’ or ‘Y’ would appear on the screen, and that they should press the space bar only when a ‘Y’ appeared, and not press any key when an ‘X’ appeared. 100 trials were administered. Number of successful trials, number of omission errors, and number of commission errors were recorded.

*Ring incident.* The ring incident was intended to measure participants’ helpful behaviours towards the experimenter, in a similar fashion to previous laboratory studies of helping behaviours (Green & Schneider, 1974). As the boys were getting ready to take part in a computer activity, the experimenter looked at her hand, gasped and said: “Oh no! I lost my ring!” The experimenter then searched the room according to a set routine, allowing boys time to help. The incident ended with the experimenter finding the ring, which had been previously hidden in the testing room. Videos of the incident for all 23 children were first coded by a trained rater, to verify whether (yes or no) children 1) noticed the incident 2) verbally expressed concern 3) visually scanned the room to search for the ring 4) physically got up from their chair to help the experimenter find the ring. A second trained rater coded a random selection of 30% of the videos for reliability. Mean interrater agreement was 91%.

*Emotion Recognition.* The emotion recognition task was originally created by Pollack and Kistler (2002). Participants were asked to identify the emotion displayed in pictures of adults making different facial expressions. The pictures were created by blending pictures of the models displaying four basic emotions: happiness, sadness, fear and anger. Thus, the pictures represented a continuum between two emotions, for example happy-fearful or angry-sad, in increments of 10%. Participants were asked to identify the emotion shown in 244 trials including both the prototypic and blended pictures, always choosing between two
response options presented at the bottom of the computer screen. All trials began with a central fixation point for 250 ms and ended with a blank screen for another 250 ms. Mean accuracy (%) of identification for each continuum was the main dependent measure.

**Analyses**

For the Taylor-Buss paradigm, group differences in number of points taken away from the “opponent”, decision time, reaction time, percentage of points shared, and impulsivity (i.e., number of inappropriate spacebar releases) were investigated through t tests, while group differences in perspective taking were assessed using chi-square analyses. Within-subject repeated measures analyses were performed separately for each group to assess patterns of reactivity to varying levels of provocation. The number of points taken away, decision time, and reaction time during the high provocation (phase 2), low provocation (phase 3) and no provocation (phase 4) phases were standardized (z scores) using the no provocation baseline means. These standardized values were then used in planned comparisons to assess the extent of deviation from baseline responding. In addition, group differences were assessed using t tests for the Go/no-Go and emotion recognition tasks. Finally, chi-square analyses were used to evaluate group differences on helpful reactions towards the experimenter during the staged ring incident.

**Results**

**Sample Characteristics**

Table 1 presents group means for age at the time of the study, family socio-economic status (96 months), verbal and non-verbal cognitive skills (84 months), and behaviours (120 months) collected prior to the present experiment as part of the larger longitudinal design. Mean probability of being assigned to the high physical aggression trajectory group is also included. Comparison of the control and tryptophan groups using independent sample t tests revealed no significant group differences on background socioeconomic, cognitive, and behavioural variables. The two groups may therefore be considered equivalent.
Response to the competitive reaction time game

Table 2 presents results of independent sample t tests investigating group differences in response to provocation during the competitive reaction time game, specifically overall number of points taken away, overall mean decision time, and overall mean reaction time. No significant group differences emerged. It is however noted that boys in the tryptophan group tended to be less impulsive than controls, as measured by the number of inappropriate spacebar releases made \((t(21) = 1.85, p = 0.08)\). Although group differences in impulsivity did not reach statistical significance, they can nevertheless be qualified as representing a large effect size (Cohen \(d = -0.77\)).

Within-subject repeated measures analyses were performed separately for each group to assess patterns of response to varying levels of provocation by the fictitious opponent. Planned comparisons investigating differences in response at phases 2 (high provocation), 3 (low provocation), and 4 (no provocation) relative to phase 1 (no provocation baseline) were performed. Of note is that the tryptophan and control groups did not differ at baseline on points taken away \((t(21) = 0.01, p = 0.99)\), decision time \((t(21) = 1.15, p = 0.26)\), and reaction time \((t(21) = -0.14, p = 0.89)\). As illustrated in Figure 2a, provocation level had a significant effect on points taken away for the control group \((F(1.46) = 7.37, p = 0.01)\) but to a lesser extent for the tryptophan group \((F(3) = 2.30, p = 0.10)\). Planned comparisons revealed that boys in the control group tended to take away more points than at baseline during the high provocation phase \((z = 0.36, F(1) = 3.81, p = 0.08, d = 0.45)\) and significantly decreased the number of points they took away during the last phase of the game \((z = -0.77, F(1) = 5.00, p = 0.05, d = -0.93)\). Boys in the tryptophan group significantly increased the number of points they took away only during the high provocation phase of the game \((z = 0.59, F(1) = 6.31, p = 0.03, d = 0.64)\). As shown in Figure 2b, provocation level had a significant effect on decision time for both the control group \((F(3) = 4.06, p = 0.02)\) and the tryptophan group \((F(1.84) = 4.33, p = 0.03)\). Planned comparisons revealed that boys in the control group significantly decreased their decision time relative to baseline during the high provocation \((z = -0.62, F(1) = 4.87, p = 0.05, d = \ldots)\).
= -0.72) and low provocation (z = -0.86, F(1) = 10.21, p = 0.01, d = -0.95) phases of the game. Boys in the tryptophan group significantly decreased their decision time relative to baseline only during the high provocation phase (z = -1.10, F(1) = 16.36, p = 0.00, d = -1.26). No significant effect of provocation level was found on reaction times for the control (F(1.40) = 0.62, p = 0.50) or tryptophan groups (F(3) = 0.39, p = 0.76).

As reported in Table 2, investigation of group differences on measures of prosociality taken during the competitive reaction time game revealed no significant differences on the percentage of points shared with the fictitious opponent at the end of the game. However, as illustrated in Figure 3, chi-square analyses revealed that boys in the tryptophan group were significantly less likely than boys in the control group to describe their opponent as emotionally neutral upon losing the game, and were more likely than boys in the control group to describe the defeated opponent as experiencing a negative emotional state (Pearson $\chi^2$ (df = 2) = 6.06, p = 0.05).

*Go/No-Go*

As shown in Table 2, comparisons of boys in the control and tryptophan groups on the number of successful trials (t(21) = 0.48, p = 0.63), number of omission errors (t(21) = -0.55, p = 0.59) and number of commission errors (t(21) = 0.57, p = 0.58) did not reveal significant differences.

*Emotion recognition*

As reported in Table 2, a statistical trend for the tryptophan group to be more accurate in distinguishing happiness and fear (t(21) = -1.82, p = 0.08) was observed. This trend represents a large effect size (d = .75). No significant group differences emerged on the happy-sad, mad-fear, and mad-sad continua.

*Reaction to the lost ring incident.*

Chi-square analyses were performed to investigate group differences in helping behaviours towards the experimenter during the staged lost ring incident (Figure 4). Analyses revealed no significant differences between the control and
tryptophan groups in terms of the number of children who made suggestions or who got up from their chair to help the experimenter search for her ring. However, in the control group, significantly more children than expected by chance verbally expressed concern (Pearson $\chi^2$ (df = 1) = 4.54, $p = 0.03$), while significantly more children in the tryptophan condition visually scanned the room in search of the lost ring (Pearson $\chi^2$ (df = 1) = 4.54, $p = 0.03$).

Discussion

The present study investigated the impact of acute tryptophan supplementation on physically aggressive boys’ aggressive and prosocial behaviours. Results revealed that boys in the tryptophan condition showed more stable levels of aggression, as well as greater levels of perspective taking and helpfulness than boys assigned to the control condition.

Boys in both the tryptophan and control conditions increased the number of points they took away during the high provocation phase (phase 2) relative to baseline. Similar aggression levels during high provocation are consistent with past studies (e.g., Waschbusch et al, 2002) having demonstrated that both healthy controls and children suffering from behavioural difficulties tend to retaliate similarly in laboratory conditions characterized by high provocation conditions meant to elicit reactive aggression. However, boys in the tryptophan and control groups were also equally aggressive during the low provocation phase, with both groups returning to their baseline level of aggression. Furthermore, while children in the tryptophan group remained at baseline during the no provocation final phase, boys in the control condition significantly decreased the number of points they took away from their opponent by approximately $\frac{3}{4}$ of a standard deviation relative to their initial baseline.

Findings of decreased aggression by the control group are not consistent with past studies of acute tryptophan manipulation and laboratory aggression (e.g., Cleare & Bond, 1995; Dougherty et al., 1999, Finn et al., 1998). However, King and colleagues (King, Waschbusch, Pelham, Frankland, Corkum, &
Jacques, 2009), using a similar competitive reaction time game to the one in the present study, recently reported that healthy control children maintained the amount of points they took away after provocation by a fictitious opponent stopped. Children diagnosed with ADHD, however, decreased the amount of points they took away from the opponent during the same period. King and colleagues (2009) concluded that healthy control children were perhaps better at developing and maintaining their competitive strategy than ADHD children.

It is possible that tryptophan supplementation promoted behaviour patterns similar to those observed by King et al. (2009) in behaviourally healthy children, while the behaviours of the boys in the control condition more closely matched those observed by King et al. (2009) in their ADHD group. Such patterns may be interpreted in light of studies investigating the impact of increased serotonergic functioning on non-human primates and human adults dominant behaviours (e.g., Melhman et al., 1995, Moskowitz et al., 2001). Specifically, these studies have pointed to a relationship between increased serotonin levels and increased dominance and appropriate assertive behaviours. From this perspective, boys in the tryptophan condition may have been better able to sustain the competitiveness of the reaction time game, remaining focused and maintaining their strategy unless highly provoked. Boys in the control condition, however, appear to have been unable to sustain the competition of the reaction time game and to have perhaps been more reactive to provocation from the fictitious opponent. This is supported by findings of quicker decision times relative to baseline for the control group during both the high and low provocation phases, while decision time was only significantly decreased relative to baseline during the high provocation phase for boys in the tryptophan condition. As well, the marginally significant finding of lesser impulsivity in the tryptophan children suggests that they may have been better at focusing on the task and better regulated in their responding.

Findings of greater prosociality in the tryptophan group may also be viewed as consistent with the literature on increased serotonergic functioning and affiliative behaviours in non-human primates and human adults. Children in the tryptophan group were more likely to select schematic faces expressing negative
emotional states to describe what they believed was their opponent’s emotional state upon losing the reaction time game than their control counterparts. They similarly tended to be more accurate than controls in distinguishing between facial expressions of happiness and fear. Greater accuracy in distinguishing between facial expressions of different emotions, particularly fear, following tryptophan supplementation and the reverse following tryptophan depletion has been observed in adults samples (e.g., Attenburrow et al., 2003). Furthermore, children in the tryptophan group were significantly more likely to visually scan the laboratory room for a ring the experimenter had pretended to have lost. Boys in the control condition were more likely to make verbal comments indicative of concerns (e.g., “oh no!”) upon the experimenter stating she had lost her ring than boys in the tryptophan condition. These latter findings may be interpreted as control children being more emotionally reactive, and tryptophan children being more instrumentally helpful when faced with the experimenter’s disarray at having lost a valued belonging. Future studies investigating the impact of tryptophan supplementation on behavioural and physiological reactivity to need for help and distress are necessary to empirically verify this interpretation.

Taken together, group differences observed on the reactive aggression and prosocial measures suggest that tryptophan supplementation may have increased the situational appropriateness of physically aggressive boys’ behaviours. Boys in the tryptophan condition appeared to be more behaviourally focused, as demonstrated by their appropriately sustained competitiveness and decreased impulsiveness when facing an opponent, as well as increased instrumental help to the experimenter. Boys receiving tryptophan were perhaps more sensitive to affectively salient cues, as exemplified by their tendency to better distinguish fear and happiness. They were also better able to take the opponent’s perspective, and described them as dissatisfied upon losing the competitive reaction time game.

The present study was the first to implement an acute tryptophan supplementation procedure with physically aggressive boys. Divergence of findings between the present study and past studies investigating the impact of acute tryptophan manipulation on laboratory aggression may be partly explained
by certain important methodological differences. The competitive reaction time game used in the present study follows from a long tradition of laboratory tasks inspired by the original Taylor-Buss paradigm (Taylor, 1967), where participants were given the option of administering electrical shock to their fictitious opponent upon winning reaction time based trials. It may be argued that, unlike the version of the task used in the present study, the original paradigm used by Taylor more closely approximated physical aggression. It will be necessary to investigate the effect of tryptophan supplementation on physically aggressive boys’ laboratory aggression using tasks tapping into perhaps more hostile forms of retaliation. Careful replication of the present study using child-appropriate designs measuring outcomes more closely linked to physical aggression, such as attack and retaliation through white noise or abrasive noise administration (e.g., King et al, 2009), would be important in clarifying the relationship between increased serotonin and physically aggressive boys’ aggressive vs. dominant behaviours. Furthermore, the majority of previous studies have focused on the contribution of acute tryptophan depletion in increasing aggression, whereas the present study employed acute tryptophan supplementation, hypothesizing that it would decrease laboratory aggression. Whether acute tryptophan depletion and supplementation are equally powerful in changing aggression levels may be questioned. As well, past acute tryptophan supplementation studies have generally also administered a tryptophan depletion condition to their participants, on different days. Behavioural effects were measured at approximately five hours post-ingestion for both conditions, to make them indistinguishable to participants. Behavioural effects of tryptophan supplementation can however be observed much more quickly (Yuwiler et al., 1981). We therefore administered our measures 45 minutes post ingestion. It is however possible that divergence between our findings and that of previous investigations could be attributable to timing effects. Such possibility should be examined in future studies. Additionally, studies using tryptophan supplementation over a period of time rather than acute supplementation have observed decreased quarrelsome, increased dominance, and increased affiliative behaviours in adult samples (Moskowitz et al., 2001; aan
het Rot et al, 2006). Studies employing a similar methodology in younger children would be highly valuable in further examining the impact of tryptophan supplementation on children’s social behaviours. Also important for clarification would be the use of competitive games where the outcome is maximized for participants through cooperation with their opponent, such as in the prisoner’s dilemma. In fact, acute tryptophan depletion decreased levels of cooperation in healthy adults during a prisoner’s dilemma paradigm (Wood, Rilling, Sanfey, Bhagwagar, & Rogers, 2006). Findings of greater cooperation on such a task from children having received tryptophan supplementation would provide support for the notion that tryptophan increases adaptive, and situationally appropriate social reactions. Although we can hypothesize that the more stable patterns of aggression and greater prosociality observed in the tryptophan group may be adaptive, our limited sample size and the presence of marginally significant findings clearly indicate a need for further investigation. It is however important to note that the marginally significant findings were still characterized by moderate to large effect sizes, pointing to the potentially robust nature of the relationships observed. Nevertheless, future studies attempting replication and expanding on the present methodology will be crucial in clarifying the nature and meaning of the group differences we observed.

Overall, results of the present study point to a contribution of the serotonergic neurotransmitter system to physically aggressive boys’s aggression and prosociality. Future studies expanding on the methodology used will be helpful in clarifying the relationship between serotonin, aggression, dominance, and affiliative behaviours in children.
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Table 1. Group means (SD) on demographic, cognitive, and behavioural characteristics.

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<tbody>
<tr>
<td>Age at time of study</td>
<td>123.17 (2.86)</td>
<td>123.18 (2.89)</td>
<td>-.01 (21)</td>
<td>.99</td>
</tr>
<tr>
<td>SES at 96 months</td>
<td>6.71 (1.60)</td>
<td>6.57 (.98)</td>
<td>.20 (12)</td>
<td>.84</td>
</tr>
<tr>
<td>PPVT at 84 months</td>
<td>101.73 (14.72)</td>
<td>106.43 (16.41)</td>
<td>-.63 (16)</td>
<td>.54</td>
</tr>
<tr>
<td>Blocks at 84 months</td>
<td>29.45 (11.55)</td>
<td>29.25 (12.53)</td>
<td>.04 (17)</td>
<td>.97</td>
</tr>
<tr>
<td>High physical aggression trajectory membership</td>
<td>.97 (.05)</td>
<td>.97 (.063)</td>
<td>.03 (21)</td>
<td>.97</td>
</tr>
<tr>
<td>Physical aggression at 120 months</td>
<td>4.33 (1.22)</td>
<td>4.71 (.95)</td>
<td>-.68 (14)</td>
<td>.51</td>
</tr>
<tr>
<td>Indirect aggression at 120 months</td>
<td>3.88 (.99)</td>
<td>3.43 (.79)</td>
<td>.96 (13)</td>
<td>.36</td>
</tr>
<tr>
<td>Hyperactivity at 120 months</td>
<td>9.67 (2.96)</td>
<td>7.29 (1.80)</td>
<td>1.87 (14)</td>
<td>.08</td>
</tr>
<tr>
<td>Inattention at 120 months</td>
<td>6.00 (1.58)</td>
<td>5.14 (1.57)</td>
<td>1.08 (14)</td>
<td>.30</td>
</tr>
<tr>
<td>Opposition at 120 months</td>
<td>5.56 (1.01)</td>
<td>5.43 (.98)</td>
<td>.25 (14)</td>
<td>.80</td>
</tr>
<tr>
<td>Prosociality at 120 months</td>
<td>8.56 (1.33)</td>
<td>8.50 (1.22)</td>
<td>.08 (13)</td>
<td>.94</td>
</tr>
<tr>
<td>Anxiety at 120 months</td>
<td>7.00 (2.12)</td>
<td>5.86 (1.57)</td>
<td>1.19 (14)</td>
<td>.25</td>
</tr>
<tr>
<td>Victimization at 120 months</td>
<td>5.11 (1.45)</td>
<td>4.86 (.90)</td>
<td>.40 (14)</td>
<td>.69</td>
</tr>
</tbody>
</table>
Table 2. Group differences on experimental tasks.

<table>
<thead>
<tr>
<th></th>
<th>Control Mean(SD)</th>
<th>Tryptophan Mean (SD)</th>
<th>t (df)</th>
<th>p</th>
<th>Cohen d</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Competitive reaction time game</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total points taken away</td>
<td>1040.00 (525.13)</td>
<td>1347.27 (730.88)</td>
<td>-1.17 (21)</td>
<td>.23</td>
<td>.49</td>
</tr>
<tr>
<td>Overall mean decision time</td>
<td>1.53 (.51)</td>
<td>1.35 (.40)</td>
<td>.96 (21)</td>
<td>.35</td>
<td>-.39</td>
</tr>
<tr>
<td>Overall mean reaction time</td>
<td>.33 (.03)</td>
<td>.33 (.05)</td>
<td>-.06 (21)</td>
<td>.95</td>
<td>.00</td>
</tr>
<tr>
<td>Impulsivity</td>
<td>2.92 (1.88)</td>
<td>1.64 (1.36)</td>
<td>1.85 (21)</td>
<td>.08</td>
<td>-.77</td>
</tr>
<tr>
<td>% of bank points shared</td>
<td>.70 (.23)</td>
<td>.66 (.30)</td>
<td>.29 (21)</td>
<td>.77</td>
<td>-.15</td>
</tr>
<tr>
<td><strong>Go/No-Go</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of successes</td>
<td>61.25 (14.76)</td>
<td>58.09 (16.53)</td>
<td>.48 (21)</td>
<td>.63</td>
<td>-.20</td>
</tr>
<tr>
<td>Number of omissions</td>
<td>34.08 (16.03)</td>
<td>37.91 (17.07)</td>
<td>-.55 (21)</td>
<td>.59</td>
<td>.23</td>
</tr>
<tr>
<td>Number of commissions</td>
<td>4.67 (3.14)</td>
<td>4.00 (2.41)</td>
<td>.57 (21)</td>
<td>.58</td>
<td>-.24</td>
</tr>
<tr>
<td><strong>Emotion recognition</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Happy-Sad accuracy</td>
<td>.84 (.06)</td>
<td>.84 (.05)</td>
<td>.24 (21)</td>
<td>.82</td>
<td>.00</td>
</tr>
<tr>
<td>Happy-Fear accuracy</td>
<td>.85 (.08)</td>
<td>.91 (.08)</td>
<td>-1.82 (21)</td>
<td>.08</td>
<td>.75</td>
</tr>
<tr>
<td>Mad-Sad accuracy</td>
<td>.88 (.07)</td>
<td>.88 (.05)</td>
<td>-.07 (21)</td>
<td>.94</td>
<td>.00</td>
</tr>
<tr>
<td>Mad-Fear accuracy</td>
<td>.82 (.10)</td>
<td>.85 (.10)</td>
<td>-.68 (21)</td>
<td>.51</td>
<td>.00</td>
</tr>
</tbody>
</table>
Figure 1. Physical aggression developmental trajectories from 17 to 84 months
Figure 2a. Points taken away at each phase of the competitive reaction time game.

Note. Change (z score) in points taken away at each phase of the game, relative to the no provocation baseline.

Figure 2b. Decision time at each phase of the competitive reaction time game.

Note. Change (z score) in decision time at each phase of the game, relative to the no provocation baseline.
Figure 2c. Reaction time at each phase of the competitive reaction time game.

Note. Change (z score) in reaction time at each phase of the game, relative to the no provocation baseline.
Figure 3. Perspective taking on the fictitious opponent’s emotional state following the competitive reaction time game.

![Bar chart showing emotion selection with positive affect, neutral, and negative affect categories. The chart compares control and tryptophan groups.](image)

Pearson chi-square (df = 2) = 6.06, p = .05. Cramer’s V = .51

Figure 4. Reaction to the loss ring incident.

![Bar chart showing reactions to the loss ring incident.](image)

*a* Pearson chi-square (df = 1) = 4.54, p = .03. Cramer’s phi = -.44

*b* Pearson chi-square (df = 1) = 0.35, p = .55. Cramer’s phi = -.12

*c* Pearson chi-square (df = 1) = 4.54, p = .03. Cramer’s phi = .44

*d* Pearson chi-square (df = 1) = 1.24, p = .27. Cramer’s phi = -.23
General Discussion

The goals of the present thesis were threefold. Firstly, we wished to clarify age trends in prosocial behaviour frequencies throughout childhood and adolescence. Secondly, we wished to examine developmental associations between prosocial behaviours and externalizing and internalizing problems in childhood, as well as predictors of such associations. Finally, we hoped to shed light on the neurochemical bases of prosocial behaviours, specifically with regards to serotonergic functioning.

Studies 1 and 2 presented prosocial behaviour trajectories, spanning ages 2 to 11 (Study 2) and 10 to 15 (Study 1). While prosocial developmental trajectories have been the object of previous investigations (Côté et al., 2002a; Kokko et al., 2006), a number of important features are unique to our studies. In study 1, data was gathered from two samples differing importantly in both their cultural (Canada and Italy) and sociodemographic (low SES and average SES circumstances) characteristics. Furthermore, prosocial behaviour ratings were obtained from mothers and teachers in Canada, and children and teachers in Italy. Study 1 thereby provides the first cross-cultural account of prosocial behaviour developmental trajectories, using multiple informants. Trajectories in Study 2 span the greatest age range in prosocial behaviour developmental trajectories presented to date, with previous studies having focused on middle childhood and early adolescence (Côté et al., 2002a; Kokko et al., 2006). Considering that past investigations have clearly established that prosocial behaviours emerge within the first years of life, developmental trajectories including younger age cohorts are highly needed. Study 2 is also the first to simultaneously present joint prosocial behaviour, physical aggression, anxiety and depression trajectories, as well as predictors of joint development.

Results from Studies 1 and 2 provide evidence of both stability and change in prosocial behaviour frequencies across childhood and early adolescence. The vast majority of children in Study 1 followed developmental trajectories characterized by stable or declining prosocial behaviours frequencies. This was true across cultures and informants, although declining levels were more
characteristic of ratings by teachers in Canada. Only one increasing trajectory
group, representing 7% of children, emerged from teacher ratings in Italy.
Different patterns emerged for Study 2, where increasing prosocial behaviour
frequencies were normative. However, increasing frequencies were most notable
between the ages of 2 to 6, with subsequent stabilization for approximately 50%
of children. Studies 1 and 2 therefore paint a complex picture of the relationship
of prosocial behaviour frequencies with age, with increasing, decreasing, and
stable prosocial behaviour trajectories emerging. Increasing frequencies however
appear to be more typical of early development, while stable levels are more
typical of middle childhood and early adolescence. Although we must be careful
in interpreting age trends based on separate samples, such pattern is consistent
with proposals of refinements and individualization in prosocial responding with
age (e.g., Caplan, 1993; Hay, 1994, Tomasello, 2009) rather than with a general
linear increase in frequencies with age (e.g., Eisenberg & Fabes, 1998).

Most importantly, our findings suggest that prosocial behaviour
development is subject to individual differences, with different children exhibiting
different developmental patterns in prosocial responding over the years. General
hypotheses of increasing, decreasing, or stable prosocial behaviour levels with age
do not therefore hold in light of population heterogeneity in development patterns.
Interestingly, subgroups of children exhibiting distinct patterns and levels of
prosocial behaviour could be identified as early as age two. Furthermore, many
of the trajectory groups identified showed impressive stability. This echoes
findings by Eisenberg and colleagues (Eisenberg et al., 2002) which demonstrated
significant positive correlations, and thus rank-order stability, between childhood
prosocial indexes and prosocial responding in adulthood. Our findings confirm
that individual differences in prosocial responding emerge early and may show
relative consistency over the years. While there has been some debate regarding
the existence of a prosocial personality or trait (Eisenberg et al., 2006), our results
offer partial support for the possibility of such dispositions. However, support is
simultaneously found for variability in patterns of prosocial behaviour
development between informants/contexts. In line with past literature (e.g.,
Achenbach et al., 1987), Study 1 found low to moderate agreement between prosocial behaviour ratings made by different informants. This was true both cross-sectionally and longitudinally, as trajectory models estimated from different informants revealed developmental patterns differing in important ways. Whether the differences observed were due to variations in children’s behaviours across contexts or rater biases is unclear. However, a number of teacher trajectories in Canada and Italy, which were based on different raters over the years, still showed relative stability over time. This leads us to believe ratings did in fact reflect children’s behaviours. Results do highlight the need to place prosocial behaviours in the context of their many observers to obtain a comprehensive developmental picture. Studies mapping prosocial behaviour developmental trajectories from early childhood into adulthood, using multiple informants, will be important in further clarifying individual differences in the stability and change of prosocial responding.

The significance of individual differences in prosocial behaviour development can only be derived by examining correlates of various developmental patterns. Study 2 provided evidence of longitudinal associations between prosocial behaviour development and the development of physical aggression, anxiety, and depression. Results indicated that membership to the low, moderate, or high prosocial behaviour trajectory could be accompanied by joint membership to physical aggression, anxiety and depression trajectories of varying levels. This is consistent with past studies having used a person-based or profile approach to children’s behaviours (e.g., Haapasalo et al., 2000; Lacourse et al., 2006; Pulkkinen & Tremblay, 1992), showing that prosocial behaviours can and do co-occur in the context of varying levels of externalizing or internalizing difficulties. Certain combinations were however more likely than others. Children following a high prosocial behaviour trajectory were more likely to follow low-level physical aggression, anxiety, and depression trajectories. Children following a low prosocial behaviour trajectory were in turn more likely to follow a high physical aggression or high depression trajectory. This is consistent with previous investigations having found that high levels of prosocial
behaviours are often accompanied by low levels of externalizing and internalizing problems and that low prosociality may be associated with higher behavioural or emotional problems (Eisenberg et al., 2006). It is important to note however that high levels of prosocial behaviours were not invariably positively associated with healthy adjustment. Approximately 1% of children followed joint developmental trajectories characterised by high levels of prosocial behaviours with high levels of physical aggression or depression, while 9% of children followed joint developmental trajectories characterised by high levels of prosocial behaviours and high/increasing levels of anxiety. In fact, tests of association revealed that membership to the high prosocial trajectory was not uniquely associated with increased likelihood of membership to the low anxiety trajectory, but also simultaneously associated with increased likelihood of membership to the high/increasing anxiety trajectory.

Study 2 therefore highlights the complexity of the relationship between prosociality and adjustment. If high prosociality is associated with low levels of physical aggression, anxiety and depression, how can it simultaneously increase the risk for high anxiety? Hay (1994) and Caplan (1993) have previously depicted prosociality’s contribution to adjustment as a double-edged sword, potentially increasing risk for psychopathology at too low or too high levels. While one must be careful in attributing directionality to the longitudinal associations observed, our findings are compatible with a potential increased vulnerability associated with low or high prosociality. Both low and high prosocial behaviour trajectories were associated with membership to high level externalizing or internalizing trajectories. While high prosociality was associated with low levels of aggression or affective problems for many children, a specific subgroup of highly prosocial children were more likely to show high anxiety. Interestingly, children assigned to the moderate prosocial behaviour trajectory were less likely to follow an extremely low or high physical aggression, anxiety, and depression trajectory. This leads us to speculate, in line with previous proposals by Caplan (1993) and Hay (1994) that prosociality may alternatively be good or bad, but rather best when optimally regulated.
It is however important to note that children from Study 2 were from a large, representative sample of Canadian children, and not from a clinical sample. The extent to which children assigned to the high physical aggression, anxiety, and depression trajectories were exhibiting problematic levels of externalizing or internalizing difficulties is therefore unknown. Similarly, while we may speculate that a subgroup of children assigned to the high prosocial behaviour trajectory exhibited dysregulation in their prosocial responding, this was not evaluated. Study 2 allowed us to observe patterns of association operating between prosociality and adjustment within the general population. Replication of such association within clinical samples would be highly valuable. Furthermore, while past studies (e.g., Perren et al., 2007) have shown that high prosociality may constitute a risk factor for internalizing symptomatology, a bidirectional relationship between prosociality and adjustment may be at play. Highly anxious children, for example, may employ prosocial interaction strategies in order to navigate their environment (e.g., Culotta & Goldstein, 2008). As well, because Study 2 used aggregate measures of prosocial behaviours, the relationships between specific forms of prosocial responding and externalizing/internalizing problems were not investigated. Initial evidence has been provided for greater risk associated with the provision of more emotional rather than instrumental forms of support (Champion, Jaser, Reeslund, Simmons, Potts, Shears, & Compas, 2009). Studies further clarifying the specific risk associated with various forms of prosocial behaviours and the direction of relationships between prosociality and adjustment are therefore needed.

Nevertheless, if associations are at play between prosocial responding and adjustment, which forces may underlie such associations? Study 2 revealed that, while a number of predictors were sensitive to prosocial behaviours or externalizing/internalizing problems, two predictors, maternal depression and low family income, were sensitive to the longitudinal interplay between prosocial behaviour and externalizing/internalizing problems. Maternal depression decreased the likelihood of following joint low prosocial behaviour and low physical aggression trajectories, but increased the likelihood of exhibiting
moderate physical aggression in the context of moderate or high prosocial behaviour levels. Low family income decreased the likelihood of exhibiting high depression in the context of moderate prosocial behaviour levels, and increased the likelihood of following joint high prosocial behaviour and high depression trajectories. Previous empirical investigations of the link between parental depression or low socioeconomic status and children’s prosocial behaviours have provided mixed evidence (e.g., Eisenberg & Fabes, 1998; Eisenberg et al., 2006; Hay & Pawlby, 2003), but both maternal depression and low socioeconomic status have been generally depicted as potential risk factors for the development of behavioural and emotional difficulties in children (Downey & Coyne., 1990; Leventhal & Brooks-Gunn, 2000). Our results suggest that environments characterized by emotional and financial stress may be conducive to combined elevated levels of prosocial behaviours with internalizing or externalizing problems. While the mechanisms underlying such relationships require empirical verification, we may hypothesize that stressful environments can increase the likelihood of oversensitivity to family members’ affective states, thereby increasing the likelihood of internalizing symptomatology.

The emergence of subgroups of children exhibiting different combinations of prosocial behaviour levels with levels of externalizing/internalizing problems suggests that the relationship between prosocial responding and adjustment is subject to individual differences. Potential neurochemical contributions to individual differences in children’s behavioural development have focused on problem behaviours, such as aggression (e.g., Gollan, Lee, Coccaro, 2005) and have not examined potential contributions in the context of prosocial responding (see Dilalla et al., 2009 for exception). Study 3 was the first to employ a double-blind, acute tryptophan supplementation procedure to investigate the contribution of serotonergic functioning to physically aggressive boys’ laboratory prosocial and aggressive behaviours. The study is thus highly innovative, demonstrating the feasibility of acute tryptophan supplementation procedure with samples of children.
Our initial hypothesis was that boys in the tryptophan condition would show less aggression (i.e., taking points away) and reactivity to provocation by a fictitious opponent than control participants during a competitive reaction time game. Consistent with this hypothesis, boys in the tryptophan condition only showed significant departure in reactivity, relative to a no provocation baseline, when highly provoked by the fictitious opponent. However, boys in the control condition significantly decreased the amounts of points they took away, relative to baseline, during the last phase of the game. This pattern of results contrasts with previous investigations of tryptophan manipulation, which observed decreased aggression with tryptophan supplementation and increased aggression with tryptophan depletion during similar competitive games (e.g., Bjork, Dougherty, Moeller, & Swann, 2000). However, we realize in hindsight that our measure of aggression may have been instrumental and competitive in nature rather than truly hostile. Results may therefore be interpreted in light of and seen as consistent with past literature on serotonergic contributions to dominance, assertiveness, and instrumental/competitive aggression (see Krakowski, 2003 for a review). Consequently we suggest that boys in the tryptophan condition were better able to sustain competition with the fictitious opponent, while boys in the control condition retreated from the competitive interactions. Additionally, boys in the tryptophan condition showed greater perspective taking and help than boys in the control condition, which may be seen as consistent with past literature showing associations between serotonergic functioning and different positive/affiliative interactional processes (e.g., Knutson et al., 1998).

Acute manipulation of tryptophan levels was therefore effective in influencing different aspects of prosocial and aggressive responding in physically aggressive boys. This extends the literature with adults and non-human primates, and suggests that serotonergic functioning can play a role in the regulation of aggressive and prosocial behaviours in children. Innovations and findings from Study 3 must however also naturally be considered within the context of its relative limitations. Blood tryptophan levels were not measured to avoid the use of invasive procedures with our child sample. While past studies have established
the effectiveness of tryptophan supplementation in increasing serotonergic functioning (e.g., Yuwiler, Brammer, Morley, Raleigh, Flannery, & Geller, 1981), this was not formally tested within our study. As well, the serotonergic neurotransmitter system is part of an intrinsically interconnected neurochemical system with other neurotransmitters, whereby changes in one chemical can greatly impact functioning and levels of other neurotransmitters. Future studies may therefore benefit from simultaneously investigating the separate and joint effects of different neurotransmitter systems to children’s behaviours.

Furthermore, the sample size for the study offered limited statistical power. It is however important to note that many of the effect sizes observed were relatively strong, pointing to the robustness of the relationships observed. Nevertheless, replication and extension of the study, using varied samples (e.g., boys and girls, children displaying high levels indirect aggression or other forms of aggression, children of various ages) and additional laboratory tasks (e.g., tasks tapping into cooperative behaviours as well as more hostile forms of aggression) will help clarify the neurochemical bases of aggressive and prosocial responding in childhood.

Taken together, results from the present thesis have shown that 1) prosocial behaviour development and its association with adjustment is the object of important individual differences, 2) certain environments may be conducive to joint elevated levels of prosocial behaviours and behaviour/emotional problems, and 3) serotonergic functioning contributes to the regulation of aggressive and prosocial behaviours in children. Individual differences in prosocial development and its association to adjustment lead us to believe that not all children are equally sensitive to the potential risk and protection associated with prosociality, or to environmental risk. There exists a compelling literature on the interaction of genetic polymorphisms, including serotonergic polymorphisms, with environmental stress in determining levels of internalizing and externalizing symptoms (e.g., Caspi, McClay, Moffitt, Mill, Martin, Craig, et al., 2002; Caspi, Sugden, Moffitt, Taylor, Craig, Harrington, et al., 2003). Our pattern of findings lead us to question whether interactions between serotonergic functioning and
environmental factors could similarly play a role in determining patterns of prosocial development and its association with adjustment. From this perspective, variations in serotonergic functioning would interact with environmental risk in increasing or decreasing the likelihood of maladaptive patterns in prosocial responding. While this possibility is highly speculative, future studies bridging biological and environmental contributions to prosocial development would be important.

In sum, the present thesis provides novel information on the development of prosocial behaviours, its longitudinal association with externalizing and internalizing problems, its predictors, and neurochemical underpinnings. Results highlight the importance of long-term longitudinal investigations in clarifying developmental trends in prosocial development, as well as the need to consider prosocial development within context, both psychosocial and biological. It therefore sets the stage for future investigations of prosocial development and its correlates across the lifespan.
General References


on developmental change (pp. 141–162). New York: Oxford University Press.


Appendices
Appendix A

Appendix B

Ethics documents