Predictors of children's conversational contingency

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Abstract: When in conversation, a child may respond to an adult's turn in different ways: by saying something that acknowledges what was previously said, saying something that furthers the topic of the conversation, saying something off topic, or by not saying anything at all. Different types of responses like these have been investigated with typically developing preschoolers and older children with autism but we still understand relatively little about what predicts their use. With a longitudinal sample of 40 Swedish-speaking five-year-olds, we carried out three studies investigating which factors, internal and external to the child, were the best predictors of the above four different aspects of children's conversational behaviour. In Study 1, we investigated the predictive value of broadly concurrent linguistic and cognitive measures and found that receptive vocabulary was related to appropriate conversation responses. In Study 2, we investigated the predictive value of environmental factors and found that later preschool entry was positively related to contingent responses in this relatively socially advantaged sample. Finally, in Study 3, we investigated the predictive value of social and cognitive factors measured in early development and found no reliable relations. Together, these exploratory studies suggest that different aspects of children's conversational skills may depend on strong lexical comprehension and may be facilitated by the caregiving environment.

Keywords: conversational contingency; pragmatic development; first language acquisition

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Citation: Pagmar, D., Abbot-Smith, K., & Matthews, D. (2022) Predictors of children's conversational contingency. Language Development Research, 2(1), 139–179. https://doi.org/10.34842/2022-511

General Introduction

During first language acquisition, several fundamental elements must fall into place: a grammar, a lexicon, and control over a modality that can carry a linguistic signal. A language-acquiring child must also acquire the ability to use these fundamentals in social interaction. The ability to successfully use language for the purpose of social interaction and also take context into account when interpreting language is termed pragmatics. Pragmatic ability is closely linked to peer likability ratings (e.g. Place & Becker, 1991), child mental health (e.g. Helland, Lundervold, Heimann & Posserud, 2014) and poor pragmatic ability is associated with poor behavioural outcomes (e.g. Mackie and Law, 2010). Broad measures of child pragmatic ability are most frequently obtained via parental and teacher completed questionnaires (e.g. LUI, CCC2). Such questionnaires include items measuring child conversational ability, which is arguably the most frequent expression of pragmatic ability in daily life and for this reason child conversational ability is the key focus of the current paper.

Conversational abilities include engaging in turn-taking, offering relevant contributions to the conversation, and signalling interest in the contributions of others. The ability to maintain a back-and-forth conversation in this manner is essential for making and maintaining friendships (e.g. Hazen & Black, 1989) as well as collaborating on problem-solving activities both in school and in the workplace. For this reason it is important to understand which cognitive and socio-cognitive abilities, and which environmental factors, relate to individual differences in child conversational ability.

While norms differ across cultures, there are types of behaviour that are essential in conversational conduct, the most crucial component being the ability to provide a conversation response which is not 'tangential' in topic. A second important component is the ability to add new but relevant information so that the conversation can move forward. We follow Bloom, Rocissano, and Hood (1976: 528) in referring to the combination of these key conversational components as 'conversational contingency'; they state that *contingent speech* is defined as utterances that share the topic of the preceding utterance and add information to it (1976: 528). When a conversation partner provides a 'non-contingent' response, as in the example below from the current dataset, this can derail a conversation.

Experimenter: *You will eat a lot of ice cream! You mustn't forget your toothbrush.*
Participant: *I saw a horse on our way here.*

The definition of conversational contingency was adopted by later papers directly examining naturalistic conversations between children and adult conversation partners (Tager-Flusberg & Anderson, 1991; Hale & Tager-Flusberg, 2005a; Capps et al., 1998; Nadig, Lee, Singh, Bosshart & Ozonoff, 2010; Abbot-Smith, Matthews, Bannard, Nice, Malkin, Williams & Hobson, in prep) as well as by a study of semi-structured verbal interaction between typically-developing four- and five-year-olds and adults (Blain-Briere et al., 2014) and various studies of conversations between peers (e.g. Hazen & Black, 1989;

Kemple, Speranza & Hazen, 1992). Certain other studies have not utilised the term 'contingency' per se, but have examined the closely related phenomenon of 'connected' conversational responses - i.e. where the child's statement is logically related to the preceding statement and the back-and-forth conversation continues for a number of turns (e.g. Slomkowski & Dunn, 1996).

Past studies have put emphasis on different aspects of conversational behaviour, sometimes focussing on specific types of 'error' including going off topic (Hale & Tager-Flusberg, 2005b) or not responding at all (Capps, et al., 1998). Though both of these behaviours, going off-topic and not responding at all, can be considered less desirable conducts of a conversational partner, they do differ from each other. Non-contingent responses are potential contributions for someone else to follow up on, while a person that is not responding at all is basically opting out of the cooperative principle (Grice, 1975) all together. Also, these responses may be driven by very different cognitive factors. For example, not responding might logically be related to core language and the ability to formulate a response, in that a child must not only follow the conversational topic and realise what would be an appropriate contribution to the activity, but also have the means of producing a contribution and doing so in a timely fashion. It is possible that a child grasps the first two mentioned steps, but is having difficulties moving forward from there. In contrast, in order to produce a non-contingent response a child needs to have access to at least a certain level of vocabulary and morpho-syntax.

The aim of the current paper was to simultaneously look at these four related, but conceptually separated, conversational behaviours in children's responses to their interlocutor:

I. to add information and further the topic
II. to acknowledge what was previously said (whether it furthers the topic or not)
III. to respond without acknowledging the previous turn
IV. to not respond at all

We know that children will become increasingly sophisticated in their conversational strategies during the transition from preschool to school (Wanska & Bedrosian, 1985), but a pressing question remains unanswered: which factors allow children to develop the use of which conversational behaviours? By investigating I and II separately, we can see to what degree different correlates agree with the ability to specifically add new information to a conversation, and to what degree these correlates agree with the ability to acknowledge one's interlocutor in general.

Previous studies on conversational development have examined the role of formal language (e.g. vocabulary and/or grammar) and social cognition in typical and atypical development (Abbot-Smith, Matthews, Bannard, Nice, Malkin, Williams & Hobson, in prep; Abbot-Smith, Matthews, Malkin & Nice, 2021; Capps, Kehres, & Sigman, 1998; Hale & Tager-Flusberg, 2005; Bishop & Adams, 1989). Thus, Slomkowski & Dunn (1996) found that average length of preschool children's connected conversational turns in peer interaction, as well as the average length of play episodes and pretend episodes, were

positively related to performance on tasks of perspective-taking and false-belief (see also Bernard & Deleau, 2007:453, who did not examine observed conversation, but conversational perspective-taking). Likewise, Blain-Brière, Bouchard, & Bigras (2014) investigated the role of executive functions (self-control, inhibition, flexibility, working memory and planning) and observed that higher inhibition skills were correlated with a decrease in talkativeness and assertiveness, and that children with a high working memory capacity were more likely to formulate contingent answers (for further review of research on the relationship between pragmatic development and individual differences in language, social cognition and executive function, see Matthews, Biney, and Abbot-Smith, 2018).

Most studies, in contrast to those just mentioned, that address the connection between pragmatic development and other developmental factors, rarely assess direct measures of conversation. Another noteworthy exception is Hoff-Ginsberg (1998), who included both child internal (core language skill) and external factors (birth order, SES) when examining the development of conversation skill in younger children, aged 1;6–2;6. She found that first borns exhibited more advanced lexical and grammatical development, while later borns were more advanced in some types of (routine) conversational response. These results could indicate a division between conversational skill and core language development, or at least that they are not entirely dependent on each other. The children participating in this study were very young and studies on older children are needed to further examine these relationships with different types of conversational behaviour.

Other studies have explored the relation between the caregiving environment and the development of conversation in both typical and atypical development (e.g., Conti-Ramsden, Hutcheson, & Grove, 1995). Tomasello, Conti-Ramsden, & Ewert (1990) have suggested that the secondary caregiver (in their study, often the father) might prepare the child for communication with less familiar adults. A study of French toddlers similarly suggested a benefit of out-of-home daycare for some conversational behaviours (Marcos et al., 2004). Any relationship with the caregiving environment could of course be bidirectional. Indeed, in a study on three young children (1;9–2;6), Hoff-Ginsberg (1987) suggested that the conversation skill of the young child in turn affects the language learning environment.

Overall, while many studies suggest that different types of conversational behaviour are related to children's social and cognitive abilities as well as their caregiving environment, research in this area is still in its early stages. Thus, we conducted three studies, using data from one longitudinal data set, to explore the relationship between both child-internal and child-external factors and direct measures of four conversational behaviours. We examined two 'positive' behaviours: contingent responses (where the child adds to the conversation by contributing to the topic) and a broader category of appropriate response (where the child acknowledges the prior turn, but not necessarily with new information). We also looked at two types of 'error' that have received attention in the clinical literature: responding off-topic and not responding at all.

All studies were based on a preexisting Swedish longitudinal data set, the MINT project, with a conversational outcome measure at the age of 5;0 created by analysing

semi-naturalistic conversation. The measures of conversational behaviour were added to that dataset specifically for the current studies. The choice of predictor variables and sample size was constrained by the available dataset. While the studies are exploratory in nature, we nonetheless pre-registered all studies (osf.io/ah23m) and made hypotheses where theoretically appropriate.

We will present three pre-registered studies, each exploring how a set of predictor measures relate to each of the four types of conversational behaviour of interest. All analysed data stems from the same aforementioned data set. Study 1 was concerned with broadly *concurrent* measures of the child's ability to act in the world (measures of core language, conduct problems, curiosity). Study 2 was concerned with *environmental* factors: SES, birth order and daycare. Finally, Study 3 investigated whether developmentally earlier core language, social cognition and/or memory *longitudinally* predicted each of the four types of conversational behaviour.

General Method

Preregistration

The variables, hypotheses, and planned analyses for all three studies were pre-registered on Open Science Framework (https://osf.io/ah23m) after data collection, but prior to any analysis. Analysis scripts can also be found on OSF.

Participants

The sample consists of 40 Swedish speaking children (19 girls). Each child was at the age of 5;0 at the time of the recording of the conversational data (observed within two week from their birthday). All participating children were part of the longitudinal study MINT (MAW2011.007). Higher education was overrepresented among the parents of participating children, with 78% percent having studied at University level. Observations were made within two weeks of the child turning any specific reported age. A child from the MINT study was included in the current study if: 1) there were available longitudinal observations of the child, 2) the child's first language was Swedish, and 3) there were no reports of atypical development. In the conversational data, the children contributed with a total of 3612 conversational turns.

Testing procedure

All children were participants in the aforementioned longitudinal study MINT. Therefore numerous developmental test results (presented in detail below, as well as in Tables 2, 4, and 6) and longitudinal data were available for each participating child. For the current study, semi-structured conversations between the 5-year-olds and a researcher (the first author) were recorded with three stationary cameras and one in-action camera, worn by

the researcher. The children had met and interacted with the researcher on several previous occasions. For each child, we selected 10 minutes of conversation from the conversation partner's initial statement. All conversations were recorded in the same interaction laboratory at Stockholm University (PICTURE 1).

PICTURE 1: Four still photos taken from the video recordings of a session, showing all camera angles.

The child entered the interaction laboratory and was asked to sit down on a chair at a table. The researcher sat down on the opposite side of the table facing the child. The researcher then said the first out of 11 predetermined utterances. The reason for using predetermined utterances was to control the theme of the conversation and to make sure that each child would be given similar input from the researcher. Free interaction took place between the predetermined utterances.

Predetermined utterances

Below is a list of the 11 predetermined utterances that each participating child was exposed to during their recording session, translated into English from Swedish:

1. ”[NAME], how old are you?”
2. ”You know, Mo, Na, and Li, they live here in our lab, but tomorrow they will no longer be here”.
3. ”Where do you think they are gonna go?”.
4. ”They are going on vacation! Can you guess where they are going?”.
5. ”They will sleep in different places. Mo will sleep in a tree, Na will sleep on a roof, Li will sleep in a house”.
6. ”Mo will be gone for four days, Li will be gone for a few days, Na will be gone for a week, that's seven days. Who do you think will come home first?”.
7. ”They packed their bags this morning. Do you have a bag?”.
8. ”Do you know what happened when they were packing? They had a quarrel”.
9. ”Na thought that Mo had the plane tickets, but Mo hadn't seen the tickets”.
10. ”Na and Mo were really upset. They didn't know that Li had taken the tickets”.
11. ”Thank you [NAME], for talking to me about our friends!”.

Coding contingency and appropriate conversational behaviour

The conversational data was coded by the first author in accordance with a coding scheme for conversational contingency, developed by Abbot-Smith, Matthews, Malkin and Nice (2021), for which the coding manual is available on OSF (osf.io/q7wa4). Every turn that

the child took in response to the researcher during the conversation, both following the predetermined utterances and under the free interaction, was categorised into four basic categories:

> *contingent*,
> defined as an appropriate, informative and on-topic response to the experimenter's statements and questions,
>
> *non-contingent*,
> defined as a utterances that do not maintain the topic of the experimenter's statements and questions,
>
> *minimal response,*
> defined as utterances with little semantic weight, such as "Yeah" or "Wow". One-word utterances are normally coded as minimal, also imitative responses repeating what was just said,
>
> *other*,
> defined as responses on the part of the child or the experimenter that do not fit into any of the other categories, including laughter, inaudible responses, not-easily categorised responses, topic shifts following minimal responses from the researcher,

In addition to the categories listed above, *Missing turns* were also coded. A missing turn was coded when (i) >2 seconds had passed after the experimenter's turn, (ii) the child was not offering any vocal or gestural response, and (iii) the experimenter once again took a turn.

The categorical definitions above share similarities to previous coding schemes of children's adjacent and contingent responses. In the original definition from Bloom et al., (1976) a contingent response was defined as being "a response which, first, shared the same topic as the preceding utterance and, second, added information to the preceding utterance". In contrast, Blain-Brière, et al., (2014) did not include requirements for the response to be informative to be categorised as contingent, but that the utterance should be an "adequately respond to a request by the interlocutor". In the current paper, we followed Abbot-Smith et al.'s coding procedure in emphasising the second part of the definition, which meant that single word utterances and other utterances that did not add information (e.g. *did you?*) were excluded from the category of contingent utterances. The original papers that used this concept (Bloom et al., 1976; Tager-Flusberg & Anderson, 1991) outlined distinct sub-types of contingent responses, which both elucidates distinct ways in which they may be considered relevant to the preceding response and also explains how a response may be relevant but may nonetheless simultaneously 'move the conversation on'. One subtype was termed 'expansion' by Bloom et al. and involved adding information and content. The second subtype was termed 'alternation' and involves adding information which opposed the truth value of the preceding utterance (e.g. Mother: *this is a man?*, Child: *no, it's a lady*). The third subtype was termed 'expatiation'

and is the type of utterance which both adds information to the topic and simultaneously introduces a new related topic (e.g. Mother: *oh I'm glad a black dog came along and saved the bunny*, Child: *no, hunter shoot him*). In the current study all of the subtypes would be categorised as contingent responses.

Aside from considering potentially 'optimal' contingent responses we were also interested to explore any kind of basically appropriate response. We considered *appropriate* any contingent response along with any 'minimal responses' (e.g. one-word responses, phrases such as 'Did you?'). This behavioural category thus covers all instances where the child acknowledged their conversational partner's turn - where the child signalled that they were listening and that they are part of the conversation.

In contrast to responding in an appropriate manner, some children quite frequently go off topic. This has been the subject of some considerable research in the literature on autism and we wanted to explore this behaviour in the current study also. Finally, some children simply do not respond at all on occasion and we considered predictors of this inability to generate a response.

Thus, the purpose of analysis, each turn was coded with respect to the following four binary outcome variables that capture conversational (in)appropriateness in four different ways:

Contingent turns: was the utterance contingent on the prior turn?
Appropriate turns: was the utterance a contingent or minimal response, i.e. acknowledged the experimenter's previous turn?
Non-Contingent turns: was the utterance non-contingent (going off-topic topic)?
Missing turns: was the prior utterance followed by no response at all?

The question of which factors would predict each of these categories of conversational behaviour are of course to some extent related. We chose to investigate each of them in their own right, since they allow us to conceptualise conversation in slightly different ways, and we can obtain potentially valuable information from each, especially since there exists no one universally agreed-upon measure of what makes for 'good' conversation. Thus, piecing the results from these four analyses together helps us obtain an idea of which cognitive factors are for which kinds of conversational behaviour. For example, working memory difficulties might be particularly likely to lead to non-contingent responses (because children simply forget the topic) whereas psycho-social difficulties might more likely to predict null responses and formal language ability might be more likely to predict contingent turns (since the child would be able to fluently generate them).

It is worth noting that minimal responses made up a large part of what the children produced during the conversations. These turns were often appropriate, especially as feedback signals. A contingent turn marks that a child is cooperative and is contributing something to the conversation, but a minimal turn also often marks cooperativeness. In the examples below, translated from Swedish, 1b, 2b, and 3b are all categorised as minimal responses.

(1a) Experimenter: *That would be so crazy!*
(1b) Participant: *I know!*

(2a) Experimenter: *Na will live on a roof…*
(2b) Participant: *A roof?*
(2c) Experimenter: *…and Mo will live in a house*

(3a) Experimenter: *They will not be here tomorrow*
(3b) Participant: *Hm, ok*
(3c) Experimenter: *Where do you think they're going?*

In 1b, the participant is smiling and nodding their head while making the utterance. In 2b, the participant raises their voice to mark surprise. In both 1b and 2b, the participants are marking that they are engaged in the conversation. It can, at times, be more appropriate to say something short rather than something long, and by repeating what someone else just said, you can signal that you were listening. In 3b, the participant does not add much to the conversation but there is a case for labelling the response "appropriate" when evaluating the participants' conversational behaviour. In contrast, consider the following example:

(4a) Experimenter: *…and my favourite is ice cream*
(4b) Participant: [missing turn]
(4c) Experimenter: *What's your favourite?*

In 4b, the participant's gaze is directed toward a stuffed animal and they do not signal any communicative act directed towards the experimenter. If we compare 3b and 4b, one of the examples is clearly more cooperative than the other. In 3b, there is a response and it is connected to the previous turn. It is important to note that the majority of minimal responses in our dataset are more resemblant of 1b and 2b, than of 3b.

Inter-rater reliability

Twelve and a half percent of the data (i.e. five children) were coded by another native speaker of Swedish, blind to how the data was coded by the first author. There was a very high degree of reliability (Cohen's k = .91). The high result is in line with previous contingency coding results, e.g. Hale and Tager-Flusberg (2005a) obtained an IRR of Cohen's kappa = .88 – 1.00 per transcript. Nadig et al. (2010) obtained IRR of Cohen's kappa = .92 for response type.

Data treatment and analyses

Descriptive statistics

The mean, standard deviation, minimum and maximum value was calculated for all measured variables, presented below. The data was examined for outliers, defined as observations beyond 1.5 interquartile range below the first quartile or above the third quartile. One outlier was found in the outcome measure *Non-contingent turns* (i.e, one child produced relatively very many of these responses compared to others) . This was not a case of measurement error and given the statistical models we employed we saw no reason for excluding it.

Correlational analyses

For each study, we first present a correlation matrix using Pearson's R to understand the simple relationships between each of the four measures of conversation and their predictors. For these analyses, each of the outcome variables was the sum of each measure of conversation for each participant.

Regression analyses

Four separate analyses were conducted, one for each investigated conversational response types. This was repeated for all three studies. We fitted multilevel logistic regression models using the lme4 package (Bates, et al, 2015) in R (R Core Team, 210614). We held each occurrence of a coded conversational turn in the data as the dependent variable (N = 3612), where a turn that corresponded to the outcome measure was ascribed the value of 1, and all other turns were ascribed the value of 0. These binary variables allowed us to ask: to what degree is the occurrence of specific response type (i.e. the specific outcome measure) dependent on the predictors, compared to any other type of turn in the data? For each of the three studies, we examined the influence of the study specific predictors over the separate conversational measures.

The model predicts the outcome of the binary dependent variable in terms of log odds (logits) as a linear function of the predictors (the fixed effects). For each model, we included random intercepts for participants. Each study included different fixed effects (outlined below) depending on the research question.

Transformations

All continuous predictor variables were transformed to z-scores for the statistical analyses. One binary predictor in study 2, Older sibling, was dummy coded.

Model build and predictor evaluation

For each study, multilevel logistic regression models were built. Each model predicted the binary outcome measurements (Contingent turns, Appropriate turns, Non-Contingent turns, and Missing turns) and included random intercepts for participants. We report marginal R^2 and conditional R^2 (Nakagawa et al., 2017) by obtaining all variance-components of the mixed models. Marginal R^2 is calculated by dividing the fixed effects variance by the total variance. Marginal R^2 indicates to what level the variance in the data can be explained by fixed effects only. Conditional R^2 is calculated by adding the random effects variance to the fixed effects variance and dividing the sum of both by the total variance. Conditional R^2 indicates to what level the variance in the data can be explained by the full model. Random effects for each model are also presented in APPENDIX A.

Model performance in regards to the conventional limit for disregarding effects, i.e. p-values, will be presented, as well as Odds ratios (Szumilas, 2010) for all predictors with 95% confidence intervals. An odds ratio (OR) of 1 represents neither outcome being more likely than the other as a function of the predictor. An OR >1 means increased odds as a function of the predictor, an OR <1 means decreased odds. The distance in decimals from 1 is to be interpreted as percentages, i.e. an OR of 1.25 means that the odds are increased by 25%, an OR of 0.75 means that the odds are decreased by 25% .

All predictors are evaluated through a likelihood ratio test using the anova function in R. The likelihood ratio test compares a model with n predictors to a model with less than n predictors, in terms of likelihood of the data. We exclude one predictor at a time from each model, and then compare the new model with the one including all predictors. The tests are conducted to evaluate predictor contribution and we report χ^2 and p-value from each test in table 3, 5, and 7. The AIC values from each run are presented in APPENDIX B.

Study 1: Preschool language ability, psycho-social wellbeing and curiosity

Study 1: Introduction

In our first study, we examined whether different aspects of children's conversational skills relate to three factors, the first being the child's vocabulary and grammar. Previous studies have found fairly consistent positive relationships between these measures and pragmatic abilities (see Matthews, et al., 2018, for a review, although note also Hoff-Ginsberg, 1998). The role of core language in conversational proficiency might be expected since a child with a large vocabulary who can easily control a variety of grammatical structures would be more likely to have the linguistic skill necessary to predict and plan turns in fluent conversation.

Second, we explored children's psycho-social well-being, which we expected may have a two-way relationship with the ability to engage well in conversation. A few studies have examined this somewhat indirectly (e.g. Helland, Lundervold, Heimann & Posserud,

2014; Mackie and Law, 2010)). Mackie and Law (2010) found that primary-school aged children who were clinically referred because they showed "behaviour that was causing concern at school" had significantly greater language difficulties than matched 'control group' children from the same schools. This between-groups difference was particularly marked for pragmatic language, which includes conversational ability. Similarly, Donno, Parker, Gilmour and Skuse (2010) found that the only language-related differences between children referred for behavioural difficulties and matched controls pertained to pragmatic and not to formal / core language. A large-scale study found that pragmatic language skill mediated the relationship between structural language, on the one hand, and behavioural difficulties, as assessed by the Strengths and Difficulties Questionnaire (SDQ) (Law, Rush, & McBean, 2014). However, none of these studies directly assessed conversational ability. We do so here, albeit with a non-clinical sample that did not contain a large number of children with behavioural difficulties.

Third, we explored the role of the children's curiosity. Epistemic curiosity is described as the desire to seek new information (Litman, 2008). We were particularly interested in epistemic curiosity in relation to conversational contingency because to respond contingently, one has to listen to and engage with what the conversation partner has just said. To achieve this, one needs to be open to new topics from external sources over and above one's own drive to talk about things pertaining to one's own habitual interests. Thus, we assumed that a child that is curious about their immediate surroundings, and generally seeks new information, might be more likely to engage in conversation and be interested in engaging with conversation topics which are set by an adult experimenter. In turn, we assume that a child that is more likely to engage in conversation will to a higher degree be exposed to, and have the opportunity to learn from, conversational norms, than would a child that is not as likely to engage in conversation.

In sum, in Study 1 we examined broadly concurrent relationships between our conversational measures on the one hand, and on the other hand formal language (as assessed by receptive vocabulary and morpho-syntax), psychosocial wellbeing (as assessed by the Strength and Difficulties - SDQ - questionnaire) and epistemic curiosity (as assessed by parent-report). We predicted that vocabulary, morpho-syntax and epistemic curiosity would be positive predictors of *Contingent* and *Appropriate turns*, and negative predictors of *Non-contingent* and *Missing turns*. We predicted that assessments of psychosocial difficulties would be a negative predictor of *Contingent* and *Appropriate turns*, and positive predictors of *Non-contingent* and *Missing turns*, and that all three would each explain unique variance.

Study 1: Method

Obtaining predictor measurements

All predictor measurements were obtained when the children were above the age of 3;0.

Vocabulary (PPVT)

The Peabody Picture Vocabulary Test, PPVT-4 (Dunn & Dunn, 2007) was conducted when the participants were at the age of 4;0. The test was adapted for Swedish participants (Ahlström & Ljungman, 2011). Because this measure has not been standardized on a Swedish sample, raw scores were used. We note that this measure was collected one year before the children's conversational data was collected. However, on the basis of Song, et al. (2015) we consider it likely that this measure would be fairly stable over this timeframe and we therefore choose to label the observed measure of receptive vocabulary at 4;0 as a broadly concurrent measure.

Grammar

Grammar was measured through an adapted version of a core language skill scoring scheme (Tonér & Gerholm, 2021), which takes into account (1) morphosyntactic accuracy score, calculated as % well-formed clauses and (2) syntactic complexity, defined as subordinate clauses per word token. The measurement was obtained from the study's conversational data. The predicates produced by a participant, following the first 10 of the experimenter's predetermined utterances, were analyzed and the number of inflections was counted.

Psycho-social wellbeing (SDQ)

The Strengths and Difficulties Questionnaire (SDQ) is a widely used tool for measuring children's mental health and psychopathology between the age of 4 and 16 (Goodman, 1997). It measures five subtypes of behaviors: conduct problems, emotional problems, hyperactivity, peer problems, and prosocial behaviors. The validity of an adapted version for children between the age of 3;0 and 4;0 has been examined with satisfactory results (Croft, et al., 2015). The participants' parents answered the SDQ questionnaire when the children were at the age of 3;6. The measurement included in the study is a composite of all five subtypes. For this measure, a higher score indicates greater psycho-social difficulties.

Epistemic Curiosity

This was measured with an adapted version of a parent-report questionnaire, answered by the children's caregivers (Piotrowski, et al., 2014:547). The participants' parents answered the questionnaire, translated from English into Swedish, when the children were at the age of 3;6. The measurement included in the study is a composite of reported answers.

Study 1: Results

Descriptive statistics

The mean and standard deviation, as well as the maximum and minimum observed values, of the four outcome measures are presented in Table 1.

Table 1. Descriptive statistics for the four conversational outcome measures, as well as for conversational turns labelled Other (i.e. turns that did not fall into any of the predetermined categories). Measures are presented with mean, standard deviation, maximum and minimum score.

	Mean	SD	Median	Min	Max
Contingent turns	21.7	10.8	19	5	50
Appropriate turns	51.8	17.8	51	21	87
Non-contingent turns	2.8	3.5	2	0	19
Missing turns	12.3	7.9	12	1	32
Other	27.1	13.3	28	6	59

The predictors for all models in Study 1 were receptive vocabulary, expressive grammar, psycho-social wellbeing, and curiosity. The descriptive statistics for the predictors in Study 1 are presented below in Table 2.

Table 2. Descriptive statistics for all predictors in Study 1.

	Mean	SD	Min	Max
PPVT	62.7	15.5	19	101
Grammar	16.9	2.6	12	24
SDQ	15	4	7	24
Curiosity	35.7	5.9	22	43

Correlational Analyses

Figure 1 below outlines which study 1 factors were correlated with each of the four conversational measures (*Contingent turns, Non-Contingent turns, Appropriate turns*, and *Missing turns*) and their predictors.

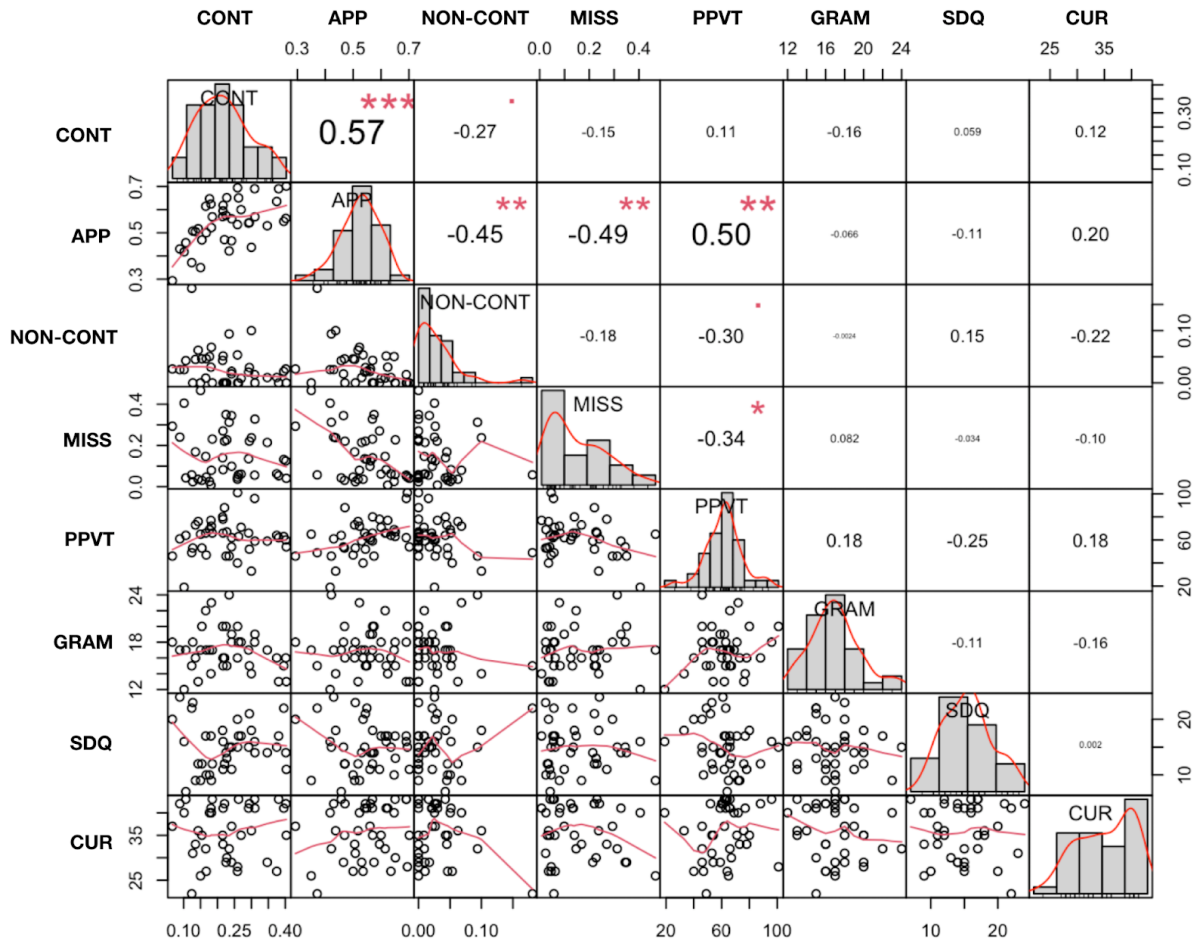

Figure 1. A correlation matrix showing pearson correlations between percentages of the four dependent variables per session: Contingent turns (CONT), Appropriate turns (APP), Non-Contingent turns (NON-CONT), Missing turns (MISS), and the predictors from Study 1 (standardized values): PPVT, grammar (GRAM), SDQ, curiosity (CUR).

Logistic regression analyses

Table 3 below reports findings for the fixed effects for each outcome variable in the logistic regression models (N = 3612), with χ^2 and p-values from the likelihood ratio test. Variance inflation factors were calculated and show no multicollinearity between predictors. Random effects for each model are presented in APPENDIX A.

Table 3. Fixed effects by dependent variable (Contingent turns, Appropriate turns, Non-Contingent turns, and Missing turns).

	CONTINGENT TURNS				APPROPRIATE TURNS				NON-CONTINGENT TURNS				MISSING TURNS			
	Est.	SE	χ2	p	Est.	SE	χ2	p	Est.	SE	χ2	p	Est.	SE	χ2	p
(Intercept)	-1.213	0.078	-	-	0.284	0.051	-	-	-3.89	0.217	-	-	-2.022	0.156	-	-
PPVT	0.090	0.084	1.138	0.286	0.221	0.055	13.337	<0.001***	-0.368	0.21	3.072	0.079 .	-0.368	0.167	4.522	<0.05 *
GRAMMAR	-0.078	0.081	0.902	0.342	-0.053	0.053	0.996	0.318	0.071	0.188	0.146	0.701	0.194	0.16	1.441	0.23
SDQ	0.029	0.08	0.133	0.714	-0.005	0.052	0.01	0.919	-0.012	0.19	0.004	0.945	-0.077	0.16	0.232	0.629
CURIOSITY	0.025	0.081	0.097	0.754	0.03	0.053	0.320	0.571	-0.03	0.2	0.023	0.879	0.036	0.161	0.05	0.822

Contingent and Appropriate turns

For Contingent responses, none of the predictors explained significant variance in the logistic regression model, all p:s > .29 (marginal R^2 = 0.003, conditional R^2 = 0.054) . As seen in Figure 2, the confidence intervals for the Odds Ratios for each predictor of contingent turns included 1. For appropriate responses, however, the vocabulary measure (PPVT) was a significant positive predictor (χ^2 =13.33, p<.001). While marginal R^2 for appropriate turns was 0.015 (conditional R^2 = 0.032), the Odds Ratios indicate that an increase in the PPVT vocabulary score by 15.5 points increases the odds for an appropriate turn by 24% [95%CI = 11%–39%].

Non-contingent and Missing turns

Vocabulary was a significant predictor of missing turns (χ^2 =4.52, p<.05) and showed a trend towards a negative relationship with *Non-Contingent turns* (χ^2 =3.07, p = 0.08). The relationship between vocabulary and the negative behaviour of missing turns mirrored the findings for appropriate turns; here an increase in vocabulary (PPVT) of 15.5 points decreases the odds of a missing turn by 31% [95%CI = 4%–51%]. No other measures reliably predicted negative conversation outcomes.

Odds ratios for Study 1

In Figure 2, below, we present the models in terms of Odds Ratios (Szumilas, 2010) with 95% confidence intervals .

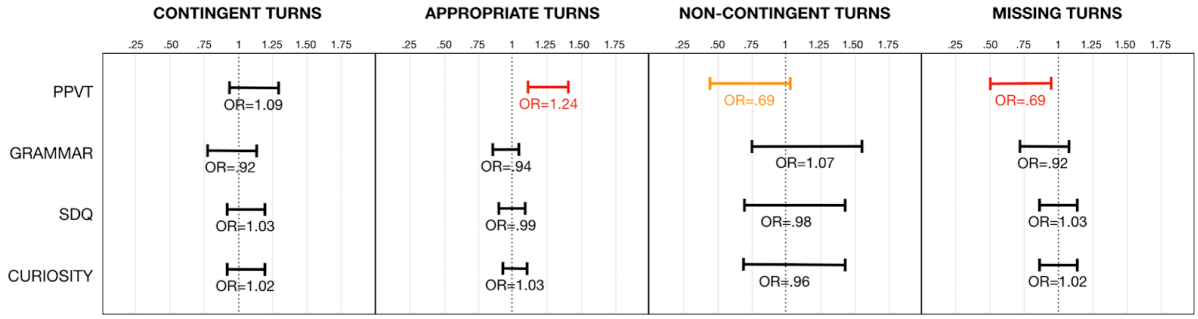

Figure 2. Odds ratios for the predictors in Study 1. The four different dependent variables are displayed in four columns (Contingent turns, Appropriate turns, Non-Contingent turns, and Missing turns). The predictors are displayed as rows. The odds ratios show how one unit in the predictor variable either increases or decreases the odds for the dependent variable to occur.

Study 1: Discussion

Vocabulary was a positive predictor for three of the measures of conversational ability. If a child had a relatively large vocabulary they were more likely to be able to generate a conversational response that was at least appropriate and they were less likely to simply not respond at all. Perhaps surprisingly, vocabulary was not a predictor of contingent responses. One might have expected that a strong vocabulary would be particularly valuable for generating contingent responses (as they tend to have more lexical content than minimal responses that do not move the conversation along). Contrary to our hypothesis, Grammar, SDQ, and Curiosity showed no significant relationships with any conversational measure.

Study 2: The language learning environment

Study 2: Introduction

Children's acquisition of formal language (vocabulary and morpho-syntax) is well-known to be influenced by environmental factors, particularly the quantity and quality of the language they hear directed to them (e.g. Hoff, 2003; Rowe, 2012). Factors such as Socio-Economic-Status (SES) or birth order are often used as proxies for the richness of child directed speech, however, to date very few studies have attempted to relate environmental factors to children's conversational ability. Study 2 thus included SES, time in day care and birth order in order to explore whether these environmental factors might predict the development of conversational proficiency.

Regarding SES, there is robust evidence for positive relationships between SES and vocabulary development in children (e.g. Huttenlocher, et al., 2010; Hoff, 2003; Rice &

Hoffman, 2015; Thornton et al, 2021). What is less clear is whether the positive direction of the relationship also holds for the development of conversational proficiency. On the one hand, parents from lower SES backgrounds have been shown to be less likely to follow in contingently on their own children's communications than do parents from middle-class backgrounds (e.g. McGillion, et al., 2017). This would suggest that children from lower SES backgrounds might have poorer conversational skills. Another aspect to consider is the environmental factors that may affect the conversational ability, like parental input. From observations of mother-child conversations, Hoff-Ginsberg (1991) found differences in the child-directed speech spoken in different settings between working class and upper-middle class mothers. Hoff-Ginsberg looked at several properties of maternal speech, e.g. number of utterances, utterances per minute, number of roots, MLU, % child utterances given topic-continuing replies, rate of conversation-eliciting utterances, rate of behaviour directives. When considering all settings, upper-class mothers scored higher in all categories, except for rate of behaviour directives. For specific settings, such as reading, all differences were not detectable. This also might suggest that children from lower SES backgrounds receive less exposure to conversational conduct compared to children from higher SES backgrounds.

On the other hand, there are suggestions from the work of Labov that higher SES children may not make better conversational partners, and indeed the reverse might even be the case in some respects (Labov, 1969). Hoff-Ginsberg (1998) found no reliable difference between mid- and high-SES when examining young children's conversational skills. In a recent study, Schulze and Saalbach (2021) looked at children's performance in a communication task and found no predictive value from parents' educational background or income. In the current study we explore the relation between conversational ability and SES operationalised as the mean income in the families' postcode areas.

Another aspect of the input which is often less considered is the language that children hear in different caregiving contexts, for example at home or at daycare. This might be particularly important in terms of learning how to hold a back-and-forth conversation. At preschool, children will be exposed to different language users including many peers and a range of caregiving adults. This might lead one to assume that an earlier start at preschool could result in better pragmatic ability. While the opportunity for peer-interactions has been explored to some degree in relation to how children learn to tell narratives (e.g. Küntay & Senay, 2003), to our knowledge there has been little exploration of this with relation to child conversational skills. One the one hand one might expect a similar advantage while on the other,, given the complexities of preschool quality and the tradeoff with alternative caregiving environments (see e.g. Burchinal, Roberts, Nabors & Bryant, 1996), there may also be reasons *not* to expect a simple positive relation between time spent in preschool and conversational skill. In one study of 27-month-old French children, Marcos et al (2004, p.145) found that there was a certain advantage for children who had daycare outside of the home or in terms of the amount of turns in conversation with their mother but not in terms of the thematic contingency of those turns on what their mother had said. On the other hand, NICHD Early Child Care Research Network (1999) looked at assessments of longitudinal mother–child interaction and found "small

but significant" results showing that more child-care hours negatively predicted two interactional components: child engagement and maternal sensitivity. If these findings persist beyond early childhood, the notion of less child engagement in interaction with parents might result in less interactional engagement overall. In the current study we explored whether starting nursery at an earlier age and spending more time there predicted better conversational contingency in Swedish 5-year-olds.

Finally, we were also interested in examining environmental effects driven by the presence of an additional sibling with whom the child has to share the parent's attention and language input. Previous findings show that first-born children are at an advantage in terms of expressive vocabulary size (Urm & Tulviste, 2016; Pine, 1995). As seen above, vocabulary is a positive predictor for conversational behavior, and therefore we might expect it to also be a positive predictor of conversational ability. However, while Hoff-Ginsberg (1998) also observed a first-born advantage for vocabulary, she simultaneously saw a trend in the opposite direction for conversational contingency, at least for 18- to 29-month-olds, which might be taken to suggest the two phenomena are somewhat separable. It appears these later-borns relied on what were coded as social *routines* to reply contingently to their caregivers more readily without taxing their more limited lexical resources. Such routine responses include saying things like "I don't know", "I can't", or "thank you" - responses that would be coded as a *minimal* turn, rather than a contingent turn in the current study (i.e., appropriate but not adding very much). When Hoff analysed the proportion of contingent responses that were expansions or expatiations (most similar to contingent replies in this study), first borns produced proportionally more such responses. The picture is thus somewhat mixed in toddlerhood. Nonetheless, when we consider development beyond toddlerhood, the literature on Theory of Mind development (e.g. Perner, Ruffman & Leekam, 1994; Hughes, 2011) might be taken to predict that having older siblings results in more advanced social cognition which could benefit conversation. In the current study we therefore also examined whether having an older sibling was associated with better conversational skill in 5-year-olds but we did not have a directional prediction.

In sum, in Study 2, we did not have a directional prediction for socioeconomic status (SES) or birth order. However we expected more time in day care to be a positive predictor for *Contingent* and *Appropriate turns,* and a negative predictor for *Non-contingent* and *Missing turns*.

Study 2: Method

The predictor measures for Study 2 were as follows.

Socioeconomic status

SES was measured in terms of the mean income in each families' postal code area because our participants' parents all came from very similar educational backgrounds.

Educational level was also recorded but the measure did not show enough variance, with a large majority of parents having undergraduate qualifications.

Preschool start

This measurement was assessed in terms of the child's age in weeks when they started attending daycare.

Preschool hours per week

The measurement consisted of the number of hours per week that the child attended day-care when aged 2;3.

Older siblings

Children who had one or more older siblings received a score of 1 and all other children received a score of 0.

Study 2 – Results

Descriptive statistics

Table 4 below presents the descriptive statistics for the Study 2 predictors that were continuous variables. 55% of our final sample had an older sibling.

Table 4. Descriptive statistics for predictors variables in Study 2: SES (represented by mean income in postal code area presented in Swedish crowns), Preschool start in weeks, and Preschool hours per week.

	Mean	**SD**	**Min**	**Max**
SES (income/postal code in SEK)	403793	87917	279199	648533
Preschool start in weeks	76	17	51	106
Preschool hours per week	34	7.6	7	46

Correlational Analyses

Figure 3 below outlines which Study 2 factors were correlated with each of the four conversational measures (*Contingent turns, Appropriate turns, Non-Contingent turns*, and *Missing turns*).

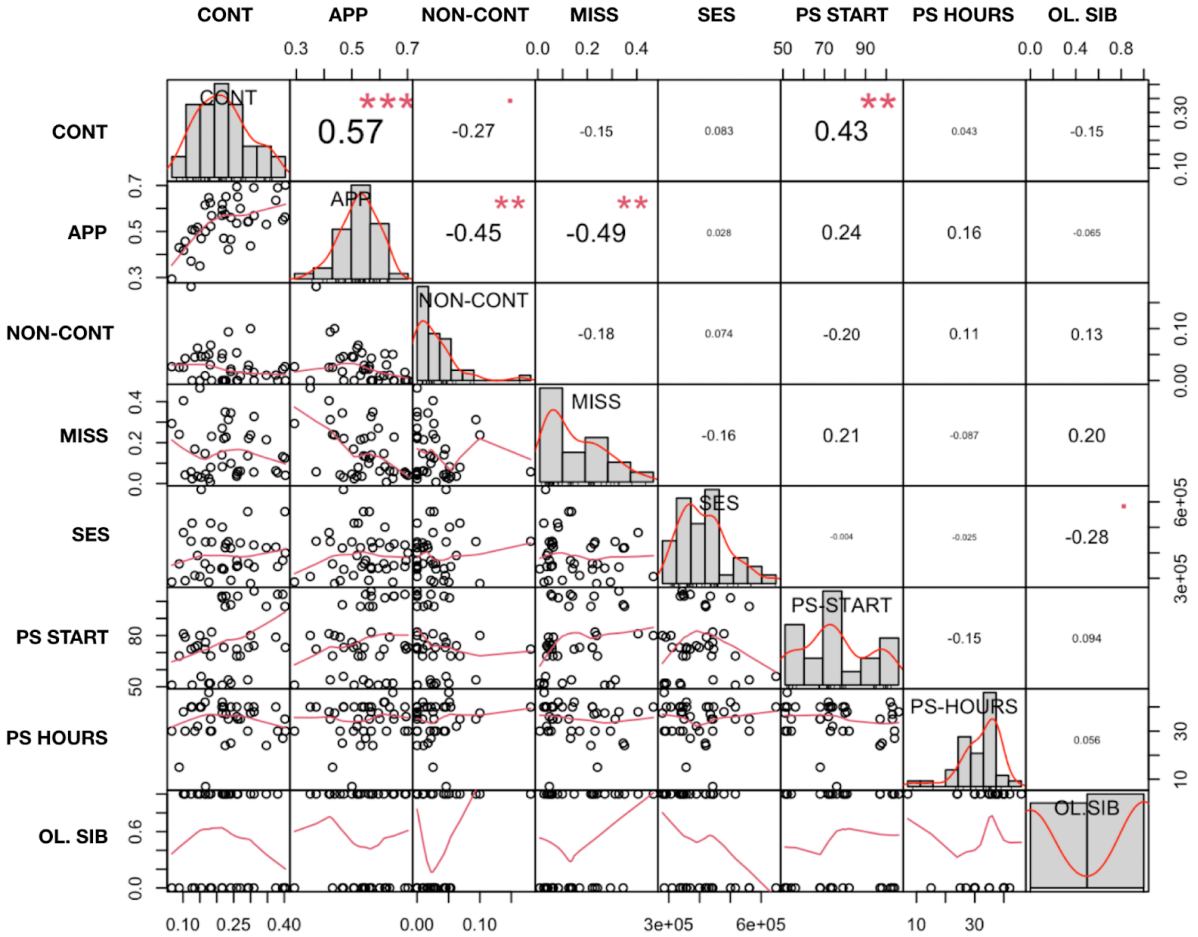

Figure 3. A correlation matrix showing Pearson's correlations between percentages of the four dependent variables per session: Contingent turns (CONT), Appropriate turns (APP), Non-Contingent turns (NON-CONT), Missing turns (MISS), and the predictors from Study 2 (standardized values): Socioeconomic status (SES), preschool start (PS START), preschool hours (PS HOURS), and older sibling (OL. SIB). For older sibling, we presented the point-biserial correlation coefficient.

Logistic regression analyses

Table 5 below reports findings for the fixed effects for each outcome variable in the logistic regression models (N = 3612), with χ^2 and p-values from the likelihood ratio test.

Variance inflation factors were calculated and show no multicollinearity between predictors. Random effects for each model are presented in APPENDIX A.

Table 5. Fixed effects in Study 2 by dependent variable (Contingent turns, Appropriate turns, Non-Contingent turns, and Missing turns).

	CONTINGENT TURNS				APPROPRIATE TURNS				NON-CONTINGENT TURNS				MISSING TURNS			
	Est.	SE	χ2	p	Est.	SE	χ2	p	Est.	SE	χ2	p	Est.	SE	χ2	p
(Intercept)	-1.130	0.104	-	-	0.303	0.089	-	-	-3.939	0.289	-	-	-2.173	0.232	-	-
SES	0.009	0.077	0.013	0.906	-0.029	0.065	0.208	0.648	0.088	0.195	0.202	0.653	-0.139	0.171	0.65	0.42
PS_START	0.224	0.071	8.671	<0.01 **	0.071	0.062	1.285	0.256	-0.312	0.204	2.37	0.123	0.243	0.159	2.2945	0.129
PS_HOURS	0.062	0.073	0.729	0.392	0.068	0.062	1.202	0.272	0.024	0.190	0.016	0.898	-0.093	0.160	0.337	0.561
OL.SIBLING	-0.177	0.15	1.347	0.245	-0.066	0.128	0.265	0.606	0.128	0.410	0.096	0.755	0.288	0.328	0.756	0.384

Contingent and Appropriate turns

Recall that contingent responses and appropriate responses were both positive measures of conversational ability. For contingent responses, there was a significant positive effect of preschool start in weeks (χ^2 =8.67, p<.01). While marginal R^2 for contingent responses was 0.015 (conditional R^2 = 0.053), the Odds Ratios (see Fig 4) indicate that starting preschool 17.6 weeks *later* increased the odds of a turn being Contingent by 25% [95%CI = 8%–44%].

Non-contingent and Missing turns

Recall that non-contingent and missing turns were both negative measures of conversational behaviour. For both non-contingent and missing turns, no predictors reliably explained variance in negative conversation outcomes (all p > .12).

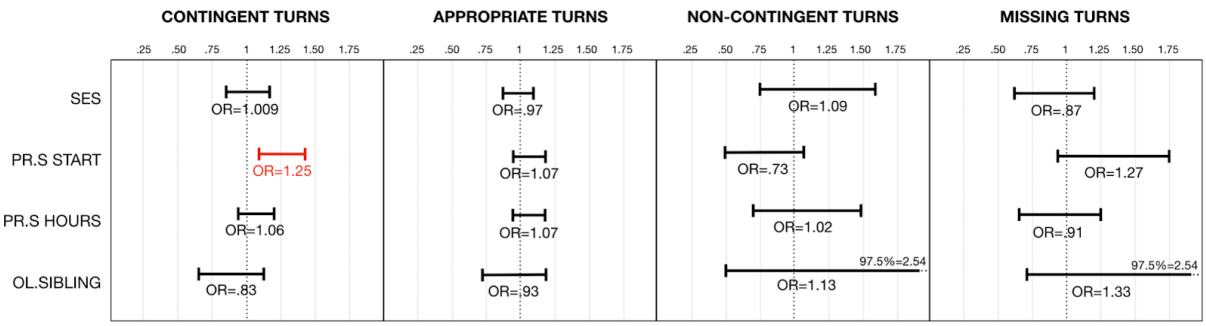

Figure 4. Odds ratios for every predictor in Study 2. The four different dependent variables are displayed in four columns (Contingent turns, Appropriate turns, Non-Contingent turns, and Missing turns). The predictors are displayed as rows. The odds ratios show how one unit in the predictor variable either increases or decreases the odds for the dependent variable to occur.

Odds ratios for Study 2

Below, we present the models in terms of odds ratios (Szumilas, 2010) with 95% confidence intervals (figure 4).

Study 2: Discussion

The results do not support the hypotheses that more time in daycare would have a positive effect on conversational contingency – if anything children with a *later* preschool start had an advantage in the number of contingent turns. Finally, neither SES nor presence of older siblings was associated with any conversation measure. In the case of SES we note that this measure did not have a high degree of variance. However, for sibling status, the sample was approximately evenly distributed regarding having an older sibling or not but this factor nonetheless showed no relationship with any of the four conversational behaviours. It might be that a finer grained analysis would reveal differences in *how* children are responding contingently (see Hoff-Ginsberg, 1998). We should also note that the current conversational measures are based on interaction with an adult not a peer, which might advantage first borns.

Study 3: Longitudinal examination of early vocabulary, short-term verbal memory, and imitation

Study 3: Introduction

To date, hardly any studies, to our knowledge, have explored whether children's conversational abilities can be longitudinally predicted on the basis of measures of their earlier cognitive and socio-cognitive development. In our third study, we explored whether children's appropriate conversational responding could be predicted on the basis of their earlier vocabulary, memory, and social cognition.

As we saw in study 1, children's conversational ability is associated with their broadly concurrent vocabulary. We do not know how stable this association is over time, however, and whether early vocabulary difficulties might be predictive of later conversational difficulties. Here we tested whether children's *expressive* vocabulary at age 2;3 was predictive of conversational ability when they were 5-years-old.

We also considered the role of short-term memory in relation to conversational ability. To provide contingent turns when taking part in back-and-forth conversation, besides keeping track of the conversation topic, one also needs to continuously keep in mind what an interlocutor just has said. The ability to maintain, manipulate and update information in short term memory is commonly referred to as working memory (Blakey, Visser, & Carroll, 2016) and has been found to correlate with conversational ability. Blain-Brière, Bouchard, & Bigras (2014) found that verbal working memory (Backwards Digit Span) related positively – with an effect size of 0.25 – to conversational contingency (and

was the only factor which correlated with contingency) in a sample of 70 typically-developing four- and five-year-olds. The memory variable we had available was a measure of phonological short-term memory (forward digit span) taken when children were 2;9. This measure did not involve manipulating information in memory (as the working memory measures noted above do) since this is difficult to assess at such an early age. Nonetheless, previous work has shown that phonological short-term memory capacity is an important predictor of vocabulary acquisition and word learning in both children (5-year-olds) and adults (Gathercole, et al, 1997) . We tested if early measurements of short-term verbal memory, taken at age 2;9, predict appropriate conversational behaviour.

Finally, to show appropriate conversational behaviour, it is arguably important to take the interlocutor's mental states into consideration. Such social cognition has often been measured by assessments of false belief which is arguably not necessary for many conversational interactions. We explored a more basic index of social cognitive ability: imitation. The imitation measure used in this study was part of the aforementioned pre-existing data set and was selected for inclusion as a marker of early social cognition, which we expected could pave the way for good conversational skills. Previous findings show that parental assessed measures of imitation show moderate explanatory value for variation in concurrent parental assessed conversation skill (Farrant et al., 2011), which prompts the question if such a relationship is detectable longitudinally as well. Meltzoff and Decety (2003) suggests that infant imitation provides the foundation for understanding that others are 'like me', i.e. have the same mental experience, and that it underlies the development of theory of mind and empathy for others. There is a large body of research showing links between action imitation and early communication development (e.g. Carpenter, Nagell & Tomasello, 1998; Carpenter, Tomasello & Striano, 2005; Zambrana, Ystrom, Schjølberg & Pons, 2013). These two abilities may be interrelated because a child that is inclined to imitate the actions of others, understands others' goals and means and is inclined to adopt them in purposive behaviour, of which conversation is an example. Findings from Nagy (2006) show that infants used previously imitated gestures to initiate communication, and although the study was concerned with very rudimental communicative actions, it exemplifies the notion of an agent observing an act, imitating the act, and later reproducing the act for their own communicative purposes. Previous studies have found that children with language impairments have greater difficulties than do well-matched neuro-typical peers with certain types of action imitation (Dohmen, Chiat & Roy, 2013). We therefore predicted that early imitation ability would predict later conversational ability.

We expected that early measures of children's vocabulary, memory and imitation would be positive predictors of conversational ability.

Study 3: Method

Vocabulary

Expressive vocabulary was assessed by the parental questionnaire SECDI-II, the normed Swedish translation of the McArthur-Bates Communicative Developmental Inventory (https://mb-cdi.stanford.edu/; Berglund & Eriksson, 2000, Larsson, 2014). This measure was chosen because direct measures of vocabulary are difficult to administer below the age of 3 years. The participants' parents answered the questionnaire every third month during the participants' first three years of life. We selected the measure which was obtained when the participants were at the age of 2;3 because the distribution showed variance without clear floor or ceiling effects.

Forward digit span

Participants were asked to repeat a series of random digits that the experimenter said, initially two at a time. The experimenter added one digit every other turn making the series of digits successively longer. The test was stopped after the participant made two errors in a row. The number of correctly repeated series of digits was counted. This measurement was obtained when the children were aged 2;9.

Imitation

Our imitation test is an adapted version of a longitudinal within-participants imitation task (Sakkalou, et al., 2013). In this task, the participant is prompted to imitate a test leader that is engaging in pretend play, making building blocks jump, building a tower with the building blocks, clapping hands, and putting the blocks into a bag. Each test part was scored as follows, no imitative action = 0, close to imitative action = 1, full imitative action = 2, for a potential maximum score of 8. The measurement was obtained when the participants were aged 1;0.

Study 3: Results

Descriptive statistics

The predictors for all models in Study 3 were early vocabulary, working memory (assessed via Forward Digit Span), and early imitation ability (assessed via the action imitation test). The descriptive statistics for the study 3 predictors are presented in Table 6 below.

Table 6. Descriptive statistics for all predictors in Study 3.

	Mean	SD	Min	Max
SECDI-II (at age 2;3)	319.2	152.6	24	653
Forward digit span	1.9	1.4	0	4
Imitation	2.8	1.4	0	6

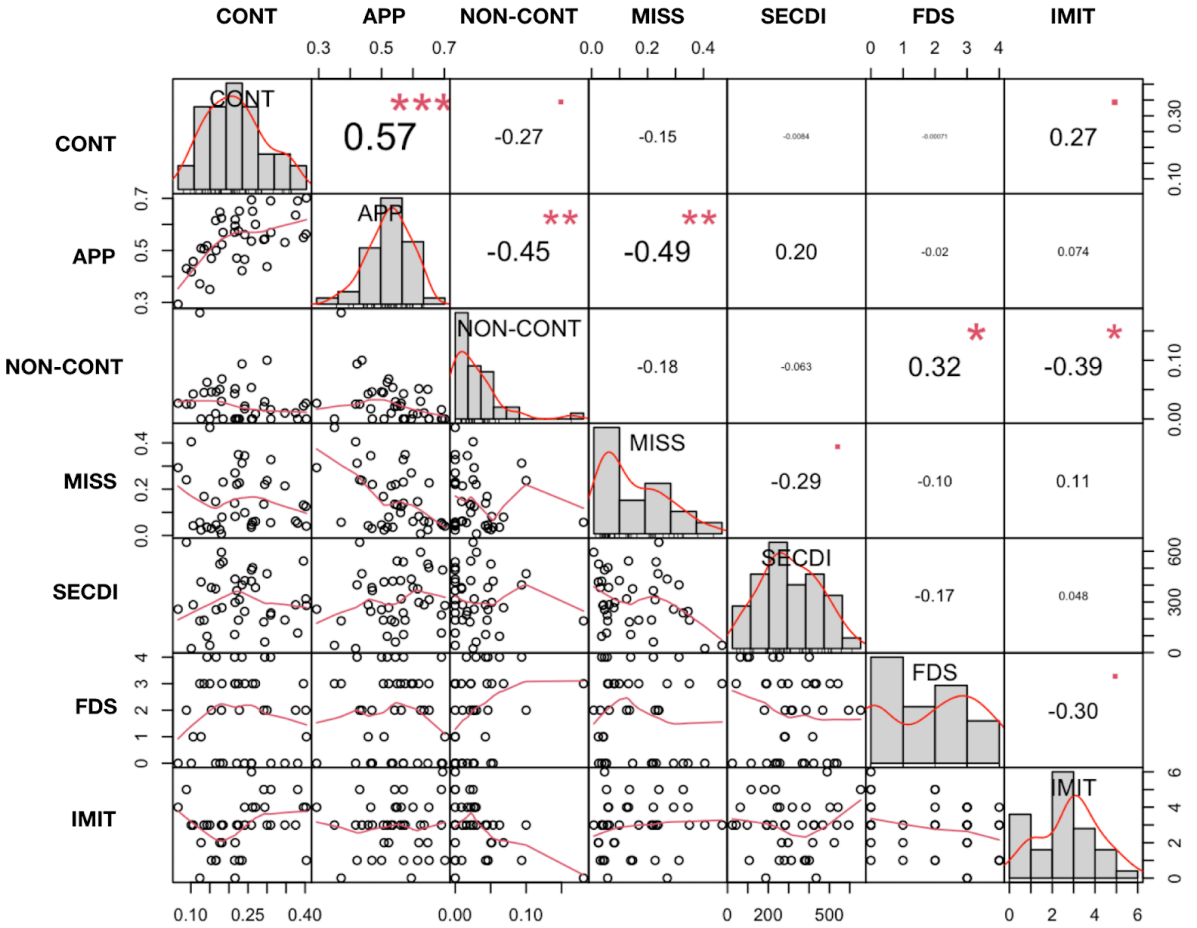

Figure 5. A correlation matrix showing pearson correlations between percentages of the four dependent variables per session: Contingent turns (CONT), Appropriate turns (APP), Non-Contingent turns (NON-CONT), Missing turns (MISS), and the predictors from Study 3 (standardized values): SECDI, forward digit span (FDS), and imitation (IMIT.).

Correlational Analyses

Figure 5 below outlines which Study 3 factors correlated with each of the four conversational measures (*Contingent turns, Appropriate turns*, *Non-Contingent turns,* and *Missing turns*) and their predictors.

Logistic regression analyses

Table 7 below reports findings for the fixed effects for each outcome variable in the logistic regression models (N = 3612), with χ^2 and p-values from the likelihood ratio test. Variance inflation factors were calculated and show no multicollinearity between predictors. Random effects for each model are presented in APPENDIX A.

Table 7. Fixed effects in Study 3 by dependent variable (Contingent turns, Appropriate turns, Non-Contingent turns, and Missing turns).

	CONTINGENT TURNS				APPROPRIATE TURNS				NON-CONTINGENT TURNS				MISSING TURNS			
	Est.	SE	χ2	p	Est.	SE	χ2	p	Est.	SE	χ2	p	Est.	SE	χ2	p
(Intercept)	-1.220	0.077	-	-	0.273	0.06	-	-	-3.86	0.198	-	-	-2.014	0.159	-	-
SECDI II	0.011	0.077	0.0206	0.886	0.106	0.06	2.941	0.086 .	0.042	0.18	0.055	0.814	-0.3	0.158	3.489	0.061 .
FDS	0.049	0.08	0.374	0.54	0.011	0.063	0.032	0.857	0.345	0.19	3.412	0.064 .	-0.077	0.165	0.218	0.64
IMITATION	0.15	0.079	3.373	0.066 .	0.032	0.063	0.265	0.606	-0.363	0.187	3.333	0.067 .	0.121	0.164	0.539	0.462

Contingent and Appropriate turns

Recall that contingent responses and appropriate responses were both positive measures of conversational ability. For both contingent responses and appropriate responses, no predictors explained significant variance in the logistic regression models (all p > .06). There is a trend towards a positive effect of early imitation for contingent turns, ((χ^2=3.37, p = .066), and of early vocabulary (SECDI) for appropriate turns, (χ^2=2.94, p = .086).

Non-contingent and missing turns

Recall that non-contingent and missing turns were both negative measures of conversational behaviour. For both non-contingent and missing turns, no predictors show reliable effects in the logistic regression models. Early imitation shows a trend towards a negative effect for *Non-Contingent turns,* (χ^2 = 3.33, p = .067) and a similar trend is found for early vocabulary (SECDI) for missing turns (χ^2 = 3.48, p = .061), Short term verbal memory (FDS) shows a trend towards a positive relationship for *Non-Contingent turns,* (χ^2 = 3.41, p = .064). Marginal R^2 for non-contingent responses was 0.072 (conditional R^2 = 0.228), the odds ratios (see figure 6) for imitation only just includes 1 [95%CI = -0.04%–48%].

Odds ratios for Study 3

W present the models in terms of odds ratios (Szumilas, 2010) with 95% confidence intervals (figure 6).

Study 3: Discussion

Early vocabulary, short-term verbal memory and early imitation showed no reliable relationships with any of the four types of conversational behaviour. In general, further exploration with a larger sample size would be needed to understand the relationship between early predictors and children's conversational behaviour.

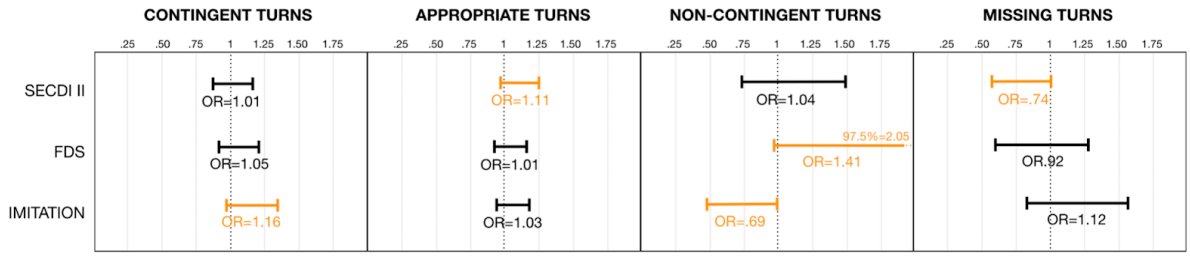

Figure 6. Odds ratios for every predictor in Study 3. The four different dependent variables are displayed in four columns (Contingent turns, Non-Contingent turns, Appropriate turns, and Missing turns). The predictors are displayed as rows. The odds ratios show how one unit in the predictor variable either increases or decreases the odds for the dependent variable to occur.

General Discussion

We carried out three studies, using one pre-existing longitudinal data set, to explore which factors might explain variance in 40 Swedish speaking 5-year-olds' conversational responses, specifically focusing on children's cognitive and social strengths in childhood, proxy measures of their environment and early measures of vocabulary, memory and imitation from infancy. In Study 1, receptive vocabulary at 4;0 predicted more *Appropriate turns,* i.e. acknowledging previous turns in general, and fewer *Missing turns,* i.e. not responding at all. In Study 2, contrary to expectation, a later age of preschool onset was associated with greater odds of responding with *Contingent turns*, i.e. responses that furthers the topic of a conversation. In Study 3, no reliable effects were found, but there were some trends that might deserve further investigation with a larger sample.

The findings from Study 1, regarding the positive relationship between receptive vocabulary at 4 years and *Appropriate turns*, aligns with previous findings - albeit with autistic children (e.g. Hale & Tager-Flusberg 2005a; Capps et al., 1998). However, to our knowledge, this is the first study to suggest a relationship between core language and a directly assessed measure of conversational ability in typically-developing children. The

predictive value of vocabulary seems easy enough to explain. If a child struggles with the comprehension of the intended meaning of lexical units in a conversation, they will struggle to understand and respond to a partner. However, it is not entirely clear why we did not find the same relationship, firstly, with (expressive) grammatical ability in Study 1 and, secondly, with parent-assessed vocabulary (Swedish version of the CDI) in Study 3 (although the latter does show a trend in the hypothesised direction, for both *Appropriate turns* and *Missing turns*). One possible explanation for the outcome of the grammatical measure would be that conversational skill is not primarily reliant on complex grammatical knowledge; someone with limited grammatical knowledge could still be appropriate and contingent, and vice versa. A non-mutually-exclusive possibility is that while an individual needs to have a certain level of morpho-syntactic ability to maintain a back-and-forth conversation, once a certain morpho-syntactic acquisition threshold has been reached, morpho-syntax no longer accounts for individual differences in child conversational ability. This possibility also helps explain the existence of a sub-group of autistic children - albeit slightly older children - who score in the high average to above-average range on morpho-syntax and vocabulary and yet find it extremely difficult to engage appropriately in reciprocal conversation (e.g. Nadig et al., 2010). Thus, future studies are required to unpack the precise relationship between lexico-grammatical knowledge, on the one hand, and appropriate responding in typically-developing children. Certainly, we assume that there is something of a two-way street between conversational development and lexical development in that it is in the context of conversation that we come to learn many words.

In our second study we investigated the role of environmental factors and found that children who started preschool later had an advantage in their *Contingent turns*. A possible explanation for this outcome is the generally high level of socioeconomic status in our sample, as well as in Sweden in general. The fact that the sample consists of families that voluntarily contributed to the longitudinal study on first language acquisition might suggest that the participating parents find language development interesting, and that they are involved in their children's development. These factors could indicate that early high quality input from a parent can aid the ability to be informative in conversation. However, preschool start did not show a reliable relationship with *Appropriate turns*, i.e. the conduct of acknowledging previous turns in general. With this in mind, and due to the complexities in measuring quality of caregiver-infant interaction and quality of daycare, this suggestion needs to be examined further, particularly in relation to possible ways in which language and conversational development could be supported in day care settings.
Finally, in Study 3, no predictors were reliably related to our four tested outcome measures. The children were very young when the imitation test was conducted, namely at 1;0, which is the developmental timepoint when fundamental abilities for understanding and sharing the basic intentions begin to be robustly evidenced (e.g. Tomasello, 2003). One way of investigating this further might be to examine imitational skill, or social cognitive insight more broadly, somewhat later in development – perhaps towards the end of the child's second year – and then assess its relationship to later conversational

ability. Future studies could also utilise imitation tasks which more closely target socio-cognitive motivation (e.g. Dohmen et al., 2013).

Limitations

While the current findings suggest avenues for future research, there are a number of limitations. Although the three studies were carried out with a rich set of available measures, the sample size was limited. The measures of conversation were reasonably ecologically valid and based on painstaking coding with excellent inter-rater reliability, but we currently do not know the test-rest reliability of this measure. When considering the short-term verbal memory measurement, it is important to note that the participants were very young and the measure might reflect knowledge of numbers more than anything else. Finally, adept conversational behavior is culturally normative and this needs to be more thoroughly explored. Studies with participants from a range of cultures will be important for understanding to what extent these results are generalizable.

Conclusion and future research

We asked which child-internal and environmental factors are related to four types of conversational behaviour when responding to an interlocutor. In line with previous findings from the literature on autistic conversation, as well as from child pragmatic development more generally –, directly-assessed receptive vocabulary was found to be a positive predictor for appropriate responding, in terms of acknowledging the turns of one's interlocutor, and a negative predictor for missing turns, i.e. not responding at all. However, neither expressive grammar nor early parent-assessed vocabulary were reliable predictors for any of the four conversational behaviours. Thus, the role of lexico-grammatical knowledge in conversational development is worth exploring further in order to understand which competencies are important limiting factors during 'live' conversation and why (e.g., due to benefits from processing speed, or depth of semantic networks, or some third variable). Contrary to what we predicted, child age when starting preschool showed a *positive* relationship with responses that further the topic of the conversation, but no reliable relationship was found with acknowledging previous turns in general. This can suggest the home environments of the children studied may have been beneficial in supporting parts of early language and communication skills (at least when observed in interaction with an adult). This needs to the explored further with respect to the quality of the home and pre-school environments. Finally, although we explored some longitudinal measures from infancy, such work would need to be done with a larger sample and better measures if one were to be certain of developmental trajectories over this time span. Overall, this preliminary exploratory study suggests an important role for lexical comprehension in responding appropriately to others. It also suggests that caregiving arrangements might influence children's conversational contingency in ways we did not initially expect, and that warrant further investigation . Future longitudinal and experimental

studies with larger sample sizes should explore the pathways that may explain such relations.

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Data and script availability statement

The anonymized datasets (CC_data_210129.csv and CC_log_data_210104.csv) and the R-script for the statistical analyses (CC_full-script_210607.R) are available at https://osf.io/ah23m/.

Ethics approvals

The collection of the data used in these studies were conducted within the MINT project, The project was conducted in accordance with the regulations of The Swedish Data Protection Authority and The Ethical Review Board at Karolinska Institutet (Dnr 2011/955-31/1) and The Personal Data Act (1998:204) and The Act concerning the Ethical Review of Research Involving Humans (2003:460).

Author contribution statement

David Pagmar and Danielle Matthews devised the studies. Kirsten Abbot-Smith, Danielle Matthews, and David Pagmar outlined the rationale for the individual studies, as well as the theoretical basis for individual predictors. David Pagmar carried out the study specific data collection, coded the material, analysed the data and wrote the first draft. All authors contributed to the finalisation of the manuscript and approved the final version.

Acknowledgements

We would like to thank the families who participated, the MINT team for painstaking annotation of the interaction data, Caroline Arvidsson for additional annotation work, Linnea Rask for help with reliabilities, Thomas Hörberg for statistical advice, and Tove Gerholm for helpful comments on the manuscript. All data in this study is part of the MINT corpus, funded by the Marcus and Amalia Wallenberg Foundation (MAW2011.007) and The Swedish Research Council (2018-01135). DM was supported by British Academy grant MD\170025.

APPENDIX A

The variance and standard deviation of the random effects for each full model in Study 1, 2, and 3 in Table A.

Table A. Random effects, based on groupings by participant, in terms of variance and standard effects for the full models in studies 1 (S1), 2 (S2), and 3 (S3).

Model	Variance	SD
S1_contingent	.17	.41
S1_appropriate	.05	.24
S1_non-contingent	.87	.93
S1_missing	.84	.91
S2_contingent	.13	.36
S2_appropriate	.10	.31
S2_non-contingent	.93	.96
S2_missing	.85	.92
S3_contingent	.16	.40
S3_appropriate	.09	.31
S3_non-contingent	.66	.81
S3_missing	.87	.93

APPENDIX B

For all the three studies, each predictor's contribution to the model was evaluated through a likelihood ratio test. Although this analysis was not conducted for model selection, we present the comparative results in terms of AIC values for each run in the

likelihood ratio test. The models in Study 1 are presented in Table B1, the models in Study 2 are presented in Table B2, and the models in Study 3 are presented in Table B3.

Table B1. AIC values from the likelihood ratio test for the models on Study 1. Presented are AIC values for the full model, and for each run with one predictor excluded. The models were compared to estimate the contribution of each predictor: curiosity (CUR), the strength and difficulties questionnaire (SDQ), grammar (GRAM), and receptive vocabulary (PPVT).

Evaluation Run	AIC for Contingent model	AIC for Appropriate model	AIC for Non-contingent model	AIC for Missing model
Full model	3927.5	4878.6	966.92	2624.3
–CUR	3925.6	4876.9	964.95	2622.4
–SDQ	3925.6	4876.6	964.93	2622.5
–GRAM	3926.4	4877.6	965.07	2623.8
–PPVT	3926.6	4889.9	968.00	2626.8

Table B2. AIC values from the likelihood ratio test for the models on Study 2. Presented are AIC values for the full model, and for each run with one predictor excluded. The models were compared to estimate the contribution of each predictor: older sibling (OLD_SIB), preschool hours per week (PR.SCHO_H), age at preschool start in weeks (PR.SCHO_W), and the measure for socioeconomic status (SES).

Evaluation Run	AIC for Contingent model	AIC for Appropriate model	AIC for Non-contingent model	AIC for Missing model
Full model	3920.2	4892.0	967.81	2624.7
–OLD_SIB	3919.6	4890.3	965.91	2623.4
–PR.SCHO_H	3918.9	4891.2	965.83	2623.0
–PR.SCHO_W	3926.9	4891.3	968.18	2625.0
–SES	3918.2	4890.2	966.02	2623.3

Table B3. AIC values from the likelihood ratio test for the models on Study 3. Presented are AIC values for the full model, and for each run with one predictor excluded. The models were compared to estimate the contribution of each predictor: imitation (IMIT), forward digit span (FDS), and parental reported productive vocabulary (SECDI).

Evaluation Run	AIC for Contingent model	AIC for Appropriate model	AIC for Non-contingent model	AIC for Missing model
Full model	3924.3	4889.1	959.74	2623.3
–IMIT	3925.7	4887.4	961.15	2621.9
–FDS	3922.7	4887.2	961.07	2621.6
–SECDI	3922.3	4890.1	957.79	2624.8

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