A bidirectional association between language development and prosocial behaviour in childhood: Evidence from a longitudinal birth cohort in the UK

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Data/code availability statements: (1) The data necessary to reproduce the analyses presented here are publicly accessible. Data are available under license from the UK Data Service and Jisc (see, for instance, https://ukdataservice.ac.uk/). This dataset was used for secondary data analysis; it had been fully anonymised and no additional ethics approvals were required for our study. (2) The analytic code necessary to reproduce the analyses presented in this paper is not publicly accessible. However, the code's output in the form of R markdown is publicly available on the OSF website: https://osf.io/jcuv5
(3) The materials necessary to attempt to replicate the findings presented here are publicly accessible.

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Abstract

This study investigated a developmental cascade between prosocial and linguistic abilities in a large sample ($N = 11{,}051$) from the general youth population in the United Kingdom (50% female, 46% living in disadvantaged neighbourhoods, 13% non-White). Cross-lagged panel models showed that verbal ability at age 3 years predicted prosociality at age 7, which in turn predicted verbal ability at age 11. Latent growth models also showed that gains in prosociality between 3 and 5 years were associated with increased verbal ability between 5 to 11 years, and vice versa. Theory of mind and social competence at age 5 mediated the association between early childhood prosociality and late childhood verbal ability. These results remained robust even after controlling for socioeconomic factors, maternal mental health, parenting microclimate in the home environment, and individual characteristics (sex, ethnicity, and special educational needs). The findings suggest that language skills could be boosted through mentalizing activities and prosocial behaviours.

Public Significance

This study provides initial evidence that children's verbal and prosocial skills are in a bidirectional relationship, and continuously shape each other across childhood development. As a result, interventions aimed at enhancing either language ability or prosocial behaviour in early childhood might have reciprocal benefits during the first decade of human development, fostering a range of sociocognitive competencies.

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Introduction

The domains of language acquisition and social behaviour in childhood are fundamental areas of developmental science. Expressive verbal ability includes a range of linguistic skills that allow a child to communicate his or her thoughts and mental states, while receptive verbal ability allows a child to understand others (Artis & Arunachalam, 2023; Chen et al., 2023; Ryan et al., 2016). Prosocial behaviours include readily sharing resources, helping others voluntarily, and comforting others when they seem to require emotional support (Flynn et al., 2015; Knafo & Plomin, 2006). Each of these constructs provides insights into the immense cognitive and socioemotional development that takes place during the early years of life, and each of them uniquely informs early education practices (Beitchman & Brownlie, 2005; Bjorklund, 2022; Girard et al., 2011; Salerni & Caprin, 2022; Snow, 2017). Notably, certain domains of prosociality and language ability have been associated across development. But while expressive and receptive verbal abilities have been shown to be predictive of prosocial behaviour—and social competence, more broadly—during childhood, the inverse association (i.e., between prosociality and verbal ability) has not been sufficiently explored.

Focusing on the more established association between verbal ability and prosocial behaviour, it has been shown that early verbal communication skills predict cognitive or executive function skills that are relevant for prosocial behaviours (Austerberry et al., 2022; Masek et al., 2023; von Stumm et al., 2020), while impairments in language development predict deficits in prosocial behaviour (Matte-Landry et al., 2020; Toseeb & St Clair, 2020), lower academic achievement (Logan et al., 2023) and poorer mental health (Burnley et al., 2023; Matte-Landry et al., 2020; Toseeb et al., 2023). For specific age groups, previous research with relatively small samples has identified an association between verbal ability and social skills in early to middle childhood (Conte et al., 2018; Grazzani et al., 2018; Longobardi et al., 2019; Ornaghi et al., 2016; Sarmento-Henrique et al., 2020). For example, vocabulary

ability predicts certain facets of social-emotional competence, which is a broader construct than prosociality as it requires self-regulation and problem-solving in social interactions (Longobardi, Spataro, Frigerio, et al., 2016). As explained in Longobardi, Spataro, Frigerio, et al. (2016), children with less developed language ability are typically rated less positively by their peers and have fewer chances of being 'liked' by other children. In addition, verbal ability predicts emotion understanding at age 3, and in turn predicts prosociality at age 4 (Ensor et al., 2011). These results were taken to show that language skills empower children to start conversations about how they feel, and to better understand what others are saying about their own emotional states.

However, despite its importance for educational practice and our broader understanding of human development, remarkably little is known about the inverse relation, namely, how the development of prosociality impacts the trajectory of language ability during childhood. If the association between the two constructs were indeed bidirectional, then prosocial behaviour in early childhood should also contribute to language development later on. However, to the best of our knowledge, only a single study (Girard et al., 2017) has investigated this possibility using a large, longitudinal dataset. Girard et al. (2017) examined both directions of the association between verbal ability and prosociality between age 3 and 5 years and reported a unidirectional association between verbal ability (at age 3) and prosocial behaviour (at age 5), but not the inverse. However, the timeframe of this study was limited to only two time points (age 3 and 5 years), which may be insufficient given that t the impact of prosocial behaviour on language ability may take longer to become evident. This is especially relevant to countries such as the UK in which primary school education starts at age 5, which considerably changed the development of prosocial behaviours (Dempsey et al., 2023; Flouri & Sarmadi, 2016). Therefore, the question of whether more prosocial behaviour in early childhood predicts better linguistic skills in middle or late childhood currently remains open.

Despite the relative lack of research on the bidirectional nature of the association between verbal ability and prosociality (and specifically of whether prosociality predicts language abilities), there is some indirect evidence for this association from the study of social-emotional competence in early years, where

early literacy skills were linked with social problem-solving (Curby et al., 2015). In particular, a Finish study of 441 children starting at age 6 years (i.e., when children were in their preschool year, as primary education starts later in Finland compared to the UK), found a bidirectional relation between stronger social competence and better early literacy and receptive vocabulary (Pakarinen et al., 2018). Taken together, this indirect evidence predicts a potential bidirectional association between language skills and prosocial behaviour during childhood, possibly extending beyond early and middle childhood.

Another open question relates to the role of theory of mind (ToM) in shaping the interrelationship between sociality and language. Previous studies have provided evidence that advanced verbal abilities in early childhood promote ToM, which, in turn, is associated with heightened prosocial behaviour (Ornaghi et al., 2016). The mediating role of ToM in this case can been explained in the following way: higher competence in verbal communication fosters a better understanding and interpretation of others' mental and emotional states (ToM ability) by facilitating richer social interactions, enhanced perspective-taking, and more effective engagement in discussions, role-playing, and other social activities (Ebert, 2020; Lohmann et al., 2005; Slaughter & Peterson, 2011; Villiers, 2005). In turn, this type of enhanced ToM enables more empathetic and prosocial behaviours towards others. In a similar vein, a few recent studies have shown that ToM abilities not only foster a direct positive influence on prosocial behaviour, but are also partially tethered to children's language abilities—e.g., better language skills enable better understanding of other children's 'emotion talk', which promotes psychological perspective taking and ToM and simultaneously fosters prosocial reciprocity—establishing a complex interrelation among these variables (Brazzelli et al., 2022; Conte et al., 2018; Longobardi et al., 2019). Therefore, existing findings underscore a cascading effect where verbal abilities promote ToM, which subsequently amplifies prosocial tendencies. However, no studies to-date have explored the potential mediating role of ToM in the inverse longitudinal association, namely, that prosociality itself may enhance ToM, and that this in turn enhances verbal ability. Therefore, here, we also ask: does prosocial behaviour in early childhood enhance ToM, and—in turn—does this mentalizing ability mediate enhancements in verbal ability in late childhood?

These questions are important in early years education for various reasons. Notably, early years educational practices typically promote theory of mind abilities through storytelling and talking about the emotions, perspectives, and intentions of the characters in a story (Bergman Deitcher et al., 2021; Grazzani et al., 2016), i.e. verbal ability is typically considered a prerequisite for mentalizing. However, if prosociality fosters language development and theory of mind, then role-playing and re-enacting the prosocial behaviours of characters in stories, and encouraging prosociality more broadly in day-to-day activities, would additionally boost verbal ability throughout childhood as well as help establish social cognitive skills.

The potential bidirectional association between language and prosociality pertains to our understanding of human cognition. According to the Social-Cognitive Approach (SCA), children's cognitive development, and particularly in the domain of their ability to understand social interactions and mental states, is crucial for the development of both language and prosocial behaviour in early to middle childhood (Dunn, 1993; Gopnik & Wellman, 1992; Hughes & Leekam, 2004; Poulin-Dubois & Yott, 2018; Tomasello, 2009; Tomasello & Carpenter, 2007). According to SCA, as children develop theory of mind and other social competencies, they also become more adept at interpreting and responding to social cues of others around them, thereby enhancing their capacity for empathy and cooperation. These skills are also fundamental for language development, seeing as effective communication also relies on understanding the perspectives and intentions of others. Hence, SCA suggests that, on an individual level, cognitive processes that underlie and support better understanding of social interactions are central to the development of both verbal abilities and prosocial behaviours, highlighting a reciprocal and dynamic interplay between these domains during child development.

Importantly, the reciprocal interplay between language and sociality over the course of child development may have deep evolutionary roots. Specifically, according to a recent evolutionary theory, the Human Self-Domestication (HSD) hypothesis, an increase in prosociality over the course of evolution may account for the development of humans' unique cognitive skills, including our complex linguistic abilities (Hare, 2017). This is not to say that 'ontogeny recapitulates phylogeny', but rather that the casual links between prosocial and linguistic behaviour may span

multiple time-scales: from individuals, to populations, to multiple generations. According to HSD, humans have undergone an evolutionary process resembling that of animal domestication (albeit through natural as opposed to artificial selection), in which reduced aggression and increased prosociality and social tolerance were selected for (Leach, 2003; Sánchez-Villagra & Van Schaik, 2019; Theofanopoulou et al., 2017). Specifically, this theory suggests that traits that facilitated more harmonious, cooperative, and social living were naturally selected for over the course of human evolution (and specifically in the middle and late Palaeolithic), which in turn led to more advanced linguistic and communicative abilities that could facilitate better coordination, planning, and information sharing in larger and more complex community structures. Crucially, these enhanced linguistic abilities would have further facilitated even more prosocial tendencies and mentalizing skills that underpin collaborative activities and social cohesion—leading to a positive evolutionary feedback loop between the development of prosociality and human language: more prosocial behaviour fosters more sophisticated language abilities, which in turn fostering more sociality, and so on—spanning many generations of Homo Sapiens (Benítez-Burraco & Elvira-García, 2022; Benítez-Burraco & Kempe, 2018; Progovac & Benítez-Burraco, 2019; Raviv & Kirby, 2023; Thomas & Kirby, 2018). Thus, the HSD hypothesis provides a new, evolutionary lens through which we can view the co-development of language and prosocial behaviour in childhood and highlights the fundamental role of these behaviours not only during an individual's lifespan but also on the societal level.

In the context of the present study, in which we directly test the bidirectionality between verbal ability and prosociality in early to late childhood, the HSD hypothesis can help conceptualise *why* these two developmental paths may be intertwined from an evolutionary perspective. In particular, and as posited by SCA, language facilitates communication and the sharing of intentions, beliefs, and knowledge, which support prosocial behaviour and vice versa, is a sort of positive feedback loop. Conversely, HSD posits that the evolution of language itself was made possible precisely *because* human culture was built around prosocial behaviours such as helping, sharing, and cooperation (Benítez-Burraco & Kempe, 2018; Raviv & Kirby, 2023). In this sense, the link between sociality and language is fundamental to

both development and evolution, echoing many theories on the emergence of language in our species (Dunbar, 1998; Dunbar, 2003; Levinson, 2019; Lohmann et al., 2005). Specifically, it predicts that (a) children who have better-developed verbal abilities would be more communicative and adept at navigating social situations, therefore having more opportunities to develop prosocial behaviours; and that (b) more prosocial children with better ToM skills would engage more readily in social interactions, leading to richer opportunities for their linguistic development.

The aim of the present study is to explore the bidirectional link between prosociality and verbal ability using a large, nationally representative birth cohort from the United Kingdom, the Millennium Cohort Study (MCS). The MCS includes suitable measures for all three constructs of interest: *prosociality* was measured with the Strengths and Difficulties Questionnaire (Goodman, 1997); *verbal ability* was measured with the British Ability Scales II cognitive assessment batteries that included naming vocabulary, word reading, and verbal similarities tests [e.g., see Sullivan et al. (2021)]; and *theory of mind* was tested in a socially demanding dyadic interaction and assessed false belief understanding at age 5 through the Sally-Anne task (Baron-Cohen et al., 1985) [also, *cf*. Tsomokos & Flouri (2023)]. Crucially, the MCS also allows us to control for a wide range of potential confounders that are known to impact both verbal ability and prosociality (Huang et al., 2022; Lerner et al., 2015; Volodina, 2023). Specifically, we controlled for a range of socioeconomic variables (area disadvantage, family income, maternal education) (Bandy & Ottoni-Wilhelm, 2012; Hoff, 2013); child characteristics (sex, ethnicity, special educational needs) (Hartas, 2011); the family environment and parenting microclimate (maternal mental health, and lack of positive maternal interactions) (Pastorelli et al., 2016).

The present work examined three main hypotheses. Hypothesis (1) concerns the bidirectional association between prosociality and language skills and includes two sub-predictions in the form of a sensitivity analysis. Hypotheses (2) and (3) elucidate the role of theory of mind (ToM) in these relations. In particular, we put forward the hypotheses that (1) there is a positive bidirectional cascade between verbal ability and prosocial behaviour from early to late childhood (ages 3, 7, and 11 years); (1A) positive gains in verbal ability during early childhood (3 to 5 years) are prospectively associated with positive gains in prosocial behaviour up to late

childhood (5 to 11 years); (1B) positive gains in prosociality during early childhood are associated with positive gains in verbal ability up to late childhood; (2) the association between verbal ability in early childhood (age 3) and prosociality in late childhood (age 11) is mediated by ToM (age 5); and (3) the association between prosociality (age 3) and verbal ability (age 11) is mediated by ToM (age 5).

Methods

Participants and analytic sample

The Millennium Cohort Study (MCS) is a large-scale, nationally representative birth cohort survey, which has been tracking approximately 19,200 children born in one of the four UK countries between late 2000 and early 2002 (Joshi & Fitzsimons, 2016). The UK's electoral wards provided the sampling frame, as explained in Plewis et al. (2004). The aim of this sampling was to accurately represent families living in high child-poverty areas, as well as families in England that lived in wards with a higher proportion of ethnic minority populations. Data collection consisted of interviews with the main adult respondent (the mother, in the vast majority of cases), as well as test batteries, assessments, and additional questionnaires in the child's home. Ethical approvals were obtained in each survey sweep by Multi-Centre Ethics Committees organised around the National Health Service Research Ethics Committee system (for instance, *cf*. MREC/03/2/022, 05/MRE02/46, and 07/MRE03/32); informed consent was given by parents before any interviews, and children provided their assent at age 11.

The (second) survey sweep at age 3 years included 15,719 cohort members who were singletons or first-born twins or triplets. Note that since there were additions and attrition in the survey from the first to second sweeps, our analysis used the final household grid. In the present study, we required that cohort members had valid data on both the prosociality and the verbal ability variables at age 3 and 11 years (the first and last point of the period studied here). Given this condition, 11,051 cohort members (50% female) remained in the analytic sample.

Measures and procedures

Verbal ability measures (3, 5, 7, and 11 years): The development of verbal ability was captured in our study across four time points, using measures from the British Ability Scales II (BAS) at each survey sweep. At ages 3 and 5, the BAS Naming Vocabulary was employed, designed to measure expressive language skills by assessing children's spoken vocabulary (i.e., participants need to name objects from a series of coloured pictures, focusing on their ability to correctly recall nouns and effectively label visual cues). At age 7, the BAS Word Reading assessment was employed, measuring reading ability (i.e., participants read aloud a sequence of words, organised in increasing order of difficulty, and the success rates were collected). At age 11, the BAS Verbal Similarities assessment was administered instead, measuring verbal reasoning and knowledge (i.e., participants discern the relation or similarity between three spoken words, and their success rates were collected). For each of these measures, we used age-standardised T-scores. Due to the different scoring ranges across these four variables, we harmonised verbal ability scores at ages 3, 5, 7, and 11 years into n-tiles ($n = 25$), with a uniform range between 1 and 25. Details on these and all other MCS variables used here, as well as further information on BAS II assessments, are provided in the Supplemental Online Material that is publicly available on the Open Science Framework (SOM, 2024).

Prosocial behaviour (3, 5, 7, and 11 years): The prosociality measure was derived from a subscale of the Strengths and Difficulties Questionnaire (SDQ) (Goodman, 1997), and is a numerical variable from 0 to 10 (recoded as 1 to 11). The full SDQ is a behavioural screening tool with 25 items in total, and 5 of these items make up the prosocial scale. The items ask the primary caregiver to rate, on a 3-level Likert scale (ranging from '0 - not true'. to '1 - somewhat true' to '2 - certainly true), whether the child is considerate of others' feelings; shares readily with others; is helpful when someone is hurt, upset or ill; is kind to younger children; and whether the child volunteers to help others. In the age 3 wave of MCS, Cronbach's $\alpha_3 = 0.56$, while for ages 5-11 years it was $\alpha_5 = 0.64$, $\alpha_7 = 0.67$, and $\alpha_{11} = 0.66$.

Theory of mind (ToM): Trained interviewers administered a vignette version of the Sally-Anne task (Baron-Cohen et al., 1985) to children aged 5, in the child's home, and this was the first task in a cognitive test battery. The task was primarily used to build rapport with the child. There were 11 pointing-and-talking interactions

(using cartoons printed on a single piece of paper) and 3 final questions that assessed false belief understanding and allowed for a 'memory' and 'reality' comprehension check. As a result of the particular administration of the task (i.e., this being the first assessment completed through a demanding dyadic interaction with an unknown assessor), the number of children who fully passed the test (answered all 3 questions correctly) were much fewer than what was expected for this age group (20% against the expected approximately > 70%, based on multiple previous studies). The test was repeated in the same way in the next survey sweep at age 7 years (and the outcome was still around 1 in 3 children answering correctly). Therefore, it seems likely that the test failed to capture correctly all the children with established false belief understanding, and instead it likely captured those cohort members who had well-established, robust false belief understanding and superior social competence, as explained elsewhere (Tsomokos & Flouri, 2023, 2024). In our study, we identify children with established theory of mind and superior social competence more broadly (given the way this task was administered) by requiring that all 3 correct answers were given in both sweeps (at age 5 and 7 years).

Covariates

Area disadvantage (survey stratum): Children's wider social background was provided by the sampling frame, based on UK electoral wards, and tracking area deprivation through the Child Poverty Index. In particular, each UK country has an advantaged and a disadvantaged stratum whereby area disadvantage corresponds to the case when a ward was in the upper quartile (poorest 25%) of the Child Poverty Index. In England, there was a third stratum (ethnic minority) that identified areas with at least 30% 'Black' (Black Caribbean, Black African and Black Other) or 'Asian' (Indian, Pakistani and Bangladeshi) populations, as defined in the 1991 Census.

Income (age 3 years): The family's total household income was a derived variable, provided in OECD equivalised quintiles (interval variable from 1 to 5).

Maternal education and psychological distress (age 3 years): the mother's highest educational level attained by the age 3 wave, based on the UK's National Vocational Qualifications and its equivalents (numerical variable ranging from 1 to 6). The mother's level of psychological distress at the age 3 wave was provided by

the self-reported Kessler 6-item scale, a numerical variable from 1 to 25 (with higher scores indicating higher levels of emotional distress) (Kessler et al., 2010).

Sex: provided by the primary caregiver as biological sex (male or female).

Ethnicity: provided by the primary caregiver according to the categories of the UK Census (White, Mixed, Indian, Pakistani and Bangladeshi, Black or Black British, Other Ethnic group including Chinese or Other). In our study this variable is categorical with two values: White and Non-White.

Statement of special educational needs (*SEN)*: reported by the primary caregiver at the age 11 sweep, this was a dichotomous variable (yes/no) indicating whether or not the child had obtained a statement of special educational needs (SEN) at any point up to then.

Parenting: lack of positive interactions (HOME environment): As part of children's cognitive assessment at age 3 years, the interviewer assessed the home environment and child interactions with the mother using the HOME short form scale from Caldwell and Bradley (1984). The subscale used here is negative maternal responsivity (or *lack of positive interactions*), a numerical variable from 0 to 6, where 6 indicates that none of the six warm and responsive interactions assessed in this subscale took place: voice when speaking of or to the child conveyed positive feeling; mother conversed with the child at least twice during visit, discounting any scolding or negative comments; mother made an effort to answer the child's questions or requests verbally; mother spontaneously praised the child's qualities or behaviour twice during the visit; mother caressed, kissed or cuddled the child at least once during the visit; mother introduced interviewer to the child (e.g., 'This is Mrs. Jones, she's here to talk to us' or 'Show Mrs. Jones the new book you got for your birthday'). A value of 0 indicates that all of these positive interactions took place during the interviewer's home visit.

Analytic strategy

Preliminary analysis: Missingness, sample bias, and correlations

We performed descriptive analyses to identify any differences between participants in the analytic sample and those excluded from it, and to ensure that missingness was both generally low and of a particular type (i.e., that values were 'Missing at Random', as explained below). This step also informed the imputation

process later on. Finally, pairwise correlations were calculated to get a better sense of the relations between the numerical variables in our study and to ensure there was no risk of collinearity in our models.

It should be noted that, in line with previous analyses on the MCS data (Connelly & Platt, 2014), we observed typical attrition and non-response patterns which mean that—as shown below—participants excluded from our final analytic sample have tended to be from disadvantaged backgrounds, male, from White or Black ethnicity. This attrition bias has been addressed through the use of sampling weights, which adjust for attrition based on the most important explanatory factors (such as, biological sex, social and economic disadvantage, race and ethnicity, family structure and type of accommodation), an approach explained in Plewis (2007).

Hypotheses testing with survey-weighted, imputed models

For each hypothesis, we employed a suitable model considering the MCS survey design characteristics (using suitable weights) and after imputing any missing data. For hypothesis 1, we used a Cross-Lagged Panel Model (CLPM) for verbal ability and prosociality, each measured at age 3, 7, and 11 years. Note that, in this case, we omitted the age 5 sweep so that the distances between time points were all equal to each other (4 years between the first and second time points, and 4 years between second and third time points), as required for the analysis of CLPMs. Three CLPMs were fitted: (1) an unadjusted model; (2) a partially adjusted model, wherein we controlled for sex, stratum (area disadvantage), ethnicity, family income, theory of mind, and statemented SEN; and (3) a fully adjusted model in which we also controlled for maternal education, maternal psychological distress, and parenting.

Additional sensitivity analyses were performed in relation to hypothesis 1. First, we used a Latent Growth Curve (LGC) model to test the hypothesis that gains in verbal ability between ages 3 and 5 years were associated with gains in prosociality between ages 5, 7, and 11 years (hypothesis 1A). Second, we tested the inverse LGC model, namely, the hypothesis that gains in prosociality between 3 and 5 years were associated with gains in verbal ability between 5, 7, and 11 years (hypothesis 1B). In each of these cases, partially and fully adjusted models were fitted to the data.

For hypothesis 2, we used path analysis to test the mediating role of theory of mind at age 5 in the association between verbal ability at age 3 and prosociality at

age 11 (both partially and fully adjusted models were fitted). For hypothesis 3, we repeated this analysis to test the mediating role of theory of mind in the inverse association (that is, between prosociality at age 3 and verbal ability at age 11 years).

Missing data were imputed using multiple imputation by chained equations (Raghunathan et al., 2001), and the imputed datasets were combined following Rubin's rules (Rubin, 1987). All calculations were performed using R (R.Core.Team, 2021) with the 'mice' package (van Buuren & Groothuis-Oudshoorn, 2011) and the structural equation modelling package 'lavaan' (Rosseel, 2012). Further details on the MCS variables, results with and without imputation, numerical accuracy, and other information can be found in the Supplemental Online Material (SOM, 2024).

Results

Missingness, sample bias, and correlations

In line with typical attrition and non-response patterns of participants in the Millennium Cohort Study, there were missing data across all survey sweeps (Connelly & Platt, 2014; Plewis, 2007). Our selection criteria ensured that the primary variables of interest (i.e., verbal ability and prosociality) had no missing data at study baseline (age 3) and endpoint (age 11) in our analytic sample. However, between 493 and 1,049 values (4.5% to 9.5% of the analytic sample) were missing for verbal ability and prosociality at age 5 and 7 years. The highest level of missingness occurred for theory of mind (Sally-Anne task) with 1,192 (11%) of missing values. Ethnicity, family income, and statement of Special Educational Needs (SEN) had very little missing data (≤ 70 values). In a separate analysis, provided in the Preliminary Analysis ('MAR v. MCAR' subsection) of the Supplemental Online Material (SOM, 2024), we provided evidence that data was 'Missing at Random' (MAR). This was done as follows. We start by highlighting that there is no single test that can be used to establish whether data are MAR. However, we may arrive at this conclusion by elimination, given the nature of birth cohort studies like MCS. To begin with, we establish that data is not Missing Completely at Random (MCAR) using from Little's MCAR test (Little, 1988) that returned $\chi^2(14889) = 40173, p < .001$. Second, we use additional points of evidence—not detailed here but provided via several plots of missingness patterns in

433 the SOM (2024)—reinforcing the known point that data in a birth cohort like MCS
434 cannot be (entirely) Missing Not at Random (MNAR). As a result, we arrive at the
435 conclusion that the mechanism is MAR by elimination (as it is not MCAR or MNAR).

436 Finally, a sample bias analysis (Table 1) showed that those excluded from the
437 sample ($N = 4{,}668$) were disproportionately male from non-white ethnicity, with
438 lower maternal education (Cohen's $d = -0.42,\ 95\%\ CI[-0.45, -0.38]$), and lower
439 income ($d = -0.34, 95\%\ CI[-0.37, -0.30]$). This sample bias is addressed through
440 the use of sampling weights, which ensure that those who remained in the survey
441 (and included in the sample at age 11) are proportionately weighted so that they
442 represent the overall youth population in the UK.

443 **Table 1.** Sample bias analysis: variable distribution between the analytic sample and
444 the rest of the Millennium Cohort Study at age 3 years (unweighted).

Characteristic	**Rest of sample** ***N*** **= 4,668 (30%)**	**Analytic sample** ***N*** **= 11,051 (70%)**	**p-value**[1]
Sex, n (%)			**<0.001**
Male	2,487 (53)	5,525 (50)	
Female	2,181 (47)	5,526 (50)	
Stratum, n (%)			**<0.001**
England - Advantaged	974 (21)	3,278 (30)	
England - Disadvantaged	1,171 (25)	2,740 (25)	
England - Ethnic	967 (21)	1,003 (9.1)	
Wales - Advantaged	154 (3.3)	544 (4.9)	
Wales - Disadvantaged	460 (9.9)	1,118 (10)	
Scotland - Advantaged	244 (5.2)	702 (6.4)	
Scotland - Disadvantaged	307 (6.6)	577 (5.2)	
N. Ireland[2] *- Advantaged*	161 (3.4)	429 (3.9)	
N. Ireland[2] *- Disadvantaged*	230 (4.9)	660 (6.0)	
Ethnicity, n (%)			**<0.001**
White	3,386 (73)	9,627 (87)	
Mixed	157 (3.4)	294 (2.7)	
Indian	171 (3.7)	232 (2.1)	
Pakistani and Bangladeshi	538 (12)	481 (4.4)	
Black or Black British	248 (5.4)	267 (2.4)	
Other Ethnic group	110 (2.4)	109 (1.0)	

Characteristic	Rest of sample *N* = 4,668 (30%)	Analytic sample *N* = 11,051 (70%)	p-value[1]
(Missing)	58	41	
Income, Mean (SD)	2.56 (1.36)	3.03 (1.40)	**<0.001**
(Missing)	167	23	
Maternal education, Mean (SD)	3.07 (1.52)	3.67 (1.38)	**<0.001**
(Missing)	296	326	
Statemented SEN, n (%)			**<0.001**
0 (No)	4,537 (98)	10,568 (96)	
1 (Yes)	92 (2.0)	413 (3.8)	
(Missing)	39	70	
Theory of mind, n (%)			**<0.001**
0 (No)	2,088 (95)	9,162 (93)	
1 (Yes)	112 (5.1)	697 (7.1)	
(Missing)	2,468	1,192	
Maternal psychological distress, Mean (SD)	4.4 (3.9)	4.2 (3.7)	0.054
(Missing)	1,175	1,028	
Parenting: lack of positive interactions, Mean (SD)	0.67 (1.05)	0.50 (0.89)	**<0.001**
(Missing)	505	717	
Verbal ability (age 3), Mean (SD)	11 (7)	14 (7)	**<0.001**
(Missing)	0	0	
Verbal ability (age 5), Mean (SD)	11 (7)	14 (7)	**<0.001**
(Missing)	1,301	493	
Verbal ability (age 7), Mean (SD)	11 (7)	13 (7)	**<0.001**
(Missing)	2,289	1,049	
Verbal ability (age 11), Mean (SD)	11 (8)	13 (7)	**<0.001**
(Missing)	3,724	0	
Prosociality (age 3), Mean (SD)	8.37 (1.93)	8.35 (1.87)	0.65
(Missing)	927	0	
Prosociality (age 5), Mean (SD)	9.26 (1.77)	9.41 (1.64)	**<0.001**
(Missing)	1,562	642	
Prosociality (age 7), Mean (SD)	9.33 (1.80)	9.64 (1.59)	**<0.001**
(Missing)	2,355	899	
Prosociality (age 11), Mean (SD)	9.24 (2.00)	9.84 (1.51)	**<0.001**
(Missing)	3,878	0	

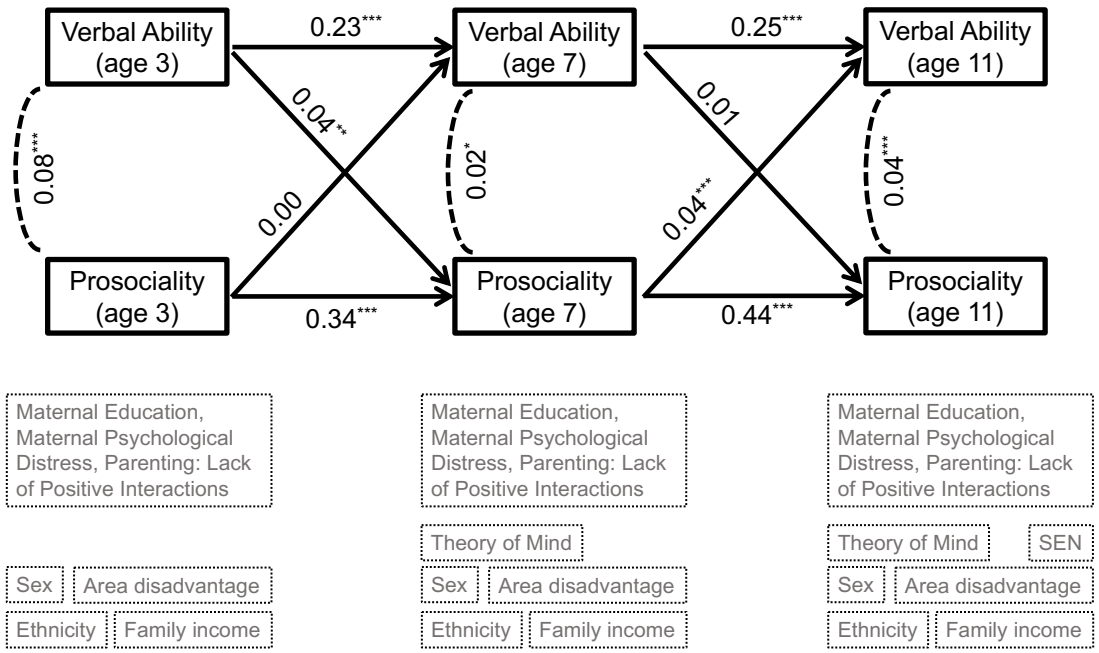
[1] Pearson chi-squared or Welch two-sample t-test | [2]N. = Northern | bold for $p < .05$

In terms of the numerical variables, a correlation matrix revealed that the strongest association occurred between family income and maternal education, $r(10707) = .52, p < .001$, and the second-strongest association was between income and verbal ability at age 3, $r(11026) = .30, p < .001$). Verbal ability scores at start and endpoint of the study (ages 3 and 11 years) were moderately correlated, with $r(11049) = .28, p < .001$, and so were the scores for prosociality between ages 3 and 11, with $r(11049) = .25, p < .001$. In terms of negative associations, the strongest one was between income and maternal psychological distress, with $r(10007) = -.22, p < .001$. The full table is included in the SOM (SOM, 2024).

Hypothesis 1: bidirectional association between language and prosociality

The bidirectionality of the association between verbal ability and prosocial behaviour was established through two significant paths in a fully adjusted CLPM, as can be seen in Table 2. Figure 1 depicts a simplified diagram of the relevant associations over the three time points. Even after controlling for the selected confounders, verbal ability at age 3 years predicted prosociality at age 7 years ($b_{V3\rightarrow P7} = 0.009, se = 0.003, z = 3.383, p = .001$, standardised $\beta_{V3\rightarrow P7} = 0.040$), and, conversely, prosociality at age 7 years predicted verbal ability at age 11 years ($b_{P7\rightarrow V11} = 0.188, se = 0.048, z = 3.896, p < .001$, $\beta_{P7\rightarrow V11} = 0.043$). Table 2 includes all three models: (1) without any adjustment; (2) with partial adjustment; and (3) with full adjustment. These effects are considered small (moderate) in the fully (partially) adjusted model, based on the classification of Orth et al. (2022).

Figure 1. Cross-lagged panel model for verbal ability and prosociality at ages 3, 7, and 11 years with confounders at each point. Standardised estimates are shown for the autoregressive and cross-lagged paths (solid lines), as well as for the covariances (broken lines) ($N = 11{,}051$, imputed, survey-weighted, fully adjusted).



Results without data imputation (using complete cases only, for various levels of adjustment) are presented in Section C of the Supplemental Online Material (SOM, 2024). We find that the effect sizes and statistically significant paths remain the same, with minor numerical fluctuations compared to Table 2.

Table 2. Unstandardised estimates (standard errors) of survey-weighted, imputed, cross-lagged panel models at ages 3, 7, and 11 for verbal ability and prosociality.

	Model 1	Model 2	Model 3
Prosociality (age 7)			
Prosociality (age 3)	0.30(0.01)***	0.29(0.01)***	0.29(0.01)***
Verbal Ability (age 3)	0.02(0.00)***	0.01(0.00)***	0.01(0.00)***
Sex: Male		-0.41(0.03)***	-0.41(0.03)***
Ethnicity: Non-White		0.04(0.07)	0.06(0.07)
Family income (age 3)		0.06(0.01)***	0.05(0.02)**
Theory of mind		-0.01(0.06)	-0.01(0.06)
Maternal Education			-0.01(0.02)
Maternal psychological distress			-0.03(0.00)***
Parenting: lack of positive interactions			-0.04(0.02)
Prosociality (age 11)			
Prosociality (age 7)	0.44(0.01)***	0.42(0.01)***	0.41(0.01)***
Verbal Ability (age 7)	0.01(0.00)***	0.00(0.00)	0.00(0.00)

Sex: Male		-0.28(0.03)***	-0.28(0.03)***
Ethnicity: Non-White		0.03(0.07)	0.03(0.07)
Family income (age 3)		0.05(0.01)***	0.03(0.01)*
Theory of mind		0.03(0.06)	0.02(0.06)
Statemented SEN		-0.48(0.11)***	-0.47(0.11)***
Maternal Education			0.02(0.01)
Maternal psychological distress			-0.02(0.00)***
Parenting: lack of positive interactions			-0.02(0.02)
Verbal Ability (age 7)			
Verbal Ability (age 3)	0.31(0.01)***	0.26(0.01)***	0.24(0.01)***
Prosociality (age 3)	0.09(0.04)*	0.04(0.04)	0.01(0.04)
Sex: Male		-0.51(0.16)**	-0.58(0.16)***
Ethnicity: Non-White		2.30(0.38)***	1.99(0.38)***
Family income (age 3)		1.05(0.07)***	0.72(0.07)***
Theory of mind		1.68(0.27)***	1.60(0.28)***
Maternal Education			0.64(0.07)***
Maternal psychological distress			-0.05(0.02)*
Parenting: lack of positive interactions			-0.26(0.11)*
Verbal Ability (age 11)			
Verbal Ability (age 7)	0.32(0.01)***	0.26(0.01)***	0.24(0.01)***
Prosociality (age 7)	0.23(0.05)***	0.20(0.05)***	0.19(0.05)***
Sex: Male		1.09(0.14)***	1.04(0.14)***
Ethnicity: Non-White		1.15(0.39)**	0.90(0.40)*
Family income (age 3)		0.83(0.07)***	0.52(0.07)***
Theory of mind		1.22(0.29)***	1.13(0.30)***
Statemented SEN		-2.59(0.44)***	-2.51(0.44)***
Maternal Education			0.62(0.07)***
Maternal psychological distress			0.01(0.02)
Parenting: lack of positive interactions			-0.48(0.11)***

*p<0.05, **p<0.01, ***p<0.001 | $N = 11{,}051$ observations | The full table in the Supplemental Online Material (SOM, 2024) includes estimates on area disadvantage, verbal ability and prosociality at age 3, and exact p-values. | Model fit was evaluated via the Standardized Root Mean Square Residual (SRMR); in all models, SRMR ≤ 0.04.

Additional analysis: Hypotheses 1A and 1B

Two further analyses provided evidence for a potential bidirectional association between verbal ability and prosociality, using suitable latent growth models (LGMs). First, we established that the trajectories of verbal ability between ages 3 and 5 years were associated with prosociality trajectories between ages 5, 7 and 11 years. In particular, the baseline (intercept i) of verbal ability significantly predicted the baseline of prosociality in the three models with different levels of adjustment (no adjustment, moderate adjustment, and full adjustment with the confounders selected in our study): even in the third model, $i = 0.019, se = 0.005, z = 3.907, p < .001, 95\%\ CI[0.002, 0.304]$. We note that, in this third model, we also controlled for prior prosociality (at age 3 years).

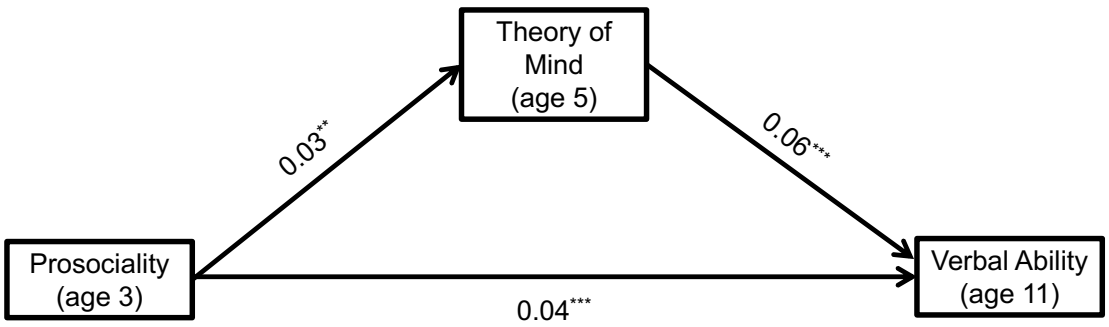
Second, the inverse was also found to be true, namely, gains in prosociality between 3 and 5 years were associated with gains in verbal ability between 5, 7, and 11 years in all three models with different levels of adjustment. Both baselines and slopes of the corresponding trajectories were associated: in the fully adjusted case, for instance, $i = 0.153, se = 0.077, z = 1.981, p = .048, 95\%\ CI[0.002, 0.304]$, and $s = 0.107, se = 0.045, z = 2.363, p = .018, 95\%\ CI[0.018, 0.196]$. Full tables are provided in Section D of the Supplemental Online Material (SOM, 2024).

Hypotheses 2 and 3: Theory of mind as a mediator in the association between language and prosociality

In a fully adjusted model testing hypothesis 2 (Model 1 of Table 3), ToM at age 5 years was considered as a mediator in the association between verbal ability in early childhood (age 3 years) and prosocial behaviour in late childhood (age 11 years). Even though verbal ability was prospectively associated with theory of mind ($a = 0.003, se = 0.000, z = 9.111, p < .001$, standardised $\alpha = 0.090$), it was not associated with prosocial behaviour in the fully adjusted case, as statemented SEN and maternal psychological distress were stronger (negative) predictors of late childhood prosociality. In addition, ToM at age 5 was not significantly associated with prosociality at age 11 (path b). As a result, in this case, there was no mediation effect ($a * b = 0.000, se = 0.000, z = 0.500, p = .617$).

In the inverse situation (Model 2 of Table 3) testing hypothesis 3, ToM at age 5 was a mediator between prosocial behaviour in early childhood (age 3) and verbal ability in late childhood (age 11). Prosocial behaviour was prospectively associated with theory of mind at age 5 ($a = 0.004, se = 0.001, z = 2.731, p = .006$, standardised estimate $\alpha = 0.029$), and it was also prospectively associated with verbal ability in late childhood ($c = 0.154, se = 0.039, z = 3.910, p < .001$, standardised $\gamma = 0.041$). Crucially, in this model, ToM was associated with verbal ability at age 11 ($b = 1.569, se = 0.278, z = 5.654, p < .001, \beta = 0.057$). As a result, in this case, there was a small but significant indirect mediation effect, where $a * b = 0.006, se = 0.003, z = 2.405, p = .016$ (standardised, $\alpha * \beta = 0.002$). Figure 2 depicts these results in a simplified path diagram.

Figure 2. Path analysis diagram (simplified, without confounding variables) showing the direct association between prosociality in early childhood and verbal ability in late childhood, mediated by theory of mind (ToM) in middle childhood (standardised estimates, $N = 11{,}051$, imputed, survey-weighted, fully adjusted model).



As previously, results on the complete cases are presented in the SOM, Section C (SOM, 2024). Effect sizes and significant paths remain the same, with minor fluctuations compared to Table 3. The same holds true for the different rescaling of the verbal ability variables across sweeps (Section E of the SOM).

Table 3. Unstandardised estimates (standard errors) of survey-weighted, imputed, and fully adjusted mediation models. In Model 1, theory of mind (age 5) mediates

the association between verbal ability (age 3) and prosociality (age 11). In Model 2, theory of mind mediates between prosociality (age 3) and verbal ability (age 11).

	Model 1 (Prosociality age 11 years)	**Model 2** (Verbal Ability age 11 years)
Verbal Ability (age 3)	0.00(0.00)	
Prosociality (age 3)		0.15(0.04)***
Theory of mind (age 5)	0.03(0.06)	1.57(0.28)***
Sex: Male	-0.49(0.03)***	0.82(0.14)***
England – Disadvantaged	-0.02(0.05)	0.04(0.46)
England – Ethnic	0.04(0.10)	-1.65(1.04)
N. Ireland – Advantaged	0.15(0.09)	2.18(0.59)***
N. Ireland – Disadvantaged	0.21(0.08)*	0.94(0.49)
Scotland – Advantaged	0.12(0.07)	-0.23(0.67)
Scotland – Disadvantaged	0.15(0.07)*	-0.30(0.54)
Wales – Advantaged	0.22(0.06)***	0.82(0.63)
Wales – Disadvantaged	0.13(0.06)*	0.30(0.46)
Ethnicity: Non-White	0.07(0.08)	1.17(0.43)**
Family income (age 3)	0.05(0.02)**	0.73(0.08)***
Statemented SEN	-0.88(0.14)***	-4.06(0.50)***
Maternal Education	0.02(0.02)	0.80(0.07)***
Maternal psychological distress	-0.03(0.01)***	-0.01(0.02)
Parenting: lack of positive interactions	-0.04(0.02)	-0.60(0.12)***
Theory of mind (age 5)		
Verbal Ability (age 3)	0.00(0.00)***	
Prosociality (age 3)		0.00(0.00)**
Partial Mediation		
Indirect effect	0.00(0.00)	0.01(0.00)*

*p<0.05, **p<0.01, ***p<0.001 | $N = 11{,}051$ observations | Full tables in Section D of the Supplemental Online Material (SOM, 2024) include exact p-values and the partially adjusted models. | Model fit was evaluated via the Standardized Root Mean Square Residual in all cases (for both models shown here, SRMR < 0.01).

Discussion

The results of the present study supported hypothesis 1, providing evidence for a bidirectional association between verbal ability and prosociality from early

childhood (age 3 years) to late childhood (age 11 years) in suitable cross-lagged panel models. In particular, the results showed that verbal ability in early childhood was prospectively associated with prosociality in middle childhood (age 7 years), and prosociality in middle childhood was prospectively associated with verbal ability in late childhood. An additional analysis using latent growth curve models also provided evidence that gains in verbal ability between 3 and 5 years were associated with gains in prosocial behaviour between 5, 7, and 11 years (hypothesis 1A); and, conversely, that gains in prosocial behaviour between 3 and 5 years were associated with gains in verbal ability between 5, 7, and 11 years (hypothesis 1B). All these associations remained significant even after adjustment with a wide range of confounders, which included socioeconomic characteristics of the family and neighbourhood, maternal mental health, and lack of positive parenting practices, as well as key characteristics of the child, such as sex, ethnicity, theory of mind development and the presence of special educational needs. Effect sizes were small to moderate in all cases. Taken together, these findings confirm our main hypothesis that there is a bidirectional longitudinal association between verbal ability and prosociality from early to late childhood for the general youth population.

Furthermore, focusing on the role of theory of mind in middle childhood, we provided evidence in favour of the third hypothesis, namely, theory of mind and social competence at age 5 partially mediated the association between prosociality in early childhood (age 3) and verbal ability in late childhood (age 11). However, there was no support for the inverse relation (hypothesis 2), as our results did not provide evidence that theory of mind at age 5 mediated the association between verbal ability at age 3 and prosociality at age 11, even though verbal ability in early childhood was a significant predictor of theory of mind, as expected. This negative finding should be contrasted with a previous study, which showed a significant mediation effect from receptive language through theory of mind to prosocial behaviour in primary school children aged 8 to 11 years (Longobardi et al., 2019), suggesting that this indirect pathway (from verbal ability to theory of mind to prosociality) could be sensitive to the type of verbal ability (receptive or expressive language), or the theory of mind assessment used per age group—or indeed a

combination of these two parameters, possibly depending on the age group involved in each case.

These results have important implications for early years education practices, suggesting that these could be tailored to simultaneously nurture language skills and prosocial behaviours, recognising their interconnected nature. For example, early years and primary school curricula emphasising cooperative learning (Veldman et al., 2020) and learning through play (Parker et al., 2022; Taylor & Boyer, 2020), storytelling (Nicolopoulou et al., 2015; Wright et al., 2013), and empathy-focused activities (Iacoboni, 2005; Waite & Rees, 2014) might not only enhance linguistic skills, but also foster a long-lasting prosocial disposition among children. Particular interventions for prosociality in the preschool years, such as the 12-week Kindness Curriculum (Flook et al., 2015), and the conversation-based programme of Brazzelli et al. (2021), can not only boost prosociality in preparation for the transition to primary education, but may also support language development from middle to late childhood. Furthermore, are findings suggest that tailored interventions that promote prosocial behaviours may also be used to promote better communication in neurodiverse children, such as children with autism spectrum disorder, who benefit from interventions targeting communication and language skills in the preschool years and whose verbal ability is predictive of future social skills and academic progress (McKernan & Kim, 2022).

Our work also provides support for the Social-Cognitive Approach (REF) and the Human Self-Domestication hypothesis (Hare, 2017) advocating for a deep link between linguistic abilities and social behaviour in humans. According to the SCA, the relationship between verbal ability at age 3 and prosocial behaviour at age 7 can be understood through the development of social understanding (also referred to as social intelligence) and perspective-taking skills. Advanced verbal abilities provide children with the tools to articulate their own thoughts and emotions and to understand and respond to the thoughts and emotions of others. This enhanced social understanding fosters empathy and cooperative behaviours, as children become better equipped to navigate social interactions effectively. These findings align with the work of Tomasello (2005) and Gopnik and Wellman (1992), who suggest that language development is intertwined with the ability to engage in

shared intentionality and mentalizing, foundational aspects of prosocial behaviour. Furthermore, our study also found that prosocial behaviour at age 7 predicts verbal ability at age 11 and, in the context of the SCA, prosocial activities provide children with richer social interactions that stimulate verbal communication; in turn, these interactions offer repeated opportunities for children to practice and refine their language skills, as they must negotiate, explain, and understand complex social situations with shared (or competing) goals, whereby understanding others' perspectives and intentions is crucial for both language and prosocial development (Wellman & Liu, 2004). These findings also support the HSD hypothesis, which posits that human evolution has been shaped by selection pressures favouring more prosocial behaviour, which also led to better mentalizing abilities and more advanced language skills (Benítez-Burraco & Kempe, 2018; Raviv & Kirby, 2023). Specifically, our study underscores the bidirectional association between prosocial behaviour and language that is predicted by HSD: they suggest that engaging in prosocial behaviours can help accelerate language development, and that better linguistic and communicative abilities can enhance more prosocial and cooperative behaviours. In some sense, the evidence provided in support of hypothesis 3 (i.e., that early prosocial behaviours are conducive to theory of mind development and later verbal ability), may reflect the evolutionary trajectory whereby human linguistic abilities evolved in tandem with, and perhaps as a result of, our proclivity for mentalizing and social cooperation—and that there is an ongoing positive feedback loop between increased prosociality and language in the course of human development.

Nevertheless, the present study also has several limitations. First, the MCS data used here were collected during 2000-2012. This precedes the reported rises in screen time and social media use from younger ages (Golden et al., 2020), which can affect both language (Anderson et al., 2017; Schwarzer et al., 2022) and peer play (Putnick et al., 2023); therefore, more recent data would be beneficial in order to evaluate the potential effects of screen time and social media on the current results. Though more robust research is needed in this area (Kaye et al., 2020; Orben, 2020; Valkenburg et al., 2022), we expect that the bidirectional association between prosociality and language development reported here would persist even after

controlling for screen time and social media use. Interestingly, studies that tested the relation between screen time and language skills in childhood suggest that what matters is the quality of screen time and the involvement of caregivers (Madigan et al., 2020), which is in line with our results that controlled for positive parenting practices in the cross-lagged panel and latent growth models. Second, our findings are based on the UK's youth population and did not consider other regions, languages, and cultures. Future studies should explore the role of family, cultural, and environmental factors (e.g., attendance of preschool, urban versus rural environments, individualist versus collectivist societies) in shaping the bidirectional relation between language and prosocial behaviour, given their potential impact on this association. However, in light of the HSD hypothesis, we predict that these results should hold in all humans and are not likely to be confined only to Western, English-speaking cultures.

A third limitation of the current work is that the MCS only includes limited measures of prosociality and linguistic abilities. Specifically, it only contains data for receptive and expressive verbal skills, and for peer relationship and prosocial behaviour as measured by the SDQ (see Measures). As such, it lacks additional and more nuanced measures of both linguistic ability (such as syntax, semantics, pragmatics, and phonology) and prosocial behaviour (such as helping, comforting, and sharing subscales or structured observations). This was a key constraint in the current study, hindering a more nuanced understanding of how different aspects of language development may relate to different aspects of prosocial behaviour. For example, pragmatic abilities, which guide the effective use of language in everyday contexts, were shown to predict better psychosocial adjustment and more prosocial behaviours (Ketelaars et al., 2010). Another important example is mental state language development, whose association with prosociality in early and middle childhood is well-established (Conte et al., 2018; Longobardi, Spataro, & Rossi-Arnaud, 2016; Ornaghi et al., 2016; Tompkins et al., 2018). However, this sort of delineation was not possible with the current measures. In addition, while the data covered a critical developmental period, these were not particularly granular in time. Future research could address these limitations by incorporating a broader range of linguistic and prosocial measures, as well as more frequent sampling intervals (e.g.,

on a bi-annual basis), which can provide more fine-grained trajectories and capture subtle within-person shifts and variations in behaviour across development. A fourth limitation, related to the available measures in MCS, is that the accuracy of Theory of Mind assessments at age 5 and 7 years was very likely compromised by the mode of administration (as the Sally-Anne task was the first task in a cognitive test battery, used to build rapport with the assessor in what would have been a demanding dyadic interaction with an unknown adult in the child's home); however, we have used the test results from both waves (5 and 7 years) and only considered whether children answered all three questions of the task correctly (in both cases), thus ensuring that we are comparing those participants who had well-established, robust ToM as well as superior social competence skills at age 5 against those who had not.

Fifth, the evidence provided in the present study points to small (or at most moderate) effect sizes, based on a standard classification of cross-panel lagged effects (Orth et al., 2022). Therefore, it should be highlighted that the practical implications may be quite limited, especially when it comes to measuring the potential impact of interventions. On the other hand, we should also mention that these longitudinal effects involve long timescales (i.e., an intervention on prosociality at age 3 years, and outcomes on verbal ability at age 7), and have been derived from a large, nationally representative survey. As a result, the size of the effects is still relevant for educational settings involving very large populations, as explained in a different context in Carey et al. (2023).

Finally, the possibility of additional, unmeasured or unobserved confounding variables cannot be ruled out, and thus no strict causal associations can be inferred from the present study alone. Such additional confounders include but are not limited to (a) genetic predispositions at the biological level (Conway & Slavich, 2017; Plomin & Dale, 2014); (b) conflict, exclusion, and targeted or social rejection, at the level of the family, school, and community (McCoy et al., 2009; Van den Bos et al., 2018); other child characteristics, for instance pertaining to attachment and transitions from infancy to early childhood development (Hay & Cook, 2007). Future work could tackle these issues by conducting additional studies, such as a genome-wide association study that tests whether variation in prosocial skills predicts later language skills or considering the impact on social cohesion and parental conflict on

the co-development of language and prosocial behavior. Other potential unobserved confounders imply that the results of the present work need to be replicated both in additional observational studies, and in experimentally controlled settings.

To summarize, understanding the complex dynamics between prosociality and language can offer valuable insights for early years education practices as well as broader issues in the study of human evolution and development. The current work offers initial evidence of a bidirectional association between these two constructs in the first 10 years of life, suggesting that children's verbal and prosocial abilities are intrinsically linked and continuously shape each other across human development. Consequently, interventions aimed at enhancing either verbal ability or prosocial behaviour in early childhood could have reciprocal benefits during development, fostering a range of socio-cognitive competencies.

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