Ontogeny of Teaching Behaviour in Early Childhood:

What Type of Information Do Young Children Transmit to Others?

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Thesis Abstract

Children effectively acquire knowledge from others and transmit the knowledge that they possess to others around them. Even though children's abilities as active learners have been investigated vastly, research on children's role as active transmitters of information remained scarce. This thesis explored the role of children, especially in the first two years of life, as active transmitters of information. The first chapter reviewed the literature on the development of teaching behaviour and factors influencing children's information transmission, focusing on the types of information young children choose to transmit. The second chapter investigated if toddlers preferred to transmit generalisable information. The findings of this study showed that a preference for transmitting generalisable information was not yet observed in toddlers. The third chapter examined how the method of learning about novel objects affected 2-year-olds' and 5-year-olds' transmission of information to a naïve learner. Results showed toddlers preferentially transmitted information they were taught, unlike 5-year-olds. The fourth chapter analysed home videos of infants aged 13 to 23 months to document natural information-transmission behaviours, revealing an increase in such activities from 13 months. The final chapter discussed the main findings from the studies reported here and evaluated how these findings fit with our current understanding. Combined, these findings provided useful insights on the role of information generalisability, learning context and early communicative interactions on the development of information transmission in early childhood. Overall, this thesis aimed to contribute to the conceptualisation of teaching as an information transmission mechanism embedded in social interactions.

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Well, here we are. It really does take a village to complete a thesis on toddlers' information transmission! I know it is customary to acknowledge the efforts of people involved in the process, but this thesis indeed would not be what it is today without some very important people.

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Declaration

I declare that the work presented in this thesis has not been submitted, in whole or in part, for the award of a higher degree at this or any other university. I further declare that this thesis is a product of my own work which was conducted and completed under the supervision of Professor Gert Westermann and Dr. Marina Bazhydai.

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Didar Karadag, Marina Bazhydai, Gert Westermann

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Through signing this statement, the Co-authors agree that:

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(b) The student can incorporate this publication within the thesis
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Prof. Gert Westermann

Dr. Marina Bazhydai

Thesis Structure

This thesis is structured as follows:

The first chapter is an introductory chapter that summarizes and critically reviews previous research conducted to study information transmission from infancy through middle childhood.

The second chapter includes the first experimental study that constitutes this thesis. This chapter focused on the role of information generalisability on 2-year-old children's information transmission. This chapter was designed as a Registered Report and is now published in *Developmental Science*. This chapter is presented in the form that it was published.

The third chapter includes the second experimental study that constitutes this thesis. This chapter focused on the role of learning context on 2- and 5-year-old children' information transmission. This chapter was submitted to *Child Development*, received a "revise and resubmit" decision and is currently under the second round of the review process. This chapter is presented in the form it was last submitted to the journal.

The fourth chapter includes the third experimental study that constitutes this thesis. This chapter examined the communicative interactions, with a focus on information giving interactions, of 13- to 23-month-old children in their natural home settings. This paper is currently being prepared for submission to *Infancy*. This chapter is presented in its current form.

The final chapter is the general discussion section that brings together the findings of all experimental studies presented in this thesis and proposes theoretical explanations and methodological considerations spanning across all presented empirical work.

References for Chapter 1 and Chapter 5 are presented at the end of the thesis in the form of a consolidated bibliography. References for Chapters 2, 3 and 4 are presented at the end of each chapter. Similarly, supplementary information and appendices for each chapter are also presented at the end of each chapter.

To acknowledge the collective theoretical and methodological intellectual contributions in Chapters 2, 3, 4, I report the studies using the first-person plural voice. In Chapters 1 and Chapter 5, I report the literature and findings in the first-person singular voice.

The experimental studies comprising this thesis are in preparation for publication, under review or were published in academic journals and presented at scientific conferences:

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2. **Karadağ D**., (2022, April). *What do toddlers and children teach? How they learnt matters!* Paper presented at the Lancaster University Faculty of Science and Technology (FST) Science Week 2022, Lancaster, UK.
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7. **Karadağ, D.,** Bazhydai, M., & Westermann, G. (2022, July). *Toddlers' selective information transmission: Pitting self-discovered information against instructed information.* Poster presented at the International Conference of Infant Studies (ICIS), Ottawa, Canada.
8. **Karadağ D**., Bazhydai, M., & Westermann, G. (2021, August). *Young children's selectivity in teaching: Do toddlers and school age children prioritize the same type of information when they transmit information?*

Poster presented at the 6th Lancaster Conference on Infant and Early Child Development, Lancaster, United Kingdom.

9. **Karadağ, D**., Bazhydai, M. & Westermann, G. (2020, August). *Children as active teachers: Do toddlers transmit generalisable or specific information?* Poster presented at the 5th Lancaster Conference on Infant and Early Child Development, Lancaster, United Kingdom.

1. Chapter 1: Introduction

Humans are born into complex social environments in which they are constantly surrounded by people caring and providing for them in many aspects. Compared to other non-human animals, human infants' maturation into fully functioning individuals comes quite later in the lifespan (for a review, see Geary & Bjorklund, 2000). From their first moment in life, they start learning about the outside world through their own observation and experiences (e.g., Akthar et al., 2001; Meltzoff, 1988; Waismeyer & Meltzoff, 2017). As they become older, the information they need in order to adapt to their social environment becomes more complex and abstract. This type of information often poses a challenge for the learners because it is mostly difficult to acquire through first-hand observation of or experiences with the world for several reasons. For instance, the information might be related to unobservable phenomena that cannot be obtained through physical observation of the world (e.g., the force of gravity, or viruses), might be dependent on the cumulative progression of information over time (e.g., the knowledge that the current advanced computing technologies were initially inspired by tally sticks), or simply it might not be readily available for the learner in their immediate environment but might be available somewhere in the world (e.g., a specific ritual that is performed by a specific community). In these cases, humans often turn to social partners around them to obtain information (Harris, 2012).

Even infants are quite skilled at seeking information from the information sources around them and they successfully navigate their own learning in line with what they wish to learn (e.g., Smith et al., 2018; Wang et al., 2012). They actively seek information from others through using gestures such as pointing (e.g., Begus et al., 2014; Begus & Southgate, 2012; Kovacs et al., 2014), giving and hold-out gestures (Boundy et al., 2016, 2019; Karadağ et al., 2024b). They look for informative cues from social others (e.g., Bazhydai et al., 2020; Schmitow & Stenberg, 2013; Tamis Le-Monda et al., 2008), ask questions (e.g., Chouinard et al., 2007) and seek explanations (e.g., Frazier et al., 2009, Liquin & Lambrozo, 2020) (for reviews, see Begus & Southgate, 2018; Harris et al., 2018; Ronfard et al., 2018).

Similarly, and importantly for this thesis, young children also take an active role in the transmission of information. Infants can track their own as well as others' epistemic states (e.g., Bazhydai et al., 2020; Liszkowski et al., 2006; O'Neill, 1996; O'Neill & Topolovec, 2001), identify others who know less than themselves (e.g., Liszkowski et al., 2008; O'Neill, 1996); preschool-aged children from 4 years onwards can reason that teaching is an intentional communicative act that might influence others' knowledge states (e.g. Jeong & Frye, 2018; Ziv et al., 2008) and should be directed to individuals who need it (Ziv & Frye, 2004), and actively transmit information to others (see Brandl et al., 2023; Gweon, 2021, Strauss & Ziv, 2012 for reviews). In the following section, I will provide a brief overview of key concepts that are crucial for the study of information transmission in children.

1.1. Key concepts, definitions, and different paths to information transmission

Research on information transmission has predominantly focused on teaching in preschool-aged children, asking whether they understand what teaching is, whether they teach others regardless of their own understanding of teaching, how they teach others -what strategies they use-, and whether their teaching is selective based on different cues such as to whom and what they teach. While these studies provide important insights into the information transmission abilities of children, they have not provided a picture of the developmental trajectory of this behaviour mostly because they focus on "teaching" as a higher-level ability without considering the developmental precursors to this ability.

In the past, there have been several attempts to define teaching and investigate this behaviour across different taxa (Thornton & Raihani, 2008, see Kline, 2015 for a review). Caro and Hauser (1992) provided one of the earliest and most prevalent definitions of teaching that has been commonly referred to in studies that investigate teaching in non-human animals. They constructed a working definition of teaching where the teacher, as the knowledgeable individual, alters their behaviour only when there is an uninformed individual. This process potentially incurs some costs to the teacher in addition to not benefiting the teacher in the first place, whilst the pupil obtains information which otherwise would be hard to acquire (Caro & Hauser, 1992). Subsequently, many different definitions of teaching, focusing on different aspects of cognition, have been proposed to study the emergence and development of teaching behaviour in humans. However, we have yet to reach an agreement on how teaching should be defined, and which behaviours should be considered as acts of teaching (Pasquinelli & Strauss, 2018).

On the one hand, some view teaching as a complex cognitive ability which requires intentionality, an ability to represent others' minds as well as a social motive (e.g., Calero et al., 2018; Strauss & Ziv, 2012; Strauss et al., 2002; Premack & Premack, 2003, Gweon, 2021, Qiu & Moll, 2022). On the other hand, others acknowledge information transmission behaviours that do not require complex cognitive abilities as simple forms of teaching (e.g., Caro & Hauser, 1992; Fogarty et al., 2011; Thornton & Raihani, 2008; see Pasquinelli & Strauss, 2018, for a review).

Empirical findings show that both types of information transmission behaviours are evident in children. For instance, the information transmission behaviour displayed by infants such as pointing to the location of objects unknown to another agent (e.g., Liszkowski et al., 2006, 2008) is often viewed as a simple form of teaching due to the episodic nature of that information (Strauss & Ziv, 2012; Strauss et al., 2014) and not relying on the ability to represent others' minds (Pasquinelli & Strauss, 2018; Strauss & Ziv, 2012) which is considered a key aspect of teaching in older children (Corriveau et al., 2018; Davis-Unger & Carlson, 2008a, 2008b; Strauss & Ziv, 2012). In contrast, older children engage in complex forms of teaching such as providing contingent feedback to their pupils (Ziv et al., 2008), and make selective decisions when deciding what and whom to teach (e.g., Asaba & Gweon, 2018, 2022; Bridgers et al., 2020; Karadağ & Soley, 2023; Kim et al., 2015, Qiu et al., 2024a).

Taken together, it becomes difficult to come up with an approach that encapsulates necessary requirements for "teaching" as well as for criteria that distinguish it from the variety of transmission behaviours displayed by humans. This brings up many questions. For instance, is “teaching” one of the different ways of transmitting information? If so, what makes an information transmission event “teaching”, then? Is it the motivation that drives this behaviour, the type of information transmitted, or the complex cognitive architecture that enables information transmission in the first place? Furthermore, how does “teaching” develop? Or at which point in the developmental trajectory can we categorise interactions that function to transmit information as “teaching”? The relative scarcity of research on information transmission in infancy and toddlerhood prevents us from providing satisfactory answers to these questions simply because of the differences in socio-cognitive capabilities in infants, toddlers, and children. What is considered as “teaching”, or the abilities considered as the prerequisites for teaching in children might not apply to infants and toddlers. However, this does not mean that younger children lack the capacity to transmit information.

Thus, this thesis set out to investigate the early manifestations of information transmission in infants, toddlers, and 5-year-old children with the intention of providing some clarity for understanding the developmental trajectory of information transmission. With this aim in mind, in this introductory chapter, I will first provide a review of findings regarding the study of teaching in humans; then I will delve into the children’s role as information transmitters in the knowledge exchange process, and the factors that might potentially influence this process.

In this thesis, I employ a comprehensive perspective on information transmission, delineating instances of knowledge transfer from one party to another through behavioural adjustment, especially when the recipient lacks immediate access to shared knowledge. I interchangeably use terms such as "knowledge transfer," "information sharing," "information transmission," “information giving”, and "informing" to encompass the inclusive approach provided earlier. My aspiration is that at the end of this thesis, we will be one step closer to unravelling the intricacies of children’s information transmission.

Additionally, I refer to complex and sophisticated information transmission displayed by children older than 4 years who have established capacities for developed Theory of Mind (ToM), executive function (EF), and social and normative understanding as “teaching” following previous definitions that include intentionality, explicit other-oriented reasoning, and pro-social motivation to help (Strauss & Ziv, 2012; Strauss, 2022). However, I use the term “information transmission” when I refer to knowledge transfer events observed in younger children aged between 1 to 3 years old in order to avoid making rich assumptions regarding the cognitive capacities that may not be necessary for the emergence of information transmission (Bazhydai & Harris, 2020) but required for high-quality and complex knowledge transfer (Corriveau et al., 2018).

In the following subsections, I will first provide an overview of how information transmission was previously studied. First, I will briefly mention the characteristics of human teaching as it is discussed in the previous literature. Then, I will move to studies that investigated child-led information transmission which will be followed by children’s selectivity in information transmission and the factors that influence this selectivity. Finally, I will focus on explaining some of the challenges associated with studying information transmission in young children and will provide the scope of the current thesis.

1.2. Adult-led Information Transmission

In this section, I will provide a brief overview of adult-led teaching in non-human and human species. The study of teaching -as a mechanism for transferring knowledge within and across generations - in humans and non-human animals mainly focuses on the vertical information transmission activities led by adults. Regardless of how information transmission is defined, or whether we focus on human or non-human information transmission, the frequency of adult-led interactions is more prevalent.

In non-human animals, adult-led information transmission tends to be more limited in forms such as demonstrating how to handle prey, use tools and execute certain calls (Hoppitt et al., 2008; Thornton & Raihani, 2010). Here, “teaching” usually concerns the transmission of useful information to offspring with a functional intention, such as finding food as observed in many animal species, that is paramount to survival (Kline, 2015). For instance, wild meerkats teach their pups how to hunt by following a multi-stage process that starts with giving them dead prey to handle, continues with providing them with live prey that is disabled to avoid harm to the pup, finalises by providing live prey under close supervision (Thornton & McAuliffe, 2006).

Teaching in humans has been investigated widely in different domains of research from archaeology (Gardenfors & Höhberg, 2017; Högberg et al., 2015) to anthropology (e.g., Boyette & Hewlett, 2017; Hewlett & Roulette, 2016; Kline et al., 2013; Lancy, 2010, 2017), to psychology (e.g., Brezack et al., 2021; Bohn et al., 2024; Köster et al., 2022; Rogoff, 2003; Rogoff et al, 2016). When teaching comes to mind, we tend to think about the concept of formal teaching that happens in highly structured education environments following a predetermined curriculum. While currently, this constitutes a large amount of teaching experience, it is a quite recent development in human history (Högberg et al., 2015). Indeed, most knowledge-transfer and teaching-like activities occur informally and may not always be explicit (Rogoff et al., 2016).

Following the broader definition of information transmission employed in this thesis, adult-led information transmission in humans can take many different forms: from providing labels of objects’ names, showing how objects work, allowing participation in daily chores, asking pedagogical questions, correcting mistakes and providing formal instruction. In a recent study, Köster and colleagues (2022) observed parental teaching events during mealtime using a taxonomy of six common teaching behaviours previously identified by Kline (2017) (i.e., requests to do, requests to stop, abstract communication of knowledge, demonstrations, provision of choices and negative feedback) across 5 different cultural settings (urban settings in Germany, Japan, Argentina; rural settings in Brazil and Ecuador). They found that across all cultures, parents used these different teaching behaviours to transmit meal-related knowledge to their children. Nevertheless, there were crucial cross-cultural differences in how frequently they used each method. For instance, whilst parents in rural contexts used prompts to encourage certain behaviours; parents in urban contexts used demonstrations and abstract communication more frequently). Similarly, in some cultures, teaching may present itself in a different form than teaching that happens in WEIRD cultures with a strong focus on more informal ways of learning for instance through “observation and pitching-in" (e.g., Paradise & Rogoff, 2009; Rogoff, 2014,2016) and learning by doing (Kline et al., 2013; Tian 2019). Additionally, more recent findings also suggest that exposure to schooling and formal education practices influence the teaching carried out by adults in cultures where they typically learn through informal teaching (see Brandl et al., 2023 for review).

In summary, previous research shows that information transmission led by adults is common across the human and non-human species and takes different forms from very simple interactions to institutionalised practices. What remains less clear is the developmental origin of this behaviour. In the following section, I will delve into the literature on child-led information transmission.

1.3. Child-led information transmission

While the idea of children sharing information with others, whether their peers, younger children or adults, is not new, the study of child-led teaching has received attention only in the past couple of decades in the developmental psychology literature. Here, I aim to provide an overview of the findings on children’s understanding of teaching, and teachers, their own active information transmission from infancy to childhood as well as the factors that influence children’s information transmission to others such as the extent to which they provide tailored instructions depending on different characteristics of their learners as well what information they share with others during these interactions.

1.3.1. Children’s understanding of teaching and expectations about teachers.

Children start explicitly reasoning about teaching developmentally early, and view teaching as a process leading to a change in the knowledge levels of individuals (Sobel & Letourneau, 2016; Wood et al., 1995; Ziv & Frye, 2004). Sobel and Letourneau (2016) conducted a study with 4- to 7-year-old children to document how children reflect on their and others' teaching. They asked children what they think teaching is and encouraged them to exemplify cases in which someone taught some information to them and cases in which they taught some information to someone. The authors aimed to understand whether children consider their experiences of teaching and being taught as a basis for their own understanding of teaching and whether children define teaching as a process that leads to a change in the learner's knowledge (Sobel & Letourneau, 2016). The results of the study showed that even though 4- and 5-year-old children could not come up with a verbal definition, they held a rudimentary understanding of teaching behaviour; on the other hand, 6- and 7-year-old children described teaching as process at the end of which a change in learner's knowledge occurs (e.g., "Someone teaches you how to do something that you don't know how to do" p. 114) and referred to the content of teaching (e.g., "To show kids about different things like math and science", p. 114). Additionally, children provided examples of different types of information others taught to them or they taught others (e.g. "My dad taught me about electricity", "how to spell a word", p. 114) and they explained how information was transmitted in these events such as through direct instruction (e.g., "My mom explained me about multiplication and adding", p. 114), demonstration ("He showed me how to swim and not to sink; he showed me how to kick my feet like this on my belly" p. 114), or helping/providing guidance (e.g., "She [mother] was helping me draw because I didn't know how to draw yet" p. 114). Sobel and Letourneau (2016) concluded that even though children are not able to make explicit statements about teaching during their preschool years, they have an early understanding of what "teaching" is, how information is transmitted, and what it conveys; and this understanding becomes sophisticated only after the preschool years (Sobel & LeTourneau, 2016).

Similarly, it was argued that preschool- and school-aged children also hold some early expectations regarding "teachers". They expect that knowledge is required to be a teacher, and teaching should be directed to the less knowledgeable person (e.g., Bensalah et al., 2012; Ziv & Frye, 2004, Ziv et al., 2016, but also see Kim et al., 2015), expect teachers to be helpful and informative, to provide necessary and complete information (e.g., Gweon et al., 2014; Gweon et al., 2018), and to selectively tailor their teaching according to their learner's needs, goals and maturity level (Bridgers et al., 2020, Gweon & Schulz, 2019, Qiu et al., 2024a, for a review, see Gweon, 2021).

Taken together, while children older than 4 years of age seem to have a developed understanding of teaching as a means for information transmission and display certain expectations regarding teachers, we lack knowledge on whether this representation of teaching is available earlier in development simply because the methods used in these studies rely on complex cognitive skills that younger children might arguably lack such as a fully developed ToM (Kulke et al., 2018, 2019; Poulin-Dubois et al., 2018) or language skills.

1.3.2. Developmental trajectory of direct active teaching

Children transmit information in several ways which can be as simple as the use of a single gesture (e.g., Liszkowski et al., 2006, 2008, Meng & Hashiya, 2014, Knudsen & Liszkowski, 2012) or as complex as providing feedback in response to the learner's behaviour (e.g., Davis-Unger & Carlson, 2008a, 2008b). Several findings in gesture research have provided a basis for understanding early behaviours relevant to information transmission (Bates, et al., 1975; Boundy et al., 2019; Karadağ et al., 2024b). Infants, before starting linguistic communication with others, use gestures such as showing (e.g., holding out objects to call social partner's attention), offering (e.g., replacing some objects closer to the social partner), and pointing (e.g., index finger pointing to an entity) to initiate communicative interactions with their social partners (for reviews, Bates, 1976; Boundy, 2018). Among these prelinguistic communication tools, showing and offering gestures (Boundy et al., 2019) have been evaluated as precursors to the pointing gesture which has been proposed to have several communicative functions (e.g., Bates et al., 1975; Begus & Southgate, 2012; Liszkowski et al., 2006, 2008; Tomasello et al., 2007) including informing (e.g., pointing to inform others about things they do have visual access to, Liszkowski et al., 2006, 2008). Even though showing and giving gestures might also come in handy in transmitting information to others, except in a recent study (Karadağ et al., 2024b), only pointing gestures have been investigated concerning their use by infants to transmit information.

In the first two years of their life, infants and toddlers can identify individuals who know less based on perceptual access (Liszkowski et al., 2006, 2008; O'Neill, 1996) and exhibit an initial form of teaching behaviour that is referred to as "proto teaching" (Strauss & Ziv, 2012; Strauss et al., 2014). Upon observing an adult failing to locate an object, 12- and 18-month-olds inform the adult by pointing to the location of the object (Liszkowski et al., 2006, 2008). In a similar vein, 13- to 18-month-old infants and toddlers selectively communicated about a novel object that was introduced in the absence of the experimenter, despite having shown similar interest in both the novel and the familiar object (Meng & Hashiya, 2014). In another study, 12- to 20-month-old infants and toddlers either corrected an adult who misplaced a puzzle piece in a wooden puzzle through demonstration or led them to correct their own mistake through pointing (Akagi, 2012). Strauss and colleagues (2012, 2014) refer to these behaviours as proto-teaching because the information transmitted during these teaching episodes is mainly about episodic knowledge and, thus, may not be possibly generalisable across other situations.

At around two years, children transmit both episodic information (e.g., transient locations of objects) and generalisable information (e.g., functions of objects) (Bazhydai et al., 2020; Flynn, 2008; O'Neill, 1996; Vredenburg et al., 2015, but see also Ashley & Tomasello, 1998). For instance, young children demonstrate actions that they have been previously taught, to naive recipients (Bazhydai et al., 2020; Vredenburg et al., 2015). In another study that used diffusion chains methodology (i.e., a design in which individual A trained on a specific task transmits this information to individual B who, then, transmits the information to individual C, forming a transmission chain with each repetition), it was shown that 2- and 3-year-old children transmit only relevant actions to retrieve a reward from a puzzle box across individuals (Flynn, 2008).

Starting from age 3, children's information transmission becomes more evident. After learning a novel board game, when asked to teach this game to someone who does not know this game, 3- to 5-year-old children readily teach how to play this game; however, how they teach and the strategies they use differ: young children tend to teach the game by solely relying on demonstrations without giving any explanation or reference to the rules, whereas older children use more explanations, incorporate these explanations into their demonstrations, give more explicit reference to game rules, become more responsive towards the learner to make the information more accessible, such as through reiterating the game's rules or asking whether the learner understood the rules (Strauss et al., 2002). Another study that tested a similar age group (3.5, 4.5, & 5.5 years) with a similar design found that as children get older, they engage longer in the teaching activity, teach more comprehensively (e.g., teaching more rules), use more diverse strategies (e.g., demonstrations, verbal explanations, rule-reminders, supplementary teaching such as giving examples relevant to the task), become more receptive to the learner's mistakes and try to use different methods depending on the mistakes made by the learner (Davis-Unger & Carlson, 2008a).

Unlike information transmission behaviour displayed by infants and toddlers such as showing functions of objects or pointing to the locations of objects, the transmission strategies used by older children such as modifying strategies based on the learner's progress or lack thereof, indeed require more complex cognitive architecture. Nonetheless, it should be noted that the complexity and sophistication of older children's teaching do not necessarily require these cognitive mechanisms to be in place in infancy and toddlerhood for them to be able to transmit information appropriately.

1.3.3. Cognitive mechanisms enabling successful information transmission

Different theories proposed different prerequisites for the quality of teaching behaviour such as joint attention and shared intentionality, ToM, metacognition, EF, information appraisal, reinforcement learning, prosocial motivation to teach, and language for good quality teaching (e.g., Brandl et al., 2023, Davis-Unger & Carlson, 2008a, 2008b; Gweon 2021; Kruger & Tomasello, 1996; Qiu & Moll, 2022;

Strauss et al., 2002). Whereas some of these cognitive processes such as ToM, shared intentionality or prosocial motivation were considered at the heart of the development of children's teaching (e.g., Ashley & Tomasello, 1998; Strauss et al., 2002; Qiu & Moll, 2022; Moll, 2020; Wood et al., 1995), others have acknowledged that despite their necessity for effective teaching, they are not necessarily prerequisites for the emergence of teaching (Corriveau et al., 2018) or are not unique to teaching (Brandl et al., 2023). Relatedly, infants do not necessarily need to have developed ToM skills to be able to appropriately transmit information to others. For instance, an infant can inform a parent about an object they previously engaged with and that fell off the table in their absence by pointing towards that object in their presence. In an interaction like this, the infant would have transferred knowledge that was not immediately accessible to the parent; however, this interaction would not necessarily require the infant to reason about the parents' knowledge state or desire to learn about an object's location. Proto-metacognitive awareness regarding their own information states, simple behaviour-tracking mechanisms (such as tracking visual access to information), or a motivation to be social rather than prosocial might suffice for infants to provide relevant information. On the other hand, older children's teaching benefits heavily from advanced cognitive skills, for instance, children who have better theory of mind skills tend to be more efficient teachers (Jeong et al., 2016) or they might be better able to tailor the information to the learner's needs (Gweon 2021).

One way to combine these theoretical stances is to view teaching as an information transmission mechanism that emerges from communicative interactions through simple information giving which becomes more sophisticated as children develop and reliably acquire more and more socio-cognitive abilities. Strauss and Ziv (2012) have previously provided a taxonomy of teaching. In their taxonomy, simple forms of information transmission observed in infants and toddlers are different from the teaching of older children. While they do not consider these behaviours as teaching due to the episodic nature of information transmitted, they view these as a precursor to teaching – or proto-teaching. This is followed by what they call as emergent teaching when children start transmitting generic or generalisable information such as transmitting rules of a game, showing how objects function and also considering the mental states of the recipients. Final stage of this taxonomy is called systematic contingent teaching which is the closest to the teaching behaviour displayed by adults (Strauss & Ziv, 2012). While their approach provides a relatively solid framework for the developmental study of teaching, I believe it overestimates the role of information generalisability as well as mind-reading skills for the emergence of teaching behaviour.

In line with my critique, Brandl and colleagues (2023) proposed an alternative view which evaluates teaching as a culturally evolved trait – a set of skills and practices developed and refined in relation to social interactions and cultural evolution – and argues that reasoning about mental states of the recipients is not necessarily central for teaching to emerge particularly in initial phases. Brandl and colleagues (2023) highlight the role of domain-general cognitive mechanisms such as EF (e.g., working memory, error detection and correction, attention, inhibition) and reinforcement learning, and other psychological mechanisms associated with the development of prosocial behaviour when children acquire teaching competencies. In this perspective, children's ability to teach is likely shaped by their social interactions with caregivers where they are habitually exposed to teaching-like behaviour. Depending on their cultural contexts, these teaching-like behaviours might involve using gestures and child-directed speech, making eye contact with the children. With the contribution of children's attentional biases towards social others, this process might draw children to these teaching-like interactions. Across different cultures, as part of their early "education" children are involved in engaging with different objects that the adults use, completing simple chores and being encouraged to follow simple instructions. As children grow older, the tasks that children complete becomes more complex requiring more sophisticated -and likely costly- forms of teaching such as providing detailed demonstrations and explanations. Using these experiences, children start practicing teaching-like behaviours they observe, whilst adapting their approaches depending on their interactions with peers. During this process, young children may adjust their teaching based on how the learners react to and other's explicit feedback on their teaching; however, this would not necessarily require more than basic cognitive abilities such as EF and reinforcement learning as mentioned at the beginning. (Brandl et al., 2023).

In conclusion, I believe that while teaching as a mechanism for information transmission can be viewed on a continuum similar to the taxonomy provided by Strauss & Ziv (2012), children may not need sophisticated cognitive capacities to be able to teach and even display relatively more complex forms of teaching. However, as they get older, they might employ ToM skills to deliver more specialized teaching tailored to the needs of the learners. In the following section, I provide an overview of the different ways in which children transmit information to others.

1.3.4. Children's information transmission patterns

Information transmission can be a costly (I operationalise "cost" as any extra effort put in) activity with no immediate pay-off for the teacher, thus, leading "teachers" to be selective about when one should make an effort to transmit information to others. This decision can be motivated by considering two main actors in this process. The most apparent actor that would benefit from a potential teaching activity is the learner; however, while it is less intuitive, the teacher can also benefit from their effort to teach which might eventually influence when information is more likely to be elicited from the teacher. Regarding the former actor -the learner-, more traditional approaches suggest that child teachers' decision to teach is other-oriented and driven by a social motive to attend to the needs of the learners (e.g., Strauss et al. 2002; Strauss & Ziv, 2012; Gweon, 2021; Moll, 2020). Following this, teachers would provide information when they notice a knowledge gap between the learners and themselves either when they observe that the information will be too difficult and/or too costly for them to learn on their own, or when the teacher decides that the learner should know particular information for some reason (similar to paternalistic helping, Martin & Olson, 2013).

Regarding the second actor -the teacher-, information transmission might or might not occur as a direct result of its benefit or cost or lack thereof to the teacher rather than the learner. Teachers might choose to teach when they think that it might benefit them somehow. For instance, a recent study showed that preschool-aged children might give up the chance to provide novel information to a naïve learner for the opportunity to show off their own abilities (Asaba & Gweon, 2022). On the other hand, when information is too costly to teach another person, it is possible that teaching might not occur. Imagine a situation where one needs to describe a complex action sequence to activate an object to someone who has never seen that object or that action sequence. While delegating the task to a novice by teaching them how to do it might be beneficial in the long run, if it is too bothersome for the teacher, they might choose to not teach it. Similarly, if the teacher thinks that the information can be learned through reasonable self-effort, then, regardless of the relative difficulty of the information, thus the cost of learning, for the learner, the teacher might pass on the decision to teach just because it is costly for them to teach. Taken together, children seem to evaluate different factors to decide when their effort to transmit information is required. In the following section, we will provide a summary of the reasons behind children's selectivity in transmitting information to others, as well as the factors that might influence this selectivity. Specifically, we will focus on whom they transmit information to and which information they choose for transmission.

1.4. Children’s selectivity in information transmission

Children’s selective decisions about information transmission become multifaceted with age. They not only decide when to share information but also with whom to share and what information to share with them. It is established that transmitting information to others might be costly and time-consuming (though this does not have to be the case). Thus, efforts to share information should not be taken lightly. When children themselves learn from others, they tend to select more knowledgeable, reliable, and accurate informants as their teachers and their selectivity is driven by the epistemic potential of the informants (Harris, 2012). However, epistemic concerns are only half of the story, because children also consider the social attributes of their teachers such as their group membership (Corriveau et al., 2013; Elashi & Mills, 2014; Terrier et al., 2016), their familiarity (Corriveau & Harris, 2009a; Danovitch & Mills, 2014), their physical and personal characteristics (Bascandziev & Harris, 2014; Castelain et al., 2016; Johnston et al., 2015; Lane et al., 2013), and prefer to learn from some informants over the others. Additionally, when epistemic characteristics and social attributes of the informants are pitted against each other they can navigate their learning in a nuanced way. For instance, they prefer to learn from more knowledgeable sources with negative social characteristics as opposed to less knowledgeable sources with positive social characteristics (See Tong et al., 2019 for a review).

Building on this, previous research also shows that children can explicitly reason about both the learning and teaching processes as they relate to the knowledge exchange process (Sobel & Letourneau, 2015, 2016). Thus, this early understanding might support that children's selectivity in learning could also be reflected in their teaching behaviour as they can represent the different properties or characteristics of the interlocutors in a knowledge exchange process. Following this, they can be selective when they take the role of teachers.

1.4.1. Recipients of information transmission

Selectivity in children's teaching concerning whom they teach can be approached in two dimensions: firstly, through the choice of learners with diverse epistemic or social attributes, and secondly, by determining the scope of teaching aimed at specific individuals – deciding what information and how much information are transmitted. Recently studies have found that children's selectivity in teaching, similar to learning, is motivated by both the epistemic states and the social attributes of the learners. In a study, Ziv and Frye (2004) found that 3- to 6-year-old children expected that teaching should be aimed at pupils who are ignorant or less knowledgeable. Even 12-month-old infants have been shown to selectively point to inform ignorant rather than knowledgeable adults (Liszkowski et al., 2008).

While considering the epistemic states of the learners is useful in allocating the cost of sharing information with others, children's selectivity regarding the knowledge states of learners, favouring the ignorant recipients, has not been well-supported. For example, in a study children aged between 3 and 6 years were informed that one puppet was familiar with a game while another puppet had never encountered the game before. When questioned about which puppet possessed knowledge about the game, the children accurately identified the knowledgeable puppet. However, they did not show a preference for teaching the puppet that lacked knowledge of the game over the puppet that was already familiar with it (Ronfard et al., 2015). Further, Kim and colleagues (2016) paradoxically found that 3- to 6-year-old children selectively chose more knowledgeable learners to share new information with them; indeed, they rarely chose less knowledgeable or ignorant learners even when they were explicitly told that these learners were ignorant. These results might seem counterintuitive at first given that teaching is considered as a remedy for lack of knowledge. The authors, while acknowledging the surprising findings, provide plausible explanations with respect to the surprising pattern observed in children's behaviour. They proposed that this pattern could indicate a tendency to associate with more prestigious social partners (such as more skilled or knowledgeable). This interpretation is interesting in two ways: first, it points to the possibility that children might consider epistemic states of other individuals as part of their social attributes (knowledge = social power, prestige, dominance, desirability); second, children's motivation to teach to globally knowledgeable individuals might reflect their epistemic expectations such that sharing knowledge with such person might have a better pay off in the form of receiving more knowledge from them in return.

Besides considering the learner's epistemic states, children also assess various social and personal attributes, including abilities, goals and maturity, when instructing others (Gweon & Schulz, 2019; Qui et al., 2024a). In a recent study, 4- to 7-year-old children were presented with a causally ambiguous toy to uncover its causal mechanism through exploring the toy. Subsequently, they were asked to demonstrate the toy to a naïve observer by considering their goals (Experiment 1): whether they just wanted to observe the effect of the toy (Show condition) or they wanted to learn about how the toy worked (Teach condition) and their abilities (Experiment 2): whether they were introduced as silly (Ordinary learner condition) or smart (Exceptional learner condition). They found that children offered more detailed information to a learner who sought assistance to learn how the toy worked, and when the learner was characterised as silly in comparison to those identified as exceptionally smart (Gweon & Schulz, 2019).

Qiu and colleagues (2024b) provided 5- to 7-year-old children with basic and complex facts about animals, asking them to choose between basic (e.g., “Tigers have tongues”, p.2) and complex information (e.g., “Tigers have black stripes and white bellies”, p.2) to teach either a baby or an adult. The results indicated that 7-year-old children but not 5-year-olds, were more inclined to teach complex facts to adults and simpler facts to babies. Although both age groups initially preferred complex facts, they demonstrated the ability to overcome this preference when the recipient of the information was a baby. Additionally, in another study, 7- to 9-year-olds shared information based on the occupations of the learners, tailoring information considering its relevance to them (Danovitch, 2020).

Finally, some studies suggested that group membership – whether based on invented social categories such as “Daxe” vs. “Fendi” or minimal group membership such as “Orange” group vs. “Green” group – also might play a role in determining the recipients of information transmission in children between 3- to 6 years of age (Karadağ & Soley, 2023). Schmidt et al. (2012) found that in a novel game context, children selectively enforced norms for ingroup members regarding violations of conventional norms but applied norms equally to both ingroup and outgroup members in response to violations of moral norms. In Karadağ and Soley's (2023) study, 5- and 6-year-old children selectively taught conventional rules to minimally formed ingroup members, while instructing moral rules to both ingroup and outgroup members without showing preference for either of them. Taken together, these studies collectively highlight the nuanced ways in which preschool and school-aged children choose whom to teach, considering various factors such as epistemic states, social attributes, group membership, and even the specific goals and characteristics of the learners involved.

1.4.2. Nature of transmitted information

When older children engage in teaching others, they also consider the nature of the information they are transmitting. This assessment involves evaluating different inherent characteristics of information such as its generalisability, veracity, complexity, or social relevance as well as the learning context such as self-explored information or socially acquired information (Ronfard & Harris, 2018). Here, I will briefly review key findings regarding these characteristics as Experimental Chapters 1 and 2 provide more detailed information about the role of information nature in children's selectivity in transmission.

One such key characteristic of information is its generalisability. Generalisability has been considered an important aspect of older children's teaching. In line with this view, from 4 years onwards well into middle childhood, children seem to prioritize generalisable information when they teach others and use more generic language in instructional contexts (Baer & Friedman, 2018; Gelman et al., 2013, Karadağ et al., in prep; Pueschel et al., 2022), and their preference for generalisability remains strong regardless of the content of the information with some exceptions (e.g., when the information is about implicit threat such as snakes or germs) (Karadağ et al., in prep). The findings of these studies despite differing in their methodology and outcome measures, converged suggesting that generalisability might be an important aspect of children's selectivity in transmission decisions.

Building on these findings, some proposed that the hallmark of teaching is to transmit generalisable information (Moll 2020; Strauss & Ziv, 2012), and they categorised infants' and toddlers' behaviour as not teaching but a precursor to teaching because the information transmitted by young children is not generalisable (Strauss & Ziv, 2012). While it is difficult to deny the role of generalisability in teaching, this is not enough to make a clear distinction between the transmission behaviour of younger and older children simply because we do not have direct evidence that younger children do not teach generalisable information. Only a handful of studies showed that 3-year-old children did not show a preference for transmitting generalisable information (Baer & Friedman, 2018; Pueschel et al., 2022); however, these tasks heavily relied on children's language abilities which are still developing at this age. Thus, the lack of preference observed, does not necessarily point to a lack of capacity to transmit generalisable information, or "teaching". It is possible that even younger children can transmit generalisable information if they are tested in age-appropriate paradigms that do not rely on advanced cognitive skills such as language. As a result, investigating the origins of this preference can provide useful insight into how we think about teaching and information transmission.

The veracity of information has also been investigated in the context of preschool children's information transmission. Pueschel and colleagues (2022) found that 4-year-old children, but not 3-year-olds, are more likely to selectively transmit information that is explicitly marked as true compared to information explicitly marked false and ambiguous information (i.e., maybe true or maybe false), and the preference was stronger in the former case. In another study, Qiu and colleagues (2024b) presented 4- and 5-year-old children with sensational and neutral information that was either true or false. They found that when they did not have information about the veracity of the information provided children preferred to selectively transmit sensational information. However, when the sensational information was regarded as "not true" by an expert, children were able to overcome their preference for sensational information to transmit true information instead. These findings together suggest that 4- to 6-year-old children appraise the veracity of information and use this appraisal selectively to guide their teaching decisions.

Other factors that influence children's information transmission include the complexity and social relevance of information. These factors are slightly different from the previous characteristics of information because they were usually studied in the context of how children modulate the type of information they transmit (e.g., socio-conventional vs. moral norms) selectively based on the recipient characteristic such as group membership (e.g., Karadağ & Soley, 2023; Schmidt et al., 2012) or to an audience differing on cognitive maturity based on the complexity of the information (i.e., simple vs. complex) (Qiu et al., 2024a). Other studies that focused on the complexity of the information or the rewards associated with the information usually manipulated the learning context such as whether the information was acquired through self-exploration or other's instruction (e.g., Bridgers et al., 2020; Ronfard et al., 2016). For instance, 5- to 7-year-old children can weigh the costs and rewards of learning through instruction versus exploration to determine the most effective information to teach. Children demonstrate selective transmission of information that is challenging to obtain through self-exploration such as complex (e.g., how to operate a complex toy, Bridgers et al., 2020) or cognitively opaque information (e.g., how to extract stickers from a puzzle box, Ronfard et al., 2016) or information that is more rewarding such as leading to more engaging effects (different coloured lights that rotate) rather than boring effects (music) (Bridgers et al., 2020). Taken together, besides the complexity and social relevance of information, other factors such as the context of learning and the rewards from learning also influence preschool and school-aged children's selectivity when they transmit information. These findings emphasize the sophisticated and multi-faceted nature of decisions children make when they select what information to transmit to others.

1.5. Challenges associated with studying the ontogeny of information transmission

In the previous sections, we provided a detailed review of the findings regarding different aspects of information transmission in early to middle childhood from different aspects. The study of child-led information transmission is relatively recent with the earliest studies on the topic being conducted approximately 30 years ago (e.g., Ashley & Tomasello, 1995; Wood et al., 1996). Despite this fact, the interest in children's role in knowledge exchange has led to the emergence of a theoretically rich and diverse literature on children's active teaching (for reviews, Brandl et al., 2023; Gweon, 2021; Qiu & Moll, 2022; Strauss & Ziv, 2012). Based on these findings, it is well-established that, from 4 years of age, children teach others, they do so in a sophisticated manner, and they continuously modify and tailor their teaching strategies selectively by considering a range of factors. What is missing in this trajectory then is what happens before the age of 4. For instance, if children can already selectively teach generalisable or true information when they are 4 years old but not when they are 3 years old despite being able to teach otherwise, what exactly changes during this transition?

While children may undergo a second socio-cognitive revolution (following the "9-month revolution," Tomasello, 2004), it might also be the case that we simply do not know due to the limited findings - perhaps just a little more than a handful - on younger children's information transmission. When younger children are tested, they are usually assessed using the same paradigms as older children, which may not be appropriate for them (e.g., Ashley & Tomasello, 1995; Baer & Friedman, 2018; Pueschel et al., 2023).

Moreover, emphasizing the role of complex socio-cognitive skills such as fully developed ToM, metacognition, and other-oriented motivation in the study of teaching could pose challenges because these skills are still in the process of developing from infancy through middle childhood. While it may be a good approach to ask a 4-year-old, who likely has some formal and informal experiences with instructional contexts, what it means to be a "teacher", “to teach" or “to pretend to be a teacher," or to provide them with verbal generic information, this would not be as meaningful nor developmentally appropriate in the case of a two-year-old. However, this does not necessarily mean that they lack the concept of information transmission or some early forms of these related cognitive capacities. For example, even though toddlers might not understand the meaning of the words listed above, infants grasp behaviours before representing mental states, enabled by their recognition of recurring behavioural patterns (Ruffman et al., 2023a). These consistent patterns allow them to anticipate future behaviour, acquire mental state vocabulary (such as "want," "like," "know"), and eventually develop an understanding of the mental states that drive behaviour. For instance, "wanting" something might mean acting in a predictable manner around the wanted object, such as showing an effort to obtain that object or smiling when getting it. If toddlers initially interpret these mental state terms as pertaining to a particular behaviour, a more parsimonious explanation would be in terms of precursors to ToM, rather than indicating reaching a full-blown ToM (Ruffman et al., 2023a).

Similarly, if toddlers, who have just started to verbalize, cannot selectively transmit verbal generic information, would this mean that they do not have a concept of generalisability going beyond perceptual similarity, or that they do not perceive this as an important aspect of information to transmit? While both could be true, it might also be because they are being expected to perform tasks that are not yet relevant or applicable to them, and their transmission might be influenced more by generalisability in an action-based rather than language-based task.

Given the emphasis on generalisability and other cognitive capacities for dominant conceptualisations of teaching as an information transmission mechanism in older children, it is crucial to examine the early manifestations of information transmission in infancy and toddlers to have a comprehensive view of the developmental trajectory of information transmission.

1.6. Scope of the current thesis

This thesis reports three empirical studies on early manifestations of information transmission. In Chapter 2, I present the first experimental study that I conducted as part of this thesis. In this chapter, we examined whether toddlers preferentially transmit generalisable information to others. The rationale before this study was to understand the role of generalisable information in guiding children's transmission process. This preference is well established in children older than 4 years of age (e.g., Baer & Friedman, 2008; Gelman et al., 2013; Karadağ et al., in prep; Pueschel et al., 2023); however, there were no findings regarding whether this would be the case for younger children. To investigate this question, we designed an interactional context, where 24-month-old toddlers were presented with non-verbal information that was either generalisable or non-generalisable and were asked to transmit this information to a naïve learner.

In Chapter 3, I present the second experimental study that I conducted as part of this thesis. Here, we examined whether the way 2-year-old and 5-year-old children learned about information would influence their subsequent transmission of this information to a naïve learner. The rationale for this chapter was to understand whether self-led exploration or receiving instruction would influence what children who are at different stages of their development transmit to others. Previous findings investigated the learning context in relation to the complexity of information in older children (e.g., Bridgers et al., 2020; Ronfard et al., 2016), studies with toddlers were mixed showing either preferred previously instructed information (Vredenburgh et al., 2015) or no preference depending on how they acquired information (Bazhydai, Silverstein et al., 2020). Thus, in this study, by using a simple paradigm, we examined whether 2-year-olds and 5-year-olds would show a preference to transmit previously instructed information when all other properties associated with the information were equal.

In Chapter 4, I present an observational study using a secondary data set to investigate whether young children transmit information in interactions with their parents as part of their daily communicative repertoire. Previously, lab-based studies showed that infants as young as 12 months are able transmit information to others (e.g., Liszkowski et al., 2006, 2008); however, there are limited findings regarding how information transmission occurs in children's naturalistic settings (e.g., Howe et al., 2015, 2006) with only few studies including children younger than 4-year-olds as information transmitters in the context of sibling relationships (e.g., Howe et al., 2015; Segal et al. 2018). Thus, in this study, we used a novel coding scheme to document young children's communicative interactions across the second year of life using a cross-sectional data set with three time points (13-, 18-, 23-months) to investigate the prevalence of information transmission in these interactions.

2. Chapter 2: The Role of Information Generalisability in Toddlers' Information Transmission

2.1. Linking Statement

In the following chapter, I provide an investigation of early information transmission in 2-year-old toddlers. Previous studies with children of similar age groups showed that toddlers can transmit information to others through action demonstrations. It is well-established that information generalisability plays an important role in older children's information transmission: from the age of 4, children associate generalisable information with teaching-like contexts and preferentially transmit generic/generalisable information compared to specific/non-generalisable information in verbal tasks (e.g., Baer & Friedman, 2018; Gelman et al., 2013, Pueschel et al., 2023). Here, we designed an action-based task that is not dependent on young children's language abilities. Our focus in this experimental study was to investigate whether they would preferentially transmit generalisable information to others. The findings of this study have both theoretical and methodological implication regarding how information transmission is studied in young children and how it is conceptualised in early development.

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Toddlers do not preferentially transmit generalisable information to others

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Contributions: DK, MB & GW conceived the research question, designed the experiment, DK wrote the original draft, collected, coded and analysed the data; MB & GW provided manuscript revisions and supervision.

Data availability statement: Anonymized data, stimuli demonstration videos, analysis outputs and approved Stage 1 protocol can be accessed on Open Science Framework here (https://osf.io/aqtwr/?view_only=2d97601d25d34f62a0ec99681ad344bb).

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Conflict of interest statement:

The authors declare no conflict of interest.

Toddlers do not preferentially transmit generalisable information to others

Research highlights:

- Young children transmit information to others and do so with some degree of selectivity to a variety of factors.
- Generalisability is an important factor affecting information transmission, and older children tend to associate generalisable information with teaching-like interactions.
- We tested whether toddlers selectively transmitted it to others over non-generalisable information.
- We found that toddlers do not show a preference to transmit generalisable over non-generalisable information.

Keywords

- information transmission
- generalisable information
- cultural information exchange
- teaching

2.2. Abstract

Children actively and selectively transmit information to others based on the type of information and the context during learning. Four- to 7-year-old children preferentially transmit generalisable information in teaching-like contexts. Although 2-year-old children are able to distinguish between generalisable and non-generalisable information, it is not known whether they likewise transmit generalisable information selectively. We designed a Behavioural study to address this question. Two-year-old children were presented with three novel boxes, identical except their colour. In each box, one of two equally salient actions led to a generalisable outcome (e.g., playing a (different) tune in each box), whereas the other led to a non-generalisable outcome (e.g., turning on a light, vibrating the box, or making a noise). In the discovery phase, children had a chance to discover the functions of each box presented one-by-one. Then, in the exploration phase, they were given the opportunity to independently explore all three boxes presented together. Finally, in the transmission phase, an ignorant recipient entered the room and asked the child to show them how these toys work. We measured whether children preferentially transmitted either generalisable or non-generalisable information when they were asked to demonstrate the function of the toys to a naïve adult. We found that children did not display any preference for transmitting generalisable information. These findings are discussed with respect to toddlers' selectivity in transmitting information but also the development of sensitivity to information generalisability.

2.3. Introduction

From very early on, children take an active role in cultural knowledge exchange by actively seeking and transmitting information. Even though there is a myriad of findings regarding children's role as active information seekers, their role as active transmitters of information and the factors that influence their transmission have remained relatively underexplored. Findings suggest that children begin actively transmitting information from infancy, and their transmission is influenced by the type of information that they transmit, among several other factors (for a review, see Ronfard & Harris, 2018). Here, we investigate the role of information generalisability on toddlers' information transmission.

Child-led information transmission is evident from early in life and manifests in several ways, from the simple use of a pointing gesture (e.g., Liszkowski, Carpenter, Striano, & Tomasello, 2006; Liszkowski, Carpenter, & Tomasello, 2008; Meng & Hashiya, 2014; O'Neill, 1996) to providing contingent feedback in response to recipient behaviour (e.g., Davis-Unger & Carlson, 2008). After observing an adult looking for an object, 12- and 18-month-old infants point to the object location to inform the adult about its place (Liszkowski et al., 2006; Liszkowski et al., 2008). At 24 months, children transmit information to naïve recipients by re-enacting the actions that they were previously taught (Bazhydai, Silverstein et al., 2020; Vredenburgh et al., 2015). Starting from 3 years of age, children use spontaneous demonstrations and verbal expressions to correct others' mistakes and to inform them about game rules and, at around 5 years of age, their demonstrations are accompanied by explanations and instructions (Davis-Unger & Carlson, 2008; Strauss et al., 2002). At 7 years, their transmission becomes contingent on the behaviour of the recipient such as updating the type or amount of information provided to others (Ziv, Solomon, & Frye, 2008; see, Strauss, Calero & Sigman, 2014; Strauss & Ziv, 2012, for reviews).

Before transmitting information, some selectivity may be required, for example, the transmitter may need to decide what type of information would be the most relevant for the recipient and how much it would benefit them (e.g., Bridgers, Jara-Ettinger, & Gweon 2020; Gweon & Schulz, 2019; Gweon, Shafto, & Schulz, 2018). It becomes an important endeavour, then, to identify what type of information children are more likely to treat as worthy of transmitting. Both in pre-schoolers and older children, preferential transmission has been found for culturally relevant information such as social norms (e.g., Rakoczy, Warneken, & Tomasello, 2008; Schmidt, Rakoczy & Tomasello, 2012) and conventions (e.g., Clegg & Legare, 2016). Additionally, 5- to 7-year-old children selectively transmit information that is difficult to acquire through self-exploration such as complex (e.g., Bridgers et al., 2020) or cognitively opaque knowledge (e.g., Ronfard, Was, & Harris, 2016), and information that has better learning outcomes such as leading to interesting over dull effects (e.g., Bridgers et al., 2020). Finally, 4- to 7-year-old children transmit generic over specific information preferentially (e.g., Baer & Friedman, 2018; Gelman et al., 2013; for a review, see Ronfard and Harris, 2018). For instance, when children are asked to provide information about umbrellas to an ignorant learner, they provide general information (e.g., "Umbrellas protect us from rain"); however, if the learner already has some information about umbrellas, they provide specific information instead (e.g., "This umbrella is colourful") (Baer & Friedman, 2018).

The generalisability of information has particular relevance for better understanding children's information transmission behaviour because it makes up a considerable amount of information that we possess about the external world (Prasada, 2000) and it enables effective learning about the world. Generalisability is often reflected in our generic, *kind-based* knowledge rather than knowledge about individuals (e.g., "Dogs have four legs") and in the essential properties that are inherent to a certain kind (e.g., "Dogs bark") that are not invalidated by limited counterexamples (e.g., a three-legged dog) (Prasada, 2000). Humans acquire this type of information through linguistic means such as using generics (Gelman, 2003) and non-linguistic ways such as tracking perceptual generalisability of the information through induction (e.g., Baldwin et al., 1993; Macdonough & Mandler, 1998) and attending to others' ostensive demonstration (for a theoretical account see Csibra & Shamsudheen, 2015). Since it is not possible to witness every single example (e.g., every single dog) that makes up a kind (i.e., dogs), it has been suggested that kind information is acquired through a "generic" heuristic (Gelman, 2003).

Generics are defined as linguistic expressions that refer to kinds and extend beyond exemplars (Gelman & Roberts, 2017), and they are ubiquitous in 2-to 4-year-old children's and parents' conversations from early on (e.g., Gelman, Ware, Kleinberg, Manczak, & Stillwell, 2014). Starting from at least 2 years of age, parents from different cultures (e.g., American and Chinese) use generic statements in their interactions with children (e.g., Gelman & Tardiff, 1998). From the ages of 2 to 4 years children progress in developing a comprehension of generics and, using different contextual cues (such as linguistic, pragmatic, and world knowledge cues), they can distinguish generic from non-generic utterances (e.g., Cimpian & Markman, 2008; Gelman & Raman, 2003). At 2.5 years, children are already attuned to linguistically transmitted information generalisability (e.g., generic noun phrases like "Blicks" vs. non-generic noun phrases like "These blicks") and use this knowledge to inform the assumptions they make about kinds (e.g., Graham et al., 2011; Graham et al., 2016). Further, 4- and 7-year-old children expect that novel generic facts (e.g., "Hedgehogs eat hexapods") are more likely to be known by others than novel specific facts (e.g., "This hedgehog eats hexapods") (Cimpian & Scott, 2012). Finally, 4- to 7-year-old children associate generalisable information with teaching contexts in which a knowledgeable person transmits information to a less knowledgeable person (Gelman et al., 2013). Overall, these findings suggest that from at least 2.5 years of age, children use linguistic means to distinguish generalisable information from non-generalisable information.

However, even preverbal infants, although, by definition, they do not produce generics themselves, track categorical generalisability based on perceptual similarity and kind-relevance (e.g., Baldwin et al., 1993, Macdonough & Mandler, 1998; Vukatana et al., 2015). Previous studies have shown that by 2 years of age, children have already developed a pronounced sensitivity to generalisability. For instance, infants between the ages of 9 and 16 months can generalise an opaque feature of an object that they previously observed even for a brief period and with only one exemplar (e.g., a horn that honks when squeezed or bitten) to other objects that are perceptually similar to the original object, and they do not expect dissimilar objects to have the same opaque feature as the original object (Baldwin et al., 1993). In another study, Mcdonough and Mandler (1998) tested 9- and 11-month-old infants' inferences about object properties. Infants were shown objects from different categories (i.e., animals and artifacts) and an action (e.g., sleeping or being keyed) on a particular model object such as a prop car being keyed or a prop dog sleeping. Later in the test phase, infants were given other objects from both the animal category and the vehicle category. Infants appropriately generalised properties of objects within the same category, namely, if they were given a prop dog or a cat, infants were more likely to imitate sleeping or drinking actions rather than riding or keying actions (McDonough & Mandler, 1998). These findings suggest that even before children are linguistically proficient enough to produce and use generics as a means for representing kind-relevant generalisable information, they can nevertheless perceive which properties of objects are generalisable based on both perceptual similarity of the objects and the kind relevance of the objects (i.e., similar objects from the same category tend to share same non-obvious properties).

Given children's sensitivity to generalisable information, several studies have also investigated whether such information holds a privileged status in their own transmission of information to others. Gelman and colleagues (2013) tested whether 4- and 7-year-old children themselves would produce more generics in a pedagogical over a conversational context. In their study, they provided the children with picture books, introduced them to a puppet and asked them to talk to the puppet about the picture books. The children were told to pretend to either be a classroom teacher (pedagogical context) or a peer having a conversation with a friend (non-pedagogical context) when talking to the puppet about the pictures. When children were asked to pretend to be a teacher, they produced generic statements more often (Gelman et al., 2013). These results, therefore, point to a developing distinction between pedagogical and non-pedagogical contexts and its relation to generic information. In a related study, Baer and Friedman (2018) found that 4-6-year-old children were sensitive to the perceived knowledge state of a recipient of information. When children were asked to transfer information about certain kinds to either ignorant or knowledgeable recipients, they referred to generic facts about a kind more when the recipient was ignorant. Additionally, the authors observed the same tendency when they manipulated the context of information transmission, with children providing generalisable information more when they were asked to "teach" over when they were asked to "tell" (Baer & Friedman, 2018; Experiment 3).

The described findings overall suggest that children from 4 years onwards preferentially transmit generalisable information in teaching-like contexts and to ignorant others. However, it is important to note that these studies were conducted with pre-school- and school-aged children, potentially benefitting from these children's experience with formal pedagogical contexts (e.g., Baer & Friedman, 2018; Gelman et al., 2013). For example, in these studies children were shown pictures of classrooms and teachers and asked to pretend to be "a teacher" (Gelman et al., 2013), or to "teach" (Baer & Friedman, 2018), and these manipulations resulted in either producing more generic statements or providing generalisable information more. This approach makes it difficult to assess whether children transmit generalisable information preferentially because of their sensitivity to this type of information and would do so even outside (and prior to experience with) such formal pedagogical contexts. While evidence suggests that even 2- to 3-year-old children produce generics more in contexts such as when looking through a picture book over manipulating objects (e.g., Gelman et al., 2005), it is less clear whether this sensitivity to information generalisability in younger children also manifests in their preferred transmission of such information to others.

Prior research conducted with preverbal infants and toddlers provides support to the notion that children, even in the first two years of life, transmit information to others – specifically those whom they observe to be less knowledgeable. Liszkowski and colleagues (2008) found that 12-month-old infants pointed to the location of an object when an adult was searching for it and had not seen where the object was, but not when the adult had visual access to the location of the searched object. In another study, 24-month-old toddlers were found to selectively demonstrate actions to naïve recipients that are simple over complex ones (Bazhydai, Silverstein et al., 2020) and that they had previously learned through pedagogical demonstrations (Vredenburg et al., 2015; but see Bazhydai, Silverstein et al., for a non-replication). It is apparent that younger children are not only capable of active transmission of information, but that they select what to transmit with respect to the characteristics of the recipient (Liszkowski et al., 2008), the context of learning, or the type of information (Bazhydai, Silverstein et al., 2020; Vredenburg et al., 2015). Given children's early sensitivity to information generalisability, and older children's selectivity for transmitting generalisable information in teaching-like contexts, one might reason that information generalisability plays a role in toddlers' information transmission also, leading them to transmit generalisable information selectively.

Answering this question has theoretical importance because it would help elucidate whether the bias for transmission of generalisable information observed in 4- to 7-year-old children is a result of a gradual developmental process, perhaps facilitated by combined experiences with schooling and a transition from tracking perceptual generalisability to representing conceptual generalisability expressed through generic language, or whether it stems from children's appreciation of generalisable information as 'special' that is present from a young age. If a preference for generalisable information in transmission is based on children's recognition of conceptual generalisability and experience with schooling, then we would expect to observe no preference for it in younger children. If, on the other hand, generalisable information is preferred because of its recognised special status that is present already in infants and toddlers, then we would expect a preference for its transmission even in these younger children. Therefore, in the current study, we specifically investigated the role of information generalisability in children's early information transmission.

2.4. The Current Study

The current study investigated whether two-year-old children have a bias for transmitting generalisable over non-generalisable information to a naïve learner. To answer this question, 2-year-olds were presented with three novel boxes, identical except their colour. In each box, one of two equally salient and easy actions led to a generalisable outcome (e.g., playing a [different] tune in each box), whereas the other led to a non-generalisable outcome (e.g., box 1: turning on a light, box 2: vibrating the box, box 3: making a noise). Children had the opportunity to interact with the boxes to discover the functions of each box and then were asked to demonstrate the boxes' functions to an ignorant recipient. We measured whether children preferentially transmitted either generalisable or non-generalisable information when they were asked about the function of the toys.

The design-relevant decisions, such as the means of information acquisition, establishment of generalisability, and target age range, are based on previous studies on information transmission. First, previous research found that 2-year-old children might be more likely to transmit information that they previously learned from pedagogical demonstrations (e.g., demonstration accompanied by ostensive cues, Vredenburg et al., 2015); however, this result could not be replicated (Bazhydai, Silverstein et al., 2020). To avoid this potential confound, in our study children were allowed to discover both types of information on their own without receiving any instruction regarding the functioning of the toys. Second, in defining generalisability we followed Prasada's (2000) conceptualisation of generalisability as an attribute that refers to the kind in general (e.g., "Dogs are mammals") and inherent properties that hold true for the kind across individual exemplars (e.g., "Dogs bark"). In line with this definition, for the generalisable information we used similar but different tunes (i.e., "This type of button plays a tune") and for the non-generalisable information, we used different perceptual effects, namely, noise, vibration, and lights ("This type of button makes a noise/creates a vibration/makes lights flash"). Third, in order to reveal whether children produce generalisable information specifically in teaching contexts, we contrast two phases ('exploration phase' and 'transmission phase') that were identical apart from the fact that in the transmission phase an ignorant adult was present and asked the child to show her 'how the toys work'. We reasoned that if toddlers produced generalisable information preferentially but equally in both phases they would do so because such information is of relevance to themselves, but if they produced it preferentially only in the presence of a learner they would do so because they consider it relevant for teaching.[1]

Finally, targeting 2-year-olds was motivated by the following considerations: First, research on children's information transmission primarily focused on 4- to 7-year-old children (see Strauss & Ziv, 2012; Gweon 2021, for reviews), with only a handful of studies testing children 2 years old or younger (e.g., Bazhydai, Silverstein et al., 2020; Lizskowski et al., 2006, 2008), leaving a gap in our understanding of the development of teaching Behaviour. This age group provides the best opportunity to explore whether a preference to generalisable information is present in young children's information transmission when generalisability of the information does not rely on verbal abilities such as producing and understanding generics and generic language or experience with formal schooling. Finally, children at this age have been shown to readily transmit information through action demonstrations (Akagi, 2012; Bazhydai, Silverstein et al., 2020; Flynn, 2008; O'Neill, 1996; Vredenburg et al., 2015).

Hypotheses: We posited that a special role for generalisable information in transmission might be reflected in two ways. The first is that toddlers would transmit generalisable information preferentially and would choose the generalisable function as the first to be transmitted to an ignorant adult ("initial preference" hypothesis). Doing so would highlight to the learner the potential relevance, importance, or interest of this information, albeit not its generalisability. To demonstrate to the learner that the information is

[1] Note that there can be an alternative explanation for children's transmission of generalisable information in both Exploration and Transmission Phases. Children might consider generalisable information as relevant to both themselves and for the learning of others. However, our current design does not allow to distinguish between these interpretations. If we observed the suggested pattern, this would be interpreted with the simpler explanation listed above (i.e., children find this information relevant for themselves, thus transmit it accordingly). Also see, *weak argument* on "theoretical interpretation of the results" in Appendix.

generalisable, the child must transmit different instances of this information (e.g., the same-type button playing different tunes across boxes). We evaluated this "systematic preference" hypothesis by investigating the second function that children showed to the learner on a different box after showing a generalisable function (as the first function).

2.4.1. Method

2.4.1.1. Participants

Based on the medium effect sizes in previous research on toddlers' information transmission (i.e., Bazhydai et al., 2020; Vredenburg et al., 2015) and an a priori power analysis[2] (See Appendix A) which aimed for 90% power to detect a medium effect size (*d* = .50) we required 44 participants in the study. The final set included 49 healthy, full-term (> 37 weeks), British English-speaking 24-month-old toddlers due to overbooking (*Mage* = 24.43 months, Range = 22.67– 25.70 months, 25 females). Participants were recruited through the database of the Lancaster University Babylab between June 2022 and May 2023. Ethics approval was received from the Lancaster University FST Research Ethics Committee (FSTREC). Participants received a storybook and £5 compensation for their travel expenses, in accordance with laboratory-wide practices.

Exclusion Criteria: As pre-registered, exclusions were made both at a participant level (if they did not contribute data from either block) and at a block level (if they did not contribute data from at least one block). Twenty-three participants who did not contribute data from at the least one block were completely excluded from analysis (46 blocks); of the 49 children remaining in the dataset, data from 22 blocks were also discarded. Pre-registered exclusion reasons are as follows: not complying with the procedure (e.g., refusing to play the game, not sitting on the caregiver's lap or high-chair) or becoming fussy or indifferent (27 blocks), failing to discover both functions for each box in the initial Discovery phase (23 blocks), experimenter/equipment error (e.g., camera failure, biased instructions, failure to follow pre-designated procedure) (3 blocks). Finally,

[2] The power analysis was based on the statistical test that required the highest number of participants.

data from 15 blocks were discarded for reasons that we did not pre-register but later deemed necessary: Four blocks from two participants were discarded because their parents later informed us that their children were undergoing assessment for autism spectrum disorder (ASD) diagnosis, and 11 blocks were discarded because children did not demonstrate any function on the toys in the Transmission Phase which we did not originally foresee.

2.3.1.2. Materials and Stimuli

Information transmission task. Two different sets of objects were created for each experimental block (See Figures 1 and 2, in Appendix B). Each set had three boxes printed using an Ultimaker 3D printer with PLA extrusion material. In both sets, the boxes were 135*93*72 mm cuboids with rounded edges and were identical except for their colour (e.g., blue, green, yellow, white, etc.). Each box included one round push button and one square push button on top which looked identical across the boxes. There was a 3-bulb LED strip on top of each box and a vibrating mechanism and audio speaker inside. The stimuli and switches were controlled by a Raspberry Pi Zero device programmed with a custom Python script. The output stimuli were triggered by pressing the buttons.

The different buttons led to separate outcomes: one type triggered a generalisable outcome across boxes (e.g., three different tunes in Boxes 1, 2 and 3) and the other type, a non-generalisable outcome across boxes as defined by the status at start-up of the device. The boxes in the second set were conceptually identical but the physical features of the box (e.g., colour of the box) and the buttons, and the outcomes associated with the buttons were different.

Auditory Stimuli were three novel tunes lasting around five seconds each, and three modified non-musical noise. Samples of these stimuli, along with the approved protocol of the Stage1 Registered Report can be found on the OSF page (https://osf.io/aqtwr/).

2.3.2. Design and Procedure

Testing took place in the Lancaster University Babylab. Children interacted with two experimenters, both equally friendly and speaking in a child-directed manner.

Upon welcoming the caregiver and the child, Experimenter 1 (E1) informed the caregiver about the aim of the study and the experimental procedure and advised them to avoid distracting their child during testing. Then, the caregiver was asked to fill in the informed consent form[3]. Later, E1 invited the child and the caregiver to the testing room. The child was seated in a highchair in front of a table with the caregiver seated behind the child, or on the caregiver's lap depending on how the child felt more comfortable. After building rapport with the child, E1 initiated the Warm-up game before the first of two blocks of the experiment.

Warm-up. E1 played with the child for 30 seconds with a marble run game to get them familiarized with the experimental set up and determine the child's reaching limits to the right-hand side, left-hand side, and to the centre of the table.

Discovery Phase. The three experimental boxes were hidden under the table in a cupboard that could not be seen by the child. E1 told the child that she had some toys she wanted to show to the child by saying: "I have really nice toys. Do you want to play with them? Let me show you one." Then, E1 took out the first toy and put it at the centre of the table within the child's reach. The child had 30 seconds to play with the toy and explore both functions associated with distinct outcomes (e.g., the round button playing a tune, the square button lighting up the LED strip). If the child did not discover any/either function after 15 seconds passed, E1 prompted the child to continue exploring the toy by saying: "I wonder what would happen if you pushed that/the other button (if they had not already managed to activate both buttons)?". Each discovery trial ended under two circumstances: if the participant discovered both functions and explicitly cued that they were done (e.g., pushing the toy away), or if 30 seconds passed and the participant still failed to discover the functions. If the participant managed to discover at least one function in each box, they were given a chance to play with the "undiscovered" toys once more for 15 seconds. The experiment continued nonetheless; however, the data from children who did not manage to discover

[3] Demographic information is collected in line with the Lancaster University Babylab's common testing practices and complies with GDPR protocols. Parents filled in the consent form using Qualtrics.

both functions in each box during the Discovery Phase were excluded from the final data.

Exploration Phase. E1 initiated the Exploration Phase by saying "Do you want to play more with these toys?" and putting all three boxes back on the table within the child's reach. E1 then diverted her attention from the child and engaged with her phone, allowing children to explore the toys independently for 30 seconds. If the children did not start playing with the toys, E1 prompted them by saying "Do you want to play with these?" When the time had elapsed, E1 told the child that she needed to leave to get something, but her friend would come. When E1 left, E2 entered the room and initiated the Transmission phase.

Transmission phase. E2 entered the room by carrying some document boxes. E2 looked at the table, sat down and by noticing the toys, said: "Wow! Are these your new toys? What do these do? Can you show me?" If the child did not initiate any action within 15 seconds, E2 asked the child again: "Can you show me what these toys do?". After 15 more seconds, if the child did not act, E2 thanked the child, and left the room. The phase ended after 30 seconds.

Then, when E2 left the room, E1 re-entered the room, and repeated the whole procedure with a second set of objects (second block). If the participants did not engage or fussed out already in the first block, they were offered a short break and were given the opportunity to proceed with the second block. After the second block of the experiment was finished, E1 thanked the child and escorted them back to the greeting area.

Each of the two experimental blocks had a set of three different boxes with different generalisable outcomes (e.g., one set had tunes as the generalisable outcome, whereas the other set had lights). Each block had 3 discovery trials (i.e., one for each box), one exploration and one transmission trial (each with all three boxes together), each lasting around 30 seconds. The experiment took around nine minutes including the warm-up (See Figure 3 in Appendix B).

The following aspects of the stimuli were counterbalanced within and across participants: The order of the box set presented in each block were counterbalanced across participants (i.e., Set 1 in Block 1 and Set 2 in Block 2 vs. Set 2 in Block 1 and Set 1 in Block 2). The generalisable outcome was counterbalanced within and across participants (e.g., for Participant 1, tunes in Block 1, lights in Block 2; for Participant 2, noises in Block 1, vibrations in Block 2). The buttons associated with the generalisable outcome were counterbalanced within and across participants (e.g., for Participant 1, round button in Block 1 and square button in Block 2 were generalisable; for Participant 2, square button in Block 1 and round button in Block 2 were generalisable). Finally, the positions of the buttons were counterbalanced across participants (e.g., square on the left, round button on the right vs. round button on the left, square button on the right). All sessions were video and audio recorded for later behavioural coding.

2.3.2.1. Measures and Coding

Behavioural coding of all participants was done by the first author. A second coder, blind to the hypotheses of the study, coded 25% of all videos. A minimum Kappa statistic of .80 and a Cronbach's α statistic of .80 were aimed for agreement across coders for dichotomous and continuous variables, respectively. For dichotomous test measures (i.e., first and second functions in Exploration and Transmission phases), coders showed 100% agreement; thus, the Kappa statistic was not computed. We did not have a continuous variable in our test measures. Children were required to complete at least one of the experimental blocks to be included in the data.

Discovery Phase. In this phase, we coded whether the participants managed to discover two functions associated with the two buttons, and this was used as an exclusion criterion to make sure that children included in data analysis had produced each function at least once. The coding for the Exploration and Transmission phases was identical.

Exploration and Transmission Phases. In these phases, we coded the first function produced by the child across all boxes (Hypothesis 1a: Children will preferentially produce generalisable information in the Transmission but not the

Exploration phase). Additionally, we coded the second function different from the first (e.g., Were the first and the second functions both generalisable and on different boxes?) (Hypothesis 1b: Children will show that the information that they transmit is generalisable by selectively demonstrating the generalisable function across boxes in the Transmission phase, but not in the Exploration phase). The aim of this coding was to evaluate whether children show a preference for producing generalisable information and whether this preference is specific to information transmission contexts.

2.3.2.2. Statistical Analyses

We conducted all proposed analyses using JASP (JASP Team, 2023). We used both Frequentist and Bayesian methods of data analysis. We used non-parametric tests as the assumptions of parametric tests were not met. The statistical significance threshold was .05. We computed a default Bayes factor for a wide Cauchy distribution centred at 0.707 for all results. A BF01 value greater than 3 was considered as moderate support for the null hypothesis and a BF10 value greater than 3 as moderate support for the experimental hypothesis (Jeffreys, 1961). The analyses for the Exploration and Transmission phases were identical.

Exploration and Transmission Phase. Following the statistical procedures used in previous studies (Bazhydai et al., 2020; Vredenburgh et al., 2015), we transformed children's first and second produced function from both experimental blocks into scores as follows: if children produced the generalisable function first in both blocks, they received +1 point, if they produced one generalisable and one non-generalisable function first, they received 0, and finally, if they produced the non-generalisable function first in both blocks, they received -1. If children provided data for only one block, they received +1 point when they produced the generalisable function first and they received -1 point when they produced the non-generalisable function first. This scoring scheme was applied for the first and second functions in each phase in each block, as well.

To understand whether children produced the generalisable function as the first function more frequently than the non-generalisable, we planned to conduct a one-sample t-test to compare these scores against the chance value 0 (Hypothesis 1a - Initial Preference: Children will preferentially transmit generalisable information). Further, we planned to analyse the second function produced only for those children who showed initial preferential engagement with generalisable information, indexed by producing a generalisable function as the first choice in each of the two blocks (including those children who only contributed one block in which they preferentially chose generalisable information first). We planned to conduct a one-sample t-test against chance value 0 (Hypothesis 1b – Systematic Preference: Children will show that the information that they transmit is generalisable by selectively demonstrating the generalisable function across different boxes).

Cross-Phase Comparison. Children's average mean scores from both blocks (or one block if they have only contributed one block) for the Exploration and Transmission Phases were calculated to analyse if children produced the same functions across phases by using a paired-samples t-test (See, Table 1 in Appendix C).

2.3.2.3. Timeline

Due to the ongoing COVID-19 pandemic and the delay in the review process, it was difficult to anticipate a certain timeline for the study. Our original plan was to collect the data between January 2022 and August 2022; however, the final timeline was between June 2022 to May 2023.

2.3.2.4. Deviations from the Stage 1 Protocol

We deviated from the Stage 1 protocol, mainly to reduce excessive drop-out and to increase the children's engagement with the task, as detailed below.

1) In the Stage 1 Protocol, we specified that we would use a button and a toggle switch. As the toddlers lacked finger strength to operate the toggle switch, we instead used a distinct looking second button.

2) If toddlers failed to discover both functions in each box (stated exclusion criterion), we did not end the study immediately, instead let the child complete it but as planned, excluded the data from these trials from the final analyses.

Further, we observed the following procedural issues that seemingly unnecessarily led to participant exclusion, and made the following additional changes to improve their engagement:

3) If participants did not engage already in the first block, we offered them a play break and if they wanted to continue afterwards, we proceeded with the second block,
4) Due to the design of the boxes, when one button was activated, it was not possible to activate the other button until the effect of the activated button ended. Thus, if children pressed both buttons at the same time or pressed the other button while one was already activated, they could not immediately see the effect of the "unactivated button". The neutral prompt that we used initially ("I wonder what would happen if one were to push that button") either led toddlers to activate the same button they had already activated previously, or they ignored the prompt. Thus, we made a slight change to the prompt instead saying, "I wonder what would happen if you pushed that (if they hadn't pressed anything)/ the other button (if they had pressed one button but not the other)".
5) Some toddlers were taken aback by the vibration function, and if this was the first function that they activated in the first box, they did not want to continue with the study. Since one of the inclusion criteria in the study is that toddlers should activate both functions in each box, this started to cause a decrease in eligible trials. Therefore, we presented the box that included a vibration function as the last box in the Discovery Phase to make sure that they had a chance to play with all boxes and activate both buttons and thus to be included in the data. To make sure that the change did not influence toddlers' behaviour in the Transmission Phase, we added a

manipulation check to ensure that toddlers were not less likely to transmit vibrations as the first function (see Supplementary Information). Though note that as vibration was counterbalanced across generalisable and non-generalisable functions such an outcome would not present a confound in our planned analyses.

2.3.3. Results

2.3.3.1. Planned Analyses

When the data were not normally distributed (Shapiro-Wilks test $p < .001$) we used non-parametric tests.

Transmission Phase

Hypothesis 1a - Initial Preference: For this analysis, 49 children contributed data. Among these, 18 children showed a generalisable function as the first function in one block and the non-generalisable function in the other block receiving a score of "0", 19 children showed a generalisable function as the first function in both blocks receiving a score of "+1", and 12 children showed a non-generalisable function as the first function in both blocks receiving a score of "-1". A one-sample Wilcoxon test revealed that children's choices for choosing the generalisable function as the first function did not significantly differ from chance ($W(48) = 304.00$, $p = .213$, $r = 0.226$). A default Bayes factor with a wide Cauchy distribution centred at 0.707 showed moderate support for the null hypothesis, BF01 = 3.404, (Median δ= 0.161, 95% CI δ[-0.135- 0.460])[4].

Hypothesis 1b - Systematic Preference: For this analysis, we focused on the data from 19 children who transmitted the generalisable function as the first function, and we analysed the second function that they performed on a different box. Two children in this sub-sample showed only one function in the Transmission phase, so their data were not included in this analysis. A one-

[4] Bayes factors reported here were based on a data augmentation algorithm with 5 chains of 5000 iterations to increase the numerical stability of the Bayes factors; "δ" signifies standardized effect size estimates (van Doorn et al., 2021).

sample Wilcoxon test revealed that children's choices for choosing the generalisable function as the second function did not significantly differ from chance ($W(16) = 72.00$, $p = .829$, $r = -0.059$). A default Bayes factor with a wide Cauchy distribution centred at 0.707 showed moderate support for the null hypothesis, BF01 = 3.204 (Median δ = 0.048, 95% CI δ [-0.485- 0.592]).

Cross-phase Comparison: We compared the toddlers' first functions in the Exploration and Transmission Phases (see Table 1). A Wilcoxon signed-rank test showed that toddlers' first choices did not significantly differ across Exploration ($M = -0.021$, $SD = 0.812$) and Transmission Phases ($M = 0.143$, $SD = 0.791$), $W(47) = 47.00$, $p = .154$, $r = -0.386$. A default Bayes factor with a wide Cauchy distribution centred at 0.707 showed anecdotal support for the null hypothesis, BF01 = 2.325 (Median δ = -0.209, 95% CI δ [-0.521- 0.094]).

In addition to the planned analyses, we conducted a set of exploratory analyses because, unexpectedly, almost half of the toddlers who passed the inclusion criteria (n = 22/49) contributed data from only one block. To investigate if contributing data from both blocks vs one block influenced the results, we repeated the same planned analyses reported above with the data from the "first contributed block" only, thus eliminating the "both" functions option (assigned the score of "0"). The results of these analyses were the same as the results of the planned analyses (see Supplementary Information).

2.4. Discussion

In this study, we aimed to investigate whether toddlers preferentially transmit generalisable over specific information to others. We presented toddlers with three novel boxes, each of which had two distinct buttons. One type of button in each box led to a generalisable outcome, whereas the other type led to a non-generalisable outcome. After children discovered both functions in each box independently (Discovery phase), they were given a chance to play with all three boxes simultaneously (Exploration phase). Later, a naïve learner asked the toddlers to show her how these boxes worked (Transmission phase). We measured whether toddlers would prefer to transmit generalisable information as the first (Initial Preference Hypothesis) and the second function transmitted (Systematic Preference Hypothesis). The results of the study revealed that toddlers did not show a preference for transmitting generalisable or non-generalisable information first. Even among the small number of toddlers who preferentially did show a generalisable function first, we did not detect any evidence of systematic preference for transmitting information generalisability. Finally, toddlers' behaviour in the Exploration and Transmission phases was similar, they neither preferentially (nor systematically) explored nor transmitted either type of information. These conclusively null findings warrant further discussion in light of the previously reported older children's selectivity in transmitting information and the development of sensitivity to information generalisability.

Previous findings show that children are exposed and attuned to generalisable information expressed through generic language as early as 2-years-old (e.g., Gelman et al., 2014; Gelman & Raman 2003, Graham et al., 2016), and as they get older they tend to associate generalisable information with teaching-like contexts and, importantly, show a preference for its transmission to others (Baer & Friedman, 2018; Cimpian & Scott, 2008; Gelman et al., 2013, Pueschel et al. 2023). Here, for the first time we investigated whether toddlers showed the same preference. Previous work has found that preverbal infants and toddlers are habitually exposed to generalisable information and are able to track generalisable properties of information (Baldwin et al., 1993, Macdonough & Mandler, 1998; Vukatana et al., 2015). Thus, we reasoned that if the preference for transmitting generalisable information is an early propensity, even toddlers would display this bias. However, if this preference is a consequence of a developmental change potentially supported by children's experiences with formal schooling and recognition of conceptual generalisability through language, then we would not expect a preference for transmitting this type of information in toddlers. We found that unlike older children, toddlers did not show a preference for transmitting such generalisable information to others.

These findings can be interpreted in at least two ways. First, it is possible that even though young infants can distinguish generalisability of information by tracking perceptual cues (Baldwin et al., 1993, Macdonough & Mandler, 1998) and by being attentive to others' ostensive communication (Csibra & Shamsudheen, 2015), the special status of such information in transmission to others might depend on a more conceptual representation of generalisability and develop gradually, perhaps in conjunction with language, theory of mind, executive function, metacognition, and other relevant cognitive abilities which are considered crucial for more selective teaching that is tailored to the learner's needs (Corriveau et al., 2017). Additionally, in order to make the step from recognizing generalisable features to a more conceptual representation of generalisability, toddlers might require more explicit cues, for example, linguistic labels and pedagogical communication. Such explicit cues have been shown to modulate young children's inductive inferences about generalisability above and beyond the perceptual similarity of objects (Butler et al., 2015; Butler & Tomasello, 2016), but they were not part of the current study. In fact, it is precisely in order to rigorously isolate and evaluate the role of mere generalisability of the information, that we avoided providing any linguistic and pedagogical input to the toddlers during the Discovery and Exploration phases. Nevertheless, it is possible that early representation of generalisability might indeed be facilitated by the presence of pedagogical cues (among other factors such as linguistic labelling, i.e., use of generics), thus enabling toddlers to use it as a heuristic for evaluating the generalisability of non-verbal information (akin to "non-verbal generics" proposed Csibra & Shamsudheen, 2015). However, if sensitivity to generalisability of information was valuable for its own sake in the context of transmission and if even preverbal infants could already track perceptual generalisability with nonverbal stimuli such as functions (Baldwin et al., 1993, Kemler-Nelson et al., 2000; Macdonough & Mandler, 1998; Vukatana et al., 2015), we would expect this to be reflected in toddlers as well. Following this view, and in light of our study's findings, at 2 years, children's information transmission choices are not affected by information generalisability due to the pre-conceptual representations of generalisability that is perhaps governed by perceptual similarity.

Alternatively, the observed lack of preference might be due to the modality of generalisability used in our study. We focused on non-verbal manifestations of generalisability that did not rely on toddlers' language abilities such as recognizing or producing generic statements. Previous studies on this topic tested relatively older children between 4 and 7 years using different variations of a teaching task, such as forced-choice paradigms where children are presented with generalisable and episodic verbal statements to share with a naïve learner (e.g., Pueschel et al., 2023), or more open-ended paradigms where children pretended to teach others about a particular topic (e.g., Baer & Friedman, 2018; Gelman et al., 2013). Crucially, in all of these studies, the generalisable information was verbal and expressed through generic language (Gelman 2003; Prasada, 2000). However, these designs are not suitable for younger children. Indeed, some studies reported that 3-year-olds failed to complete these tasks (e.g., Baer & Friedman, 2018; Pueschel et al., 2023) which might be due to younger children's limited language or other cognitive abilities. Therefore, here we focused on non-verbal manifestations of generalisability by using action demonstrations. It is possible that in an action-based task like ours, children are less sensitive to generalisability than in verbal tasks due to the higher level of abstraction required to conseptualise generalisability. This could be tested by using similar tasks to ours with older children who do show such sensitivity on verbal tasks.

Further to this interpretation, it is possible that toddlers might have failed to represent the generalisability inherent to our stimuli. The differences between the generalisable (i.e., different exemplars of the same type of effect in each box (i.e., square button playing different tunes) and non-generalisable information (i.e., different "type" of effect in each box, e.g., round button turning a light on, vibrating the box, and making a non-musical sound) might have been too subtle for toddlers to drive their transmission behaviour. We conseptualised generalisable information as information that is distinct but similar (such as three distinct tunes), and non-generalisable information as information that is distinct and not similar (such as light/vibration/sound). Additionally, this higher level of abstraction enabled us to make sure that with each press of each button in each box, something novel – but either generalisable or non-generalisable – happened. Nonetheless, this choice might have made it difficult for 2-year-old children to detect generalisability between these stimuli and instead they demonstrated actions they themselves found of interest at that moment. It is important to emphasize that toddlers could have transmitted what they themselves found interesting, rather than generalisable, regardless of whether or not they had conceptual understanding of the information's generalisability. However, our design did not allow for teasing these two possibilities apart.

Accordingly, the obtained inconclusive evidence for the null hypothesis indicated that toddlers' behaviour in the Exploration and Transmission phases was similar in that they were not selective in either exploring or transmitting the generalisable information. In similar information transmission paradigms, participants are typically presented with a phase where they learn about the information and a phase where they transmit the previously learned information (e.g., Bazhydai et al., 2020; Vredenburgh et al., 2015). One notable limitation of these paradigms is that it is difficult to conclude that children deliberately intended their behaviour as "transmitting information". Hence, it is possible that their behaviour, albeit happening during a "transmission phase", might have other functions such as playing with the objects that they found interesting or consolidating their own knowledge of the objects. The inclusion of the exploration phase was a carefully designed feature in our modification of the paradigm. The cross-phase comparison results therefore suggest toddlers' overall lack the preference for generalisability as expressed through our stimuli. To investigate whether toddlers indeed intend to transmit information to the learner upon their request, behavioural coding could be implemented to distinguish between intentionality in the Exploration and Transmission phases. Particular behaviours of interest that children might exhibit would be those argued to signal communicative intentions, such as establishing joint attention, using gestures and producing verbal instructions (e.g., Carpenter et al., 1998; Liszkowski et al., 2004; Tomasello et al., 2005). Previous research showed that children aged 3-8 years tend to use ostensive signals (e.g., eye contact, contingent reactivity, or use of non-specific gestures such as head nodding) when they transmit relevant information to others in pedagogical episodes (Calero et al., 2015). Capturing such Behaviours as initiating social looks, gaze shifts, or using simple verbal instructions (e.g., “Look!”, “Here!”, “Push”, etc.) would allow to detect behaviour change in toddlers at Transmission compared to the Exploration phase. Research incorporating such behavioural coding in toddler samples is under way in our lab with the aim to shed light on this issue.

Some limitations in our study warrant further discussion. As mentioned above, we assumed that toddlers would be able to represent the generalisability of information in the current study, given that even preverbal infants can track generalisability of object features based on perceptual similarity (Baldwin et al., 1993; Macdonough & Mandler, 1998), that 2-year-old children use function information to categorize objects and object features (e.g., Kemler-Nelson et al., 2000; Madole et al., 1993), and that 2.5-year-old children can make a distinction between generalisable and non-generalisable information (e.g., Graham et al., 2011; Graham et al., 2016). Unlike the studies with older children where verbal manipulation checks can be conducted, we did not have a way to check for this without biasing the toddlers’ subsequent behaviour. Second, we encountered an unexpected fuss out rate which was surprising given similar studies conducted in our lab before the COVID-19 pandemic. This might be due to toddlers born during the pandemic having limited social interactions compared to their pre-pandemic peers. While the lockdown measures were in place, toddlers’ exposure to social interaction decreased substantially (Byrne et al., 2023; Sledge et al., 2022). Indeed, a recent study suggested that pandemic-born babies might have deficits in some aspects of social communication such as producing first words, pointing and waving goodbye compared to babies born before the pandemic (Byrne et al., 2023). It is possible that visiting new environments, interacting with new people and objects might have been overwhelming leading to higher rates of fuss out. Future research should investigate the possible effect of the unprecedented measures due to the COVID-19 pandemic on toddlers’ sustained engagement in similar interactive experimental paradigms.

Our findings have both theoretical and methodological implications. The emerging field studying teaching behaviour in children is predominantly focused on preschool and school-aged children. This work shows that children at this age become evidently good at sharing information with others by considering a multitude of factors (Bazhydai & Karadağ, 2022): which teaching strategies to use (Strauss & Ziv, 2012), with whom to share information (Danovitch, 2020; Karadağ & Soley, 2023; Kim et al., 2016), and what information to teach (Bridgers et al., 2020; Danovitch et al., 2023; Pueschel et al., 2023). While these studies enhance our understanding of children's teaching abilities, by overlooking infants and toddlers, they underemphasize the developmental trajectory of this behaviour. Given that some theoretical accounts emphasize the relationship between generalisable information and pedagogical experiences (e.g., Moll, 2020; Strauss et al., 2012), the lack of research in younger children is surprising. As we discussed earlier, testing toddlers and young children in this context has important implications in understanding children's appreciation of information generalisability developmentally which would enable more complete theoretical accounts of children's teaching. While our paradigm can be further improved, it translated tasks with verbal information transmission into a nonverbal domain, making it possible to test younger children without relying on their explicit conceptual understanding of generalisability.

Future studies could implement a manipulation check to clarify whether toddlers understood the generalisability of the functions which would help interpret the robust null findings found in this study. A follow-up study could be designed to specifically test this. For instance, after children discovered the functions of boxes independently and explored them simultaneously, the experimenter could show them a puppet, tell them the puppet wants to see the lights (i.e., when the light was the generalisable effect) and ask them which button the puppet should press to see the lights. Toddlers' choices could inform us whether they understand the generalisability of such stimuli. Alternatively, older children can be tested on the stimuli used in our study along with a version of verbal information tasks to see whether children's transmission decisions with respect to information generalisability converge between verbal and non-verbal domains.

In summary, our study suggests that unlike 4- to 7-year-old children, 2-year-olds do not display a preference to transmit generalisable information to others. These findings might suggest that sensitivity to generalisability as it relates to teaching-like contexts develops gradually and could be linked to linguistic information.

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Appendices and Supplementary Information

Appendices

Appendix A

t tests - Means: Difference between two dependent means (matched pairs)

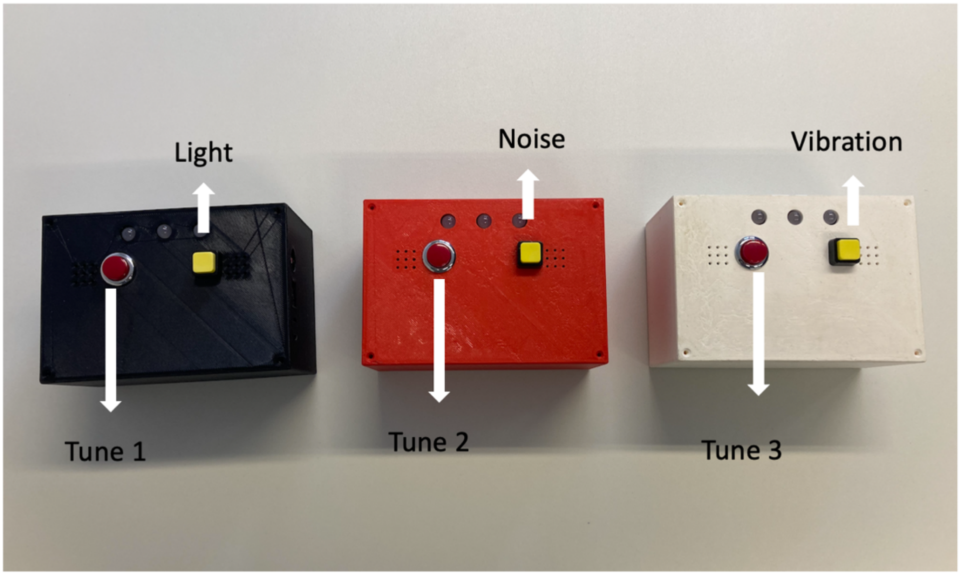
Analysis:	A priori: Compute required sample size		
Input:	Tail(s)	=	Two
	Effect size dz	=	0.5
	α err prob	=	0.05
	Power (1-β err prob)	=	0.90
Output:	Noncentrality parameter δ	=	3.3166248
	Critical t	=	2.0166922
	Df	=	43
	Total sample size	=	44
	Actual power	=	0.9000306

Appendix B

Figure S-1. Example Box

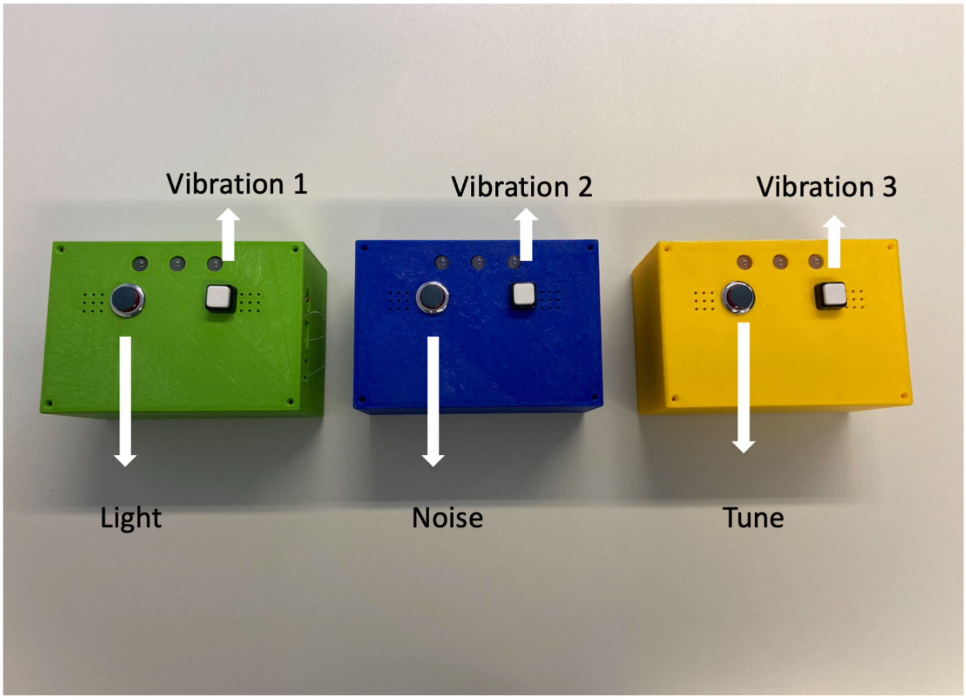
Note. Each of these buttons can do the following: Play one of 3 musical tunes, play one of 3 non- noises, perform one of 3 vibration patterns, activate one of 3 lights.

Figure S-2a. Box Set 1



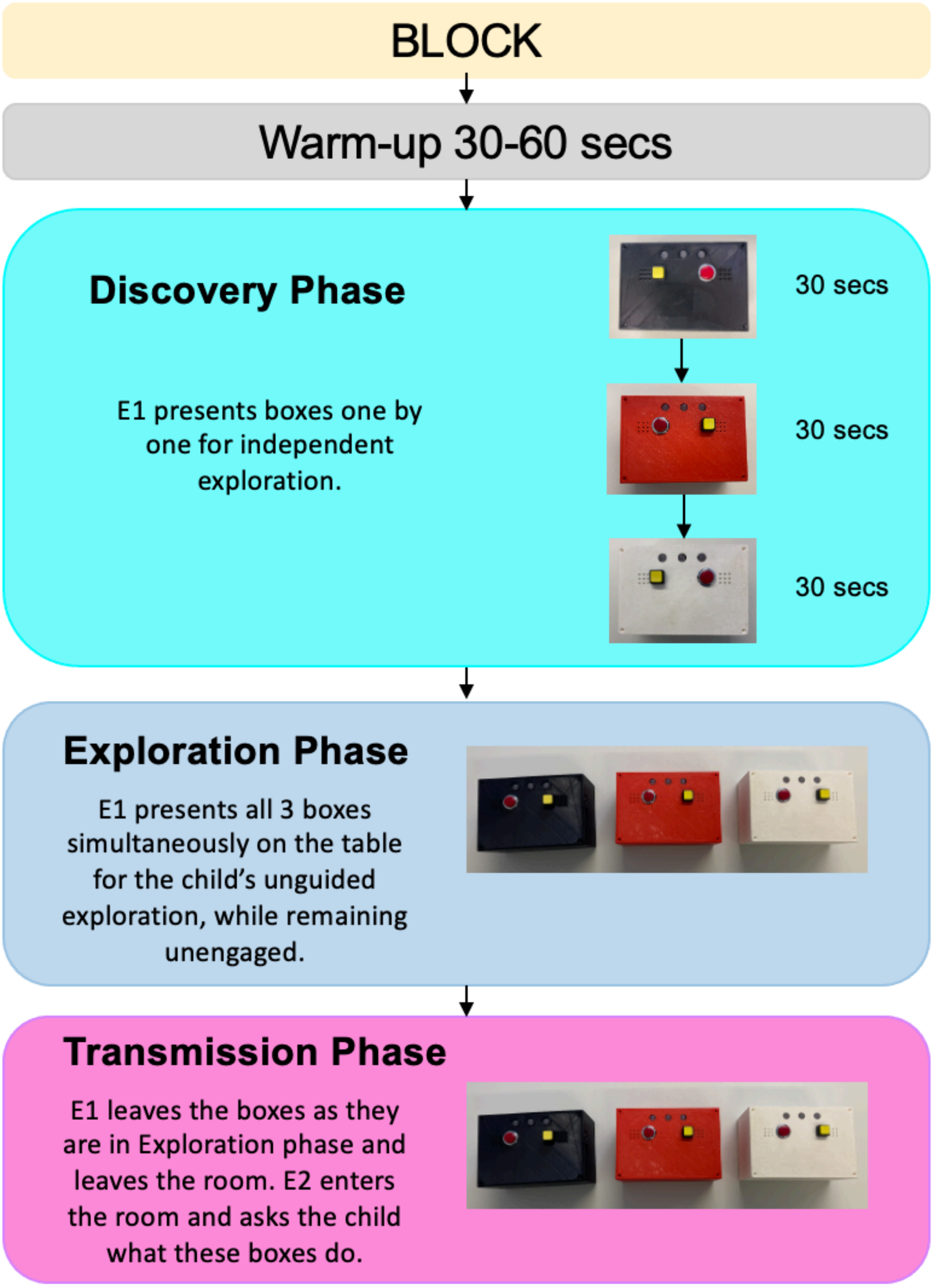
Round push buttons lead to GENERALIZABLE outcome (here, tunes)
Square push buttons lead to NONGENERALIZABLE outcome (here, light, noise, vibration pattern)

Figure S-2b. Box Set 2



Round push buttons lead to NONGENERALIZABLE outcome (here, light, noise, tune)
Square push buttons lead to GENERALIZABLE outcome (here, vibration pattern)

Figure S-3. Experimental Flow for a Block



Note. This is a depiction of one experimental block with an example of Box Set 1 (see Figure 2a). One of the same buttons in each box (round button in this case) produces varied tunes in each box; whereas the other one (square) produces a different effect in each box such as a light pattern, a non-musical noise, and a vibration pattern. The same procedure is repeated in Block 2 with Box Set 2, where the effects of the buttons are counterbalanced. So, one of the same buttons in each box will lead to a different vibration pattern (square button in this case), whereas the other one (round button) will lead to a different effect such as a light pattern, a non-musical noise, and a tune (e.g., Tune 1). See Supplementary Information for a detailed counterbalancing plan

Appendix C – Preregistered Analysis Plan

Table S1. Main Analyses Plan

Note. Please note that the main hypotheses that will be tested pertain to the Transmission Phase and we will use the cross-phase comparison to inform our interpretation of the results in the Transmission Phase. The bolded text represents the pre-registered interpretation that we ended up making based on the results.

Phase & Hypothesis	Operationalized hypothesis	Statistical tests	Interpretation
Transmission Phase: **1a. Initial Preference Hypothesis:** Toddlers will transmit generalisable information when asked by a naïve learner.	**1a.** Toddlers will produce the generalisable function first more often than they will produce the non-generalisable function first.	**1a.** One-sample t-test of score (+1 to -1) against chance (0) will be conducted.	**1a.** If the frequentist test shows significantly higher score than chance, toddlers preferentially transmit generalisable information first. If the frequentist test shows significantly lower score than chance, toddlers preferentially transmit nongeneralisable information first. **If the frequentist test result is at chance, and BF01 > 3, toddlers do not have a preference for transmitting generalisable or non-generalisable information first.** If the frequentist test is not significantly different from chance and BF01 < 3, results remain inconclusive.

1b. Systematic Preference Hypothesis: Toddlers will transmit the generalisability of the information when asked by a naïve learner. **Cross Phase Comparison:**	**1b.** Toddlers who demonstrate initial preference for generalisable information will produce the generalisable function as both first and second functions on two different boxes more often than the generalisable function as first and non-generalisable function as second functions across different boxes.	**1b.** One-sample t-test of score (+1 and -1) against chance (0) will be conducted.	**1b.** If the frequentist test shows significantly higher score than chance, toddlers systematically transmit generalisable information (i.e., the generalisability of information). If the frequentist test shows significantly lower score than chance, toddlers systematically transmit different types of information as first and second functions (i.e., generalisable first, non-generalisable second). **If the frequentist test result is at chance, and BF01 > 3, toddlers do not systematically transmit generalisability of information.** If the frequentist test is at chance and BF01 < 3, results remain inconclusive.

1a. Initial Preference Hypothesis: Toddlers will not explore generalisable function preferentially in the Exploration phase; however, they will transmit generalisable information preferentially in the Transmission phase.	**1a.** Toddlers will not produce the generalisable function as the first function preferentially in the Exploration phase, but they will produce the generalisable function as the first function preferentially in the Transmission phase.	**1a.** Paired-samples t-tests will be conducted on toddlers' averaged Exploration and Transmission first function scores from each block.	**1.** If the frequentist test shows significantly higher score for Transmission Phase, toddlers do not preferentially explore but preferentially transmit generalisable information. If the frequentist test shows significantly higher score for Exploration Phase, toddlers preferentially explore but do not preferentially transmit generalisable information. If the frequentist test result is not significantly different across phases, and BF01 > 3, toddlers neither preferentially explore nor transmit the same type of information. **If the frequentist test is not significantly different across phases and BF01 < 3, results remain inconclusive.**

Theoretical interpretation of the results

Main research question: Do toddlers preferentially transmit generalisable information?

1a- Do toddlers preferentially transmit generalisable information?

Initial Preference Hypothesis: Toddlers will preferentially transmit generalisable information. This will be measured by the first function that toddlers produce in the Transmission Phase.

1b- Do toddlers transmit that the information is generalisable?
Systematic Preference Hypothesis: Toddlers will transmit that the information is generalisable. This will be measured by the second function that toddlers produce on a different box after showing a generalisable function as the first function.
Interpretation:

Since the type of generalisable information (i.e., the perceptual effects: tune, light, noise, vibration) will be counterbalanced and the first function that toddlers transmit will be measured, this behaviour is unlikely to be driven by their own interest in certain types of perceptual effects. If toddlers transmit generalisable information as first and second functions, there are two ways to interpret this result: ***Strong argument:*** Toddlers transmit the generalisability of the information, rather than the generalisable information itself. ***Weak argument:*** If toddlers find generalisable information more interesting for themselves, they will transmit that information as the second function as well. However, it can be speculated that this is less likely because in the transmission phase, the learner specifically asks the child “What do these boxes do? Can you show me?” Previous findings in the literature on infant helping behaviours suggest that 12-month-old infants are sensitive to the others’ needs and provide necessary help when they are asked for help (e.g., Liszkowski, Carpenter, & Tomasello, 2008, upon searching for the unknown location of an object, the actor asks infants: “Hmm? Where has it gone? “Where is it?” and receives help); hence toddlers in our sample are expected to take such requests into account rather than just act out of their own interest (as they would do in the preceding Exploration phase of the experiment). Evidence for either the weak or strong argument will also come from comparing toddlers’ performance in the Exploration and Transmission phases. Namely, if toddlers produce generalisable functions preferentially (as both first and second functions) in the Exploration phase, as well as the Transmission phase, this would support the weak argument. However, if toddlers produce generalisable functions preferentially (as both first and second functions) only in the Transmission Phase, this would support the strong argument. On the other hand, if the first function transmitted is generalisable whereas the second is not, this might be because toddlers themselves found generalisable information more interesting but not enough so to show the generalisability of the information to the naïve recipient

Exploratory Analyses

Unexpectedly, almost half of the toddlers who passed the inclusion criteria (n = 22/49) only contributed data from one block. To investigate if contributing data for both blocks vs one block could influence the results, we repeated the same planned analyses reported above with the data from the "first contributed block" only, thus eliminating the "both" functions option (assigned the score of "0").

Hypothesis 1a - Initial Preference: For this analysis, 49 children contributed data. Among these, 30 children showed a generalisable function as the first function, whereas 19 children showed a non-generalisable function. A one-sample Wilcoxon test showed that children's first function choice did not significantly differ from chance ($W(48) = 750.00$, $p = .117$, $r = .224$). A default Bayes factor with a wide Cauchy distribution centred at 0.707 showed anecdotal support for the null hypothesis, BF01 = 2.887, (Median δ = 0.182, 95% CI δ [-0.137- 0.510]).

Hypothesis 1b - Systematic Preference: For this analysis, we focused on the data from 30 children who transmitted the generalisable function as the first function in their "first contributed block", and we analysed the second function that children transmitted. Three children showed only one function in the transmission phase, so their data were not included in this analysis. A one-sample Wilcoxon test showed that children's choices for the generalisable function as the second function did not significantly differ from chance ($W(26) = 210.00$, $p = .573$). A default Bayes factor with a wide Cauchy distribution centred at 0.707 showed moderate support for the null hypothesis, BF01 = 3.804 (Median δ = 0.088, 95% CI δ [-0.332- 0.505]).

Cross-phase Comparison: A Wilcoxon signed-rank test showed that toddlers' first choices did not significantly differ across Exploration ($M = 0.125$, $SD = 1.003$) and Transmission Phases ($M = 0.224$, $SD = 0.985$), $W(47) = 48.00$, $p = .458$. A default Bayes factor with a wide Cauchy distribution centred at 0.707 showed moderate support for the null hypothesis, BF01 = 4.723, (Median δ = -0.094, 95% CI δ [-0.407- 0.219]). Overall, the results of the exploratory analyses remained the same as with the planned analyses.

Manipulation Check for Effect Type

As part of the necessary protocol changes, we added a manipulation check to see if different types of generalisable effects had an influence on the first function that children showed in the Transmission phase in all eligible trials (n = 76). We conducted a Chi-Square Test of Independence to assess the relationship between the type of generalisable effect (tune, light, vibration, noise) and the first function transmitted (generalisable vs. non-generalisable). There was no significant relationship between the two variables, X^2 *(3,76) = 1.685, p = .640 (See Table 2), confirming that there was no effect of the function type on children's choices*.

Table S2. Distribution of first function in Transmission Phase across different types of effects

Type of Generalisable Effect	**Transmission First Function**		
	Generalisable	**Non-generalisable**	**Total**
Light	10	11	21
Noise	11	5	16
Tune	11	9	20
Vibration	11	8	19
Total	43	33	76

Counterbalancing Plan

Box set: Set 1 (black-white-red) Set 2 (green-blue-yellow)

– The order of presentation for the box sets will be counterbalanced across participants (e.g., Set 1 in Block1, Set 2 in Block 2 –Orders 1-4– vs. Set 2 in Block 1, Set 1 in Block 2 –Orders 5-8–).

Button orientation: Round button-left/Square button-right vs. Square button-left/Round button-right.

– The button orientation was counterbalanced across participants (e.g., one child saw the "Round button-left/Square-right" combination whereas the other saw the "Square button-left/Round button-right" combination).

Generalisable outcome: Light, Vibration, Non-musical Sound, Tune.

– Generalisable outcome were counterbalanced both within and across participants. Since each participant could have only 2 blocks, they could only see two of these perceptual effects as generalisable outcomes (e.g., Participant 1: light & tune, Participant 2: noise & vibration, Participant 3: tune & vibration, Participant 4: noise-light).

Button-Outcome matching: Round button-generalisable, Square button-nongeneralisable vs. Square button- generalisable, Round button-nongeneralisable.

– The button-outcome matching was counterbalanced within participant (e.g., in Block 1, round button leads to generalisable outcome whereas square button leads to nongeneralisable outcome; in Block 2, round button leads to nongeneralisable outcome whereas square button leads to generalisable outcome)

See the orders below:

		Block 1			Block 2		
Order 1	**Colour of the box**	Box 1	Box 2	Box 3	Box 4	Box 5	Box 6
	Button orientation	Round button-left & Square button-right	Round button-left & Square button-right	Round button-left & Square button-right	Round button-left & Square button-right	Round button-left & Square button-right	Round button-left & Square button-right
	Generalizable Outcome	Round button-Tune 1	Round button-Tune 2	Round-button-Tune 3	Square button-Light 1	Square button - Light 2	Square button- Light 3
	Specific Outcome	Square button- Vibration 1	Square button- Noise 1	Square button-Light 1	Round button-Vibratio	Round button-Noise 1	Round button-Tune 1

		Block 1			Block 2		
Order 2	**Colour of the box**	Box 1	Box 2	Box 3	Box 4	Box 5	Box 6
	Button orientation	Round button-left & Square button-right	Round button-left & Square button-right	Round button-left & Square button-right	Round button-left & Square button-right	Round button-left & Square button-right	Round button-left & Square button-right
	Generalizable Outcome	Round button-Noise 1	Round button-Noise 2	Round-button-Noise 3	Square button- Vibration 1	Square button- Vibration 2	Square button- Vibration 3
	Specific Outcome	Square button- Vibration 1	Square button- Tune 1	Square button-Light 1	Round button-Light 1	Round button-Noise 1	Round button-Tune 1

		Block 1			Block 2		
Order 3	**Colour of the box**	Box 1	Box 2	Box 3	Box 4	Box 5	Box 6
	Button orientation	Round button-left & Square button-right	Round button-left & Square button-right	Round button-left & Square button-right	Round button-left & Square button-right	Round button-left & Square button-right	Round button-left & Square button-right
	Generalizable Outcome	Round button- Vibration 1	Round button- Vibration 2	Round-button- Vibration 3	Square button- Tune 1	Square button- Tune 2	Square button- Tune 3
	Specific Outcome	Square button- Tune 1	Square button- Noise 1	Square button- Light 1	Round button-Vibratio	Round button-Noise 1	Round button-Light 1

		Block 1			Block 2		
Order 4	**Colour of the box**	Box 1	Box 2	Box 3	Box 4	Box 5	Box 6
	Button orientation	Round button-left & Square button-right	Round button-left & Square button-right	Round button-left & Square button-right	Round button-left & Square button-right	Round button-left & Square button-right	Round button-left & Square button-right
	Generalizable Outcome	Round button-Light 1	Round button-Light 2	Round-button-Light 3	Square button- Noise 1	Square button - Noise 2	Square button- Noise 3
	Specific Outcome	Square button- Vibration 1	Square button- Tune 1	Square button- Noise 1	Round button- Vibration 1	Round button- Light 1	Round button- Tune 1

		Block 1			Block 2		
Order 5	**Colour of the box**	Box 4	Box 5	Box 6	Box 1	Box 2	Box 3
	Button orientation	Round button-right & Square button-left	Round button-right & Square button-left	Round button-right & Square button-left	Round button-right & Square button-left	Round button-right & Square button-left	Round button-right & Square button-left
	Generalizable Outcome	Round button-Tune 1	Round button-Tune 2	Round-button-Tune 3	Square button-Light 1	Square button - Light 2	Square button- Light 3
	Specific Outcome	Square button- Vibration 1	Square button- Noise 1	Square button-Light 1	Round button-Vibratio	Round button-Noise 1	Round button-Tune 1

		Block 1				Block 2		
Order 6	Colour of the box	Box 4	Box 5	Box 6		Box 1	Box 2	Box 3
	Button orientation	Round button-right & Square button-left	Round button-right & Square button-left	Round button-right & Square button-left		Round button-right & Square button-left	Round button-right & Square button-left	Round button-right & Square button-left
	Generalizable Outcome	Round button-Noise 1	Round button-Noise 2	Round-button-Noise 3		Square button-Vibration 1	Square button - Vibration 2	Square button- Vibration 3
	Specific Outcome	Square button-Vibration 1	Square button- Tune 1	Square button-Light 1		Round button-Light 1	Round button-Noise 1	Round button-Tune 1

		Block 1				Block 2		
Order 7	Colour of the box	Box 4	Box 5	Box 6		Box 1	Box 2	Box 3
	Button orientation	Round button-right & Square button-left	Round button-right & Square button-left	Round button-right & Square button-left		Round button-right & Square button-left	Round button-right & Square button-left	Round button-right & Square button-left
	Generalizable Outcome	Round button-Vibration 1	Round button-Vibration 2	Round button-Vibration 3		Square button- Tune 1	Square button- Tune 2	Square button- Tune 3
	Specific Outcome	Square button- Tune 1	Square button- Noise 1	Square button- Light 1		Round button-Vibratio	Round button-Noise 1	Round button-Light 1

		Block 1				Block 2		
Order 8	Colour of the box	Box 4	Box 5	Box 6		Box 1	Box 2	Box 3
	Button orientation	Round button-right & Square button-left	Round button-right & Square button-left	Round button-right & Square button-left		Round button-right & Square button-left	Round button-right & Square button-left	Round button-right & Square button-left
	Generalizable Outcome	Round button-Light 1	Round button-Light 2	Round-button-Light 3		Square button- Noise 1	Square button -Noise 2	Square button- Noise 3
	Specific Outcome	Square button-Vibration 1	Square button- Tune 1	Square button- Noise 1		Round button-Vibration 1	Round button- Light 1	Round button- Tune 1

3. Chapter 3: Two-year-old, but not 5-year-old Children Preferentially Transmit Instructed over Self-discovered Information

3.1. Linking Statement

Extending the findings from the Chapter 2, which examined whether toddlers preferentially transmit generalisable information to others in an action-based task, the following chapter will focus on a related but distinct aspect of what information is selected by children for further transmission. Specifically, our focus in this chapter moves to understanding the nuances of how 2- and 5-year-old children distinguish between and choose to transmit information that they previously learned through self-exploration or through others' explicit instruction. This was motivated by the reasoning that salience of the cues associated with the information and the learning context might play an important role in the selection of information for further information transmission. Further, we argue that a potential preference for transmitting information acquired through a particular manner might undergo a change in relation to the developmental milestones achieved with age (such as better language skills, theory of mind, executive function, understanding of norms and social structures as well as more experience with different methods of learning). Here, we conducted 2 experiments with two age groups: 2-year-olds who are exposed to other's instruction primarily within informal play contexts, and 5-year-olds who have experiences with a broader spectrum of learning methods including formal pedagogical settings and possess more developed socio-cognitive skills.

This chapter aims to uncover whether the propensity to transmit explicitly taught information over self-explored information is a developmental tendency that transforms as children grow. This exploration is an important first step in enhancing our understanding of the mechanisms of early information transmission and in generating new insights into how such phenomena are studied and conceptualised from early development onwards.

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Two-year-old but not 5-year-old Children Preferentially Transmit Instructed over Self-discovered Information

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The data and analysis output necessary to reproduce the analyses presented here are publicly accessible on Open Science Framework (OSF) through this link. The materials necessary to attempt to replicate the findings presented here are not publicly accessible due to the nature of the stimuli; however, extensive description is provided in the Method section. The analyses presented here were not preregistered.

This paper constitutes a part of the doctoral dissertation of the first author.

Declaration of conflicting interests: The authors have no conflict to declare.

3.2. Abstract

The current study aimed to investigate whether young children make a distinction between two types of information – self-explored vs taught – when they transmit information to others, and whether these preferences undergo a developmental change. Two- and 5-year-old children (N = 82, 37 females, predominantly White) learned about functions of novel boxes either through self-exploration or through being taught and were then asked to share information about these boxes with a naïve learner. Two-year-old children transmitted the instructed function first more often than the self-explored function (*Cohen's d = .55*) whereas 5-year-olds did not show a preference. Implications of these results with respect to development and selectivity in teaching are discussed.

Keywords:

- information transmission,
- preferential transmission,
- instruction,
- exploration,
- developmental change,
- teaching.

3.3. Introduction

From the moment they are born, infants embark on an immense learning journey about how the world works. Although there are many formal and informal routes to knowledge (Rogoff et al., 2016), two important ways in which children effectively acquire knowledge are learning through independent exploration, and through others' explicit instruction. From infancy, they actively drive their own learning experience by selectively attending to visual stimuli and manipulating objects in diverse manners, and with increasing age their exploration becomes more sophisticated (e.g., Chen et al., 2022; Kidd et al., 2012, Sim & Xu, 2017; see Schulz, 2012 for a review). Through independent exploration, children learn ample information about the world such as how novel objects function (e.g., Bonawitz et al., 2011; Schulz & Bonawitz, 2007) and causal mechanisms inherent to their environment (e.g., Sobel & Sommerville, 2010; Yuniarto et al., 2020). When interacting with novel objects, children seem to prioritize the evidence that they themselves generated over the evidence generated by others and learn better from their own interventions (e.g., Kushnir & Gopnik, 2005; Schulz et al., 2007; Sobel & Sommerville, 2010). For instance, Sobel and Sommerville (2010) presented 4-year-old children with a novel box featuring different underlying causal relations as to how different buttons could activate different coloured lights (e.g., the button associated with a red light could also activate the green light but not vice versa). After familiarizing them with the novel box, children were assigned to three conditions: discovery (i.e., children acted on the novel box to discover the novel causal relationship, then watched the experimenter act on the box), confirmation (i.e., children first observed an experimenter and then acted on the box themselves to confirm the efficacy of the actions that were previously performed), and observation condition (i.e., children only observed others act on the novel box), and were later asked several questions about the underlying causal structure of the box. Children who acted on the novel box to discover rather than to confirm or observe the efficacy of the actions performed better with regards to understanding the causal structure of the box.

While children are good at learning from independent exploration, a considerable amount of what they learn about the world is achieved through the involvement of others such as observing them, watching their explicit demonstrations, or receiving information from them (Harris, 2012; Paradise & Rogoff, 2009; Tomasello, 1999). Learning from instruction in a play situation can take different forms, from being presented with objects and labels on a screen or being provided labels of physical objects (e.g., Hilton & Westermann, 2017; Ma et al., 2022; Suanda et al., 2019), to being shown how to operate a toy or use a tool (e.g., Bazhydai, Silverstein et al., 2020; Bonawitz et al., 2011), to being verbally informed about a particular topic by another person (e.g., Gelman & Markman, 1987; Lane & Shafto, 2017), or to being corrected upon making a mistake (e.g., Wood et al., 1978). While observing others and acting on the world based on the observed information can be crucial for learning (Paradise & Rogoff, 2009), as children get older, the amount and complexity of information that they learn through others increases and goes beyond the limits of the observable and actionable physical world (Harris, 2012). By benefiting from both their own independent exploration and the instruction of other people, children accumulate most of their knowledge repertoire.

When information transmission is considered, the possession of knowledge is undoubtedly a defining feature of the teacher. In a typical teaching-like situation, the knowledgeable ones (often adults such as parents, teachers, or older siblings) share information with the less knowledgeable ones, typically children, pupils, or younger siblings. Even though typically maturity is associated with increased knowledge, the knowledge states can also be transient, and parties that are typically knowledgeable might be the ones lacking information depending on the immediate informational context. As a result, the knowledge exchange between adults and children is often bidirectional because the acquired information can then be used by children to inform others; however, children's role as useful, informative teachers remains disproportionately understudied.

While being active learners, young children also effectively pass on the information that they possess to others (Bazhydai & Harris, 2021; Gweon, 2021). Initial forms of information transmission (i.e., providing episodic information that is relevant and accurate at a given time) emerge as early as 12 months through pointing (e.g., Liszkowski et al., 2006); however, most of the studies investigating children's information transmission have focused on children older than 4 years (see Gweon, 2021; Strauss & Ziv, 2012 for reviews). While there have been some studies that might be evaluated as providing support for early teaching abilities of children, these studies mostly focused on children's instrumental helping rather than informing behaviour (e.g., Buttelmann et al., 2009; Martin & Olson, 2013; Warneken & Tomasello, 2006, 2007). Although there are undeniable parallels between these behaviours such as considering the needs of others (in case of helping) and others' lack of knowledge (in case of informing), there are also important differences. For instance, by nature, instrumental helping relates to the "here-and-now", whereas informing – while still applicable to the "here-and-now" – tends to transcend the momentary goals as information is retained beyond the here and now which might employ different socio-cognitive mechanisms. Despite the emergence of studies on early information transmission, research with infants and toddlers is still in its infancy compared to information transmission that becomes reliable at age 4. This is surprising as theoretical arguments about children's information transmission are often focused on rich explanations assuming complex skills (e.g., ascribing intentionality and theory of mind; see Corriveau et al., 2018; Strauss, 2022) that may arguably not be present in younger children (Kulke et al., 2018).

Children between 3.5 and 5 years, increasingly share information with others. These transmission episodes start as mere demonstrations of actions necessary to achieve a goal such as playing a game. Later, these demonstrations are woven into instructions that are accompanied by, for example, explaining game rules (e.g., Davis-Unger & Carlson, 2008; Strauss et al. 2002). Like any other cognitive ability, children's information transmission skills get better and become more sophisticated with age (Strauss & Ziv, 2012) as they start applying a more tailored approach to their information transmission by considering a multitude of factors including who they share information with (e.g., Karadağ & Soley, 2022; Kim et al., 2016) and what type of information they transmit to others (e.g., Bridgers et al., 2020; Danovitch et al., 2023; Gweon & Schulz, 2019; Pueschel et al., 2022; Pueschel et al., 2023). Despite these findings, the current body of research is insufficient to explain how this complex teaching behaviour that we see in older children emerges in infancy and toddlerhood when children have limited socio-cognitive skills.

While children's decisions as to what information to transmit to others are often influenced by what others know or do not know, considering the vast variability in knowledge levels between individuals, focusing solely on a knowledge gap (e.g., Strauss et al., 2002) is not always useful for effective information transmission. Instead, it might be more beneficial to invest transmission efforts in imparting information that holds a certain unique significance. Such significance might depend on the inherent properties of the information, such as the complexity, generalisability, or social relevance of information (Ronfard & Harris, 2018), as well as the context in which they learned about it, such as whether they were explicitly taught about it or learned it through their self-exploration (Bazhydai & Karadağ, 2022). A question that remains unanswered is, then, whether the way in which toddlers and children learn information influences what they themselves transmit to other people. It is possible that children's own learning history might drive what they select to transmit (Ronfard et al., 2016). Indeed, a specific claim has been made about preferential transmission of information learned through others' instruction (Vredenburgh et al., 2015), arguing for a special status of taught information by the virtue of ostensive communication signalling culturally relevant generalisable knowledge (see also Csibra & Gergely, 2009, 2011, though their theory does not make assumptions about child-led information transmission). Ostensive cues are important for attention selection and might influence how children make inferences about information acquired in different contexts (e.g., learner-driven or teacher-led) (Butler & Markman, 2012; Buchsbaum et al., 2011; Rhodes et al., 2010); however, their engagement with the pedagogically acquired information does not stay uniform and children can increasingly combine different cues in their learning environment and treat the information acquired through these cues in more nuanced ways.

While it is possible that children might nonetheless prioritize taught information for transmission, the existing evidence is not strong enough to support this notion especially for younger children because a handful of findings specifically on this question have been conflicting. Vredenburgh and colleagues (2015) found that 2-year-old children learn from adults' pedagogical demonstrations (i.e., accompanied by ostensive cues) equally well as from non-pedagogical demonstrations (i.e., intentional but lacking ostensive cues); however, they preferentially transmitted pedagogically acquired actions to a naïve recipient (Vredenburgh et al., 2015). In a later study, however, this finding was not replicated, and 2-years-olds did not show any preference between choosing to transmit actions learned through pedagogical or non-pedagogical demonstrations. Instead, their transmission was influenced by the complexity of the information favouring a simple over a complex action (Bazhydai, Silverstein et al., 2020). Considering these findings, whether toddlers have a preference for transmitting taught information, or not is not clear. While toddlers may be sensitive to, and their learning might benefit from, ostensive communication, this alone is not enough to prescribe a special status to ostensively communicated information enabling copying or propagating it as culturally relevant (e.g., Bazhydai, Silverstein et al., 2020; Tecwyn et al., 2020). It is important to note that in both studies the main experimental manipulation was whether children were taught ostensively or not. Thus, these two studies do not provide us with insights about children's preferential transmission when taught information is pitted against self-explored information.

Another study, on the other hand, addressed this specific question. Ronfard and colleagues (2016) investigated whether 4- to 7-year-old children's teaching would be influenced by how they initially learned about the target information (i.e., their own learning history). They presented children with novel puzzle boxes holding stickers inside and taught them different methods varying in complexity to retrieve the stickers from the box. Additionally, half of the children were provided with a chance to actively explore the boxes before being taught how to retrieve the stickers. The authors found that children transmitted the method faithfully if they only learned it through instruction, and they preferentially transmitted the taught over the self-discovered method only when the taught method was more complex to figure out on their own. Finally, when the difficulty of both methods was similar, they did not show a preference for either method in their transmission decisions. Ronfard and colleagues (2016) concluded that, at this age, children's information transmission is influenced by how children themselves initially acquired the information in conjunction with the complexity of the acquired information. However, two aspects of the study should be noted: the nature of the tasks was instrumental to retrieving a reward, and the information learned was causally relevant to the instrumental goal. These two aspects might have primed children to consider other factors such as figuring out the quickest and/or more efficient way of retrieving the reward from the box in addition to how they learned about the different methods ("naïve utility calculus", e.g., Aboody, et al., 2021; Jara-Ettinger et al., 2016).

Combined, while the findings reported above generate important insights regarding older children's behaviour, they shed little light on the question whether children, especially toddlers, would transmit taught or self-explored information preferentially when there is no immediate instrumental goal. One could expect a preference for both transmitting information acquired through instruction and self-exploration simply because the information learned through these different means can be differently salient. Salience is often described in relation to attention selection (Koch & Ullman, 1985; Posner, 1980) such that the properties of the external world that are immediately attention-grabbing and difficult to suppress or ignore are considered salient. This is important because salience positively biases information retention and salient information is often processed better than non-salient information (Santangelo, 2015). In any learning situation, then, there are differently weighted cues associated both with the information itself (i.e., how salient the different features of the object are) and the learning context (i.e., how salient the learning from self-generated actions or other's instruction is to the learner). The combined salience of these different cues is weighted against each other by the learner implicitly, and the more salient cues are selected for further learning (see Yurovsky & Frank, 2017 for a similar approach in the word learning domain). This approach can be applied to the information transmission context as well (Bazhydai, Silverstein et al., 2020), such that the weight assigned to different salience-based cues during learning might influence what information children transmit to others leading them to form a preference for one over the other. The salience-based cues might be related to either the properties of information or the learning context associated with this information. By keeping the former almost identical for each learning context, it is possible to test the role of the learning context on children's subsequent transmission of learned information.

Taking children's competence in learning from independent exploration into this salience-based account, one could argue that children might be inclined to preferentially transfer this type of information to others. In other words, this potential preference might stem from the salience of their own self-exploration. For example, when children act on an object independently, their interaction with the object is more likely to be driven by their own interests (e.g., Mani & Ackerman, 2018, in the context of word learning) compared to when they would be explicitly (and passively) taught the same information by others. Supporting the role of self-exploration argument, a recent study conducted with 3- to 5-year-old children found that children tend to overestimate the role of one's own actions on others' learning, even when they observe that learning actually occurs through the instruction of a teacher rather than through self-exploration of the learner (Sobel & Letourneau, 2018). Thus, at the core of this argument is the idea that if learning about an object is self-driven by inherent attention, interest or simply the involvement of the self (through self-generated, unsupervised actions) during the learning process, transmitting what was learned through this salient self-led exploration might be prioritized.

On the other hand, children might prefer to transmit information that they were explicitly taught due to their heightened attention to the context where a social partner, typically using ostensive cues, demonstrated a particular action or shared new facts. Based on the salience-based account, this would increase the child's focus on the learning environment without the need to assume its special status due to communicative and referential intentions of social partners (Heyes, 2016; 2017). While acknowledging the prominence of ostensive communication in children's learning, it can be ultimately construed as one of the cues among other highly salient social and non-social cues.

As children get older, a developmental change in their preferential transmission might occur. This might be because the weights initially assigned to different salience-based cues might change or because older children might be better able to use and weigh these cues due to the development in their cognitive skills such as attention, working memory or inhibition (Yurovsky & Frank, 2017). Additionally, children's developing understanding of the knowledge exchange process, theory of mind and executive functioning skills and increased exposure to more formal modes of learning, such as schooling, might overall contribute to how the salience of different information is processed, and how different salience cues are integrated, and how they may guide decision-making.

Hence, investigating whether children would preferentially transmit taught or self-explored information in light of this framework might provide a new venue for the debate on the factors that influence children's preferential information transmission.

3.4. The Current Study

In this study, we asked whether toddlers and children selectively transmit information that they were explicitly taught over the information that they self-explored. Since both possibilities are motivated by the salience-based account as both carry the salient weight, we did not form a directional hypothesis.

We further reasoned that children's preference for one type of information over the other might undergo a developmental change. Thus, we investigated this question with two age groups, 2- and 5-year-old children who are different from each other in several aspects (e.g., language skills, executive function, theory of mind, social and normative understanding) and have different learning experiences (e.g., 2-year-olds are only exposed to instruction in informal play contexts, whereas 5-year-olds are exposed to both formal and informal educational settings as well as are able to demonstrate more sophisticated exploration skills). We report the study with 2-year-olds in Experiment 1 and the study using the slightly modified paradigm with 5-year-olds in Experiment 2.

3.4.1. Experiment 1

3.4.1.2. Method

3.4.1.2.1. Participants

Forty-one 2-year-old, healthy, predominantly White, middle-class, English-speaking children living in Lancashire County in Northwest England (*Mage* = 24.75 months, Range = 22.86 – 26.20, 18 females) were recruited to take part in this study. Data from three participants were excluded, with 38 participants in the final data (See Results for exclusion criteria). This age group was chosen in line with previous research on toddlers' information transmission suggesting that children at this age can readily transmit information that they acquired from others (Bazhydai et al., 2020; Vredenburgh et al., 2015). Ethics approval was received from the Faculty of Science and Technology

Research Ethics Committee at Lancaster University. Data collection took place between December 2021 and September 2022. Participants were recruited from the Lancaster University Babylab database and social media accounts, were compensated with £5 for their travel expenses and received a storybook or a T-shirt to take home with them as a thank-you gift.

3.4.1.2.2. Materials and Stimuli

Four novel wooden boxes were created for this study (i.e., two sound boxes and two light boxes). The two sound boxes were perceptually almost identical. They were both oval-shaped, orange and each had one push button on one side of the box (i.e., Box 1 had a black button on the left side of the box, where Box 2 had a silver button on the right side of the box). Each box played a different novel tune that was composed using simple tones, and each tune lasted around 3 seconds. The two light boxes were also perceptually almost identical. They were both rectangular with a rounded top, green and each had one small push button and a light bulb on one side of the box (i.e., Box 1 had a red button and a green bulb on the left side of the box, whereas Box 2 had a silver button and red bulb on the right side of the box). Each box turned on a different coloured light though the lights were dependent on the button presses, thus, they were on as long as the push buttons were pressed (See Figure 1 for the Stimuli). It should be noted that the stimuli were designed to test both 2-year-old toddlers and 5-year-old children. Since the younger age group has limited skills compared to the older age group, we focused on 2-year-old toddlers' communicative and cognitive capacities when designing the study. This led us to design a task that would not rely on language skills and create simpler toys with few functions that would be engaging enough but not too distracting.

Figure 1. Box sets used as stimuli.

3.4.1.2.3. Design and Procedure

Testing took place at the Lancaster University Babylab. Before coming to the lab, researchers sent the informed consent form through a Qualtrics link to the parents along with the lab approved testing guidelines during pandemic. Two experimenters who were equally friendly and child-directed interacted with the child. After welcoming the participant and the caregivers into the lab, Experimenter 1 (E1) explained the aim of the study and the experimental procedure, went over the key points in the informed consent form and ensured that the informed consent form was filled in by the caregivers. Later, E1 provided a chance for the caregivers to ask any questions that they might have about the study and invited the dyad into the testing room. There were two blocks per child with two different sets of objects (i.e., sound boxes vs. light boxes). Since the boxes were almost identical, the main manipulation was whether participants learned about the boxes through independent exploration or through the experimenter's instruction.

Before the study, both E1 and E2 played with the child for about a minute using a wooden marble run game to familiarize the child with the experimental set-up.

Learning Phase. This phase had two trials. In each trial, one box from each set (i.e., sound boxes vs. light boxes) were presented. Children learned about the boxes in different ways such that if the first box was shown by E1, the second box was independently explored by the child, and vice versa. The boxes used in the procedure were hidden in a cupboard under the table away from the child's view. E1 initiated the procedure by telling the child that she had some toys that she wanted to show them by saying "Let's now play with other toys, let me show you one". Then, E1 took out one of the sound boxes. In the first trial (e.g., *instruction-first* order), E1 took out the first box and put it on the table outside the child's reach. Upon making sure that the child was attending to the box and making eye-contact with the child, E1 told the child "Look [child's name]! This is how it works.", then demonstrated the target function of the box once. E1 told the child "Your turn" then pushed the box within the child's reach for the child to try. If the child did not engage with the box after 10 seconds, E1 prompted the child by saying "Do you want to play with it?", if children played with the box, then stopped but had still time to play, E1 told the child "You can play more if you want." After 20 seconds had elapsed, E1 took the box away from the child and thanked the child. By putting the first box back into the cupboard, E1 took out the second box. This time the experimenter held the box in her hands, turned it around for a second and told the child "Oh, you can play with it", then put the box within the child's reach without showing how the box worked. After giving the box to the child, E1 took her phone and pretended to engage with her phone as the child played with the toy. If the child did not explore the box within 10 seconds, E1 looked at the child and said, "Do you want to play with it?". If the child played initially but stopped and still had the time, E1 said "You can play more if you want". After 20 seconds had elapsed, E1 took the box away from the child and thanked them. Then, E1 took both boxes from the cupboard when E2 knocked on the door. E1 told the child, "Did you hear that? I think they need me outside; I will go but I will come back. Can you wait for me here?". E1 put the boxes on her chair and left the room. Immediately, E2 entered the room and initiated the transmission phase.

Transmission Phase. E2 approached the child and said "Hi [child's name], are you okay?" Then, E2 looked at the chair, noticed the boxes E2 and said "Wow, what are these? I haven't seen these before!" E2 then took the boxes and put them on the table, and by pushing the boxes toward the child, asked "What do these do? Can you show me?" and looked at the child smiling. If the child did not show anything on the box within 10 seconds, the experimenter prompted the child by saying "Can you show me what these toys do?". If the child showed anything, E2 followed up with saying phrases like "oh", "wow", "cool", "thank you for showing me". After 20 seconds had elapsed, E2 thanked the child and took the boxes and left the room. Then, E1 re-entered the room and repeated the whole procedure with a different set of boxes with different effects (e.g., light boxes) in the second order (*exploration-first* order). The orders used in the two trials were counterbalanced across participants (See Figure 2).

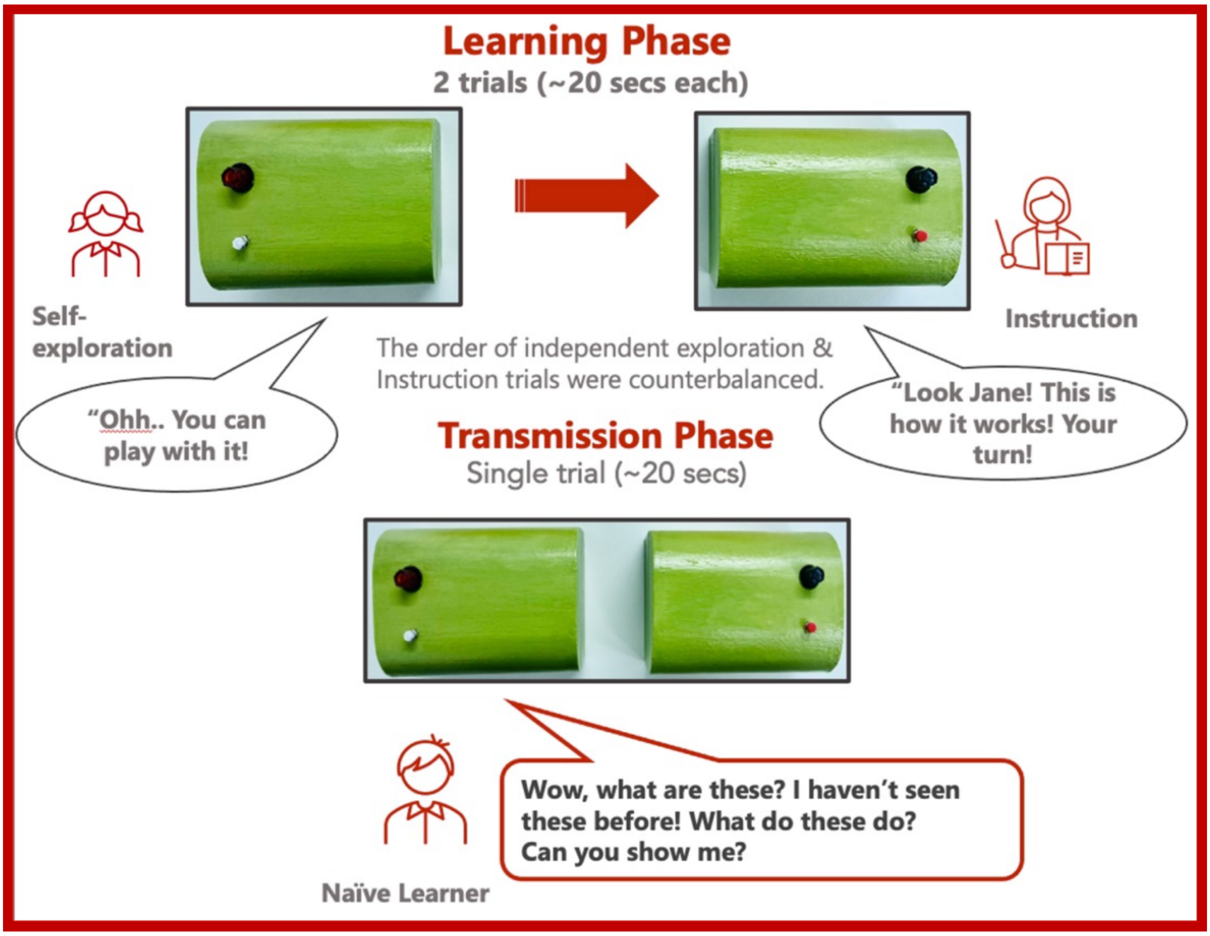

Figure 2. Visual depiction of the procedure in both Experiment 1 and 2.

The order of presentation (i.e., *instruction-first* vs. *exploration-first)* was counterbalanced both within and between blocks and between children. The order of presentation for the sound vs. light boxes was counterbalanced across children.

3.4.1.2.4. Measures and Coding

Behavioural coding was done offline from the video recordings. A second coder coded 25% of all videos, and a Kappa statistic of .70 and a Cronbach's α statistic of .80 were aimed for agreement across coders for dichotomous and continuous variables, respectively. The results of the reliability analyses showed a perfect Kappa statistic of 1.00 for categorical variables and a minimum Cronbach's α statistic of .90 for continuous variables. All disagreements were resolved through discussion and a third coder's judgment.

Learning Phase: We coded whether children activated each function that was either explored independently or taught at least once. If children did not activate one of the functions at least once, that trial was discarded from the analyses. Additionally, we coded how many times children activated each function.

Transmission Phase: For the main outcome of interest, we coded the first function that children showed to E2. We also coded how many times they activated each function in each trial as an additional measure. The choice of these measures and the coding procedure was based on the preceding research in information transmission by Bazhydai, Silverstein and colleagues (2020) and by Vredenburgh and colleagues (2015) – i.e., first function and the number of actions. Some children contributed data for both trials, whereas others contributed data for only one trial. If children contributed data for both trials, their overall scores were calculated by averaging their choices as follows. If a child showed the "Instructed" or "Explored" function as first choices in both trials, they were given +1 or -1 respectively. If they showed different function as first choices in both trials (e.g., showing the "Instructed" function in the first trial and showing the "Explored" function in the second trial) or if they showed both functions simultaneously in both trials, they were given a score of 0. Finally, if they showed both functions simultaneously in one trial and either "Instructed" or "Explored" function as first choices, they were given a score of +1 or -1 respectively. We additionally ran exploratory mixed effects models using the block level data which are presented in the Supplementary Information.

3.4.1.3 Results

Exclusions: We excluded data on a trial basis so that if a participant contributed data from one trial, they were kept in the data. Two participants failed this criterion. Data from one more participant was lost due to camera failure. In total, 20 trials were excluded for the following reasons: not activating both functions at least once during the learning phase (15 trials), not showing anything to E2 in the transmission phase (4 trials), parental interference (1).

Learning Phase: As a control check, we conducted a paired-samples t-test to analyse whether toddlers equally activated the instructed vs explored functions. As expected, the results showed that there was no significant difference in how they activated the instructed function (M = 6.42, SD = 4.28) and the explored function (M = 7.68, SD = 6.21), $t(37)$ = 1.585, p = .121, *Cohen's d* = .26.

Transmission Phase: Our main measure of transmission selectivity was the first function shown to E2. Twenty-two children contributed data from both trials, whereas 16 children contributed data from only one trial. For this measure, we conducted a one-sample t-test to investigate whether children's first choices significantly differed from the chance value of 0. The result showed that children selectively chose to show the instructed function first $t(37)$ = 3.389, p = .002, *Cohen's d* = .55. Overall, 20 children showed the instructed function as the first function, five children showed the explored function as the first function; and 13 children either showed both functions simultaneously or showed the instructed function in one trial and the explored function in the other trial as the first function. Since choosing "Both" adds a data point to each category, by disregarding the trials where the first choice was "Both", we conducted a binomial test showing that children were significantly more likely to show the instructed function as the first function, p = .004 (See Figures 3 & 4).

Additionally, we examined the total number of activations for each function. To do this, we averaged the number of times children activated each function during the transmission phase and conducted a paired-samples t-test. The results showed that there was no significant difference in how often children activated the instructed function (M = 5.29, SD = 5.80) and the explored (M = 4.68, SD = 5.49) functions, $t(37)$ = -1.259, p = .22.

We additionally ran control analyses to account for the role of box set and order of presentation on both measures in Learning and Transmission phases, full report of these analyses can be found in the Supplementary Information.

3.4.2. Experiment 2

3.4.2.1.0. Method

In the first experiment, we aimed to examine whether toddlers preferentially transmitted information depending on how they learned about this information, and we found that they preferentially transmitted information that they were previously taught over information they had discovered themselves. In Experiment 2 we aimed to examine if this preference observed in toddlers undergoes a developmental change perhaps influenced by overall socio-cognitive development as well as experience with formal schooling settings. Thus, in this experiment, we tested 5-year-old children that had at least a couple of months of their reception year or completed reception (i.e., the first year of formal schooling in the UK). We used the same paradigm as for the 2-year-old children but made slight modifications to the design to make it more context-appropriate for older children.

3.4.2.1.1. Participants

Forty-one 5-year-old, healthy, predominantly White, English-speaking children (*Mage* = 60.30 months, Range = 54.43 - 71.36, 19 females) were recruited to take part in this study. Data collection took place between December 2021 and September 2022. Participants were compensated with £5 for their travel expenses and received a storybook to take home with them as a thank-you gift.

3.4.2.1.2. Materials and Stimuli

Materials and stimuli were identical to Experiment 1.

3.4.2.1.3. Design and Procedure

Design and procedure were identical to Experiment 1 except the following: First, before starting the study, E1 told the children that she was going to show some toys, but these were baby toys, thus might be a little easy for them, and she was just curious about how they would play with these toys. Second, the trial times were not fixed; once the child overtly demonstrated that they were done with the toys or approximately 20 seconds elapsed, the experimenter took the toys back and proceeded with the study.

3.4.2.2.0 Results

Exclusions: Exclusion criteria were identical to Experiment 1. In total 10 trials were excluded for the following reasons: not activating both functions at least once during learning phase (8 trials), experimenter error or equipment failure (2 trials).

Learning Phase: As expected, there was no significant difference between how often children activated the instructed (M = 17.51, SD = 10.16) and the explored functions (M = 19.17, SD = 14.15), $t(40)$ = .733, p = .468.

Transmission Phase: Thirty-one children contributed data for both trials, and 10 children contributed data from only one trial. For the main outcome measure, we conducted a one-sample t-test to investigate whether children's first choices significantly differed from the chance value 0. The result showed that children's transmission choices did not significantly differ from chance, $t(40)$ = 1.840, p = .073. Overall, 14 children showed the instructed function as the first function, six children showed the explored function as the first function; and 21 children showed either both functions simultaneously or the instructed function in one trial and the explored function in the other trial as the first function. Since choosing "Both" adds a data point to each category, by disregarding the trials where the first choice was "Both", we conducted a binomial test showing that children were not significantly more likely to show the instructed function as the first function, p = .115.

As in Experiment 1, we also averaged the number of times children activated each function during the information transmission phase. We conducted a paired-samples t-test to investigate if children engaged more with one function over the other. The results showed that there were no significant differences in how often they activated the instructed (M = 9.63, SD = 7.61) and the explored (M = 9.88, SD = 8.16) functions, $t(40)$ = .630, p = .53, (See Figures 3 & 4).

3.4.2.2.1. Cross-group comparisons:

We compared children's responses in the transmission phase across both age groups to investigate age differences in transmission preference. First, using an independent samples t-test we found that toddlers' and children's choices as the first function did not differ significantly, $t(77) = 1.385$, $p = .17$. For the secondary measure analysis, we conducted a two-way mixed ANOVA (within-subjects variable: mode of acquisition: instructed vs. explored; between-subjects variable: age group: 2 vs. 5 years). Results showed that there was no main effect of the mode of acquisition on the number of overall activations for each function ($F(1, 77) = .347$, $p = .56$), with instructed function and explored function being activated equally. However, there was a main effect of age ($F(1, 77) = 9.795$, $p = .002$, $\eta p^2 = .11$), with five-year-olds activating each function significantly more than two-year-olds (See Table 1). Finally, there was no interaction between age group and the mode of acquisition on children's overall activation of each function in the transmission phase $F(1, 77) = 1.919$, $p = .17$).

Table 1. Frequency of activating each function in Transmission across age groups.

	Age Group	M	SD
Explored Function	2-year-olds	4.68	5.49
	5-year-olds	9.88	8.16
Instructed Function	2-year-olds	5.29	5.80
	5-year-olds	9.63	7.61

In the figures below, we present both participant level responses that were used to conduct the statistical analyses (Figure 3) and the trial level responses where raw responses from each transmission trial without averaging across blocks (for participant who contributed data from both blocks) that were separately analysed in the Supplementary Information which mirrored the results reported here.

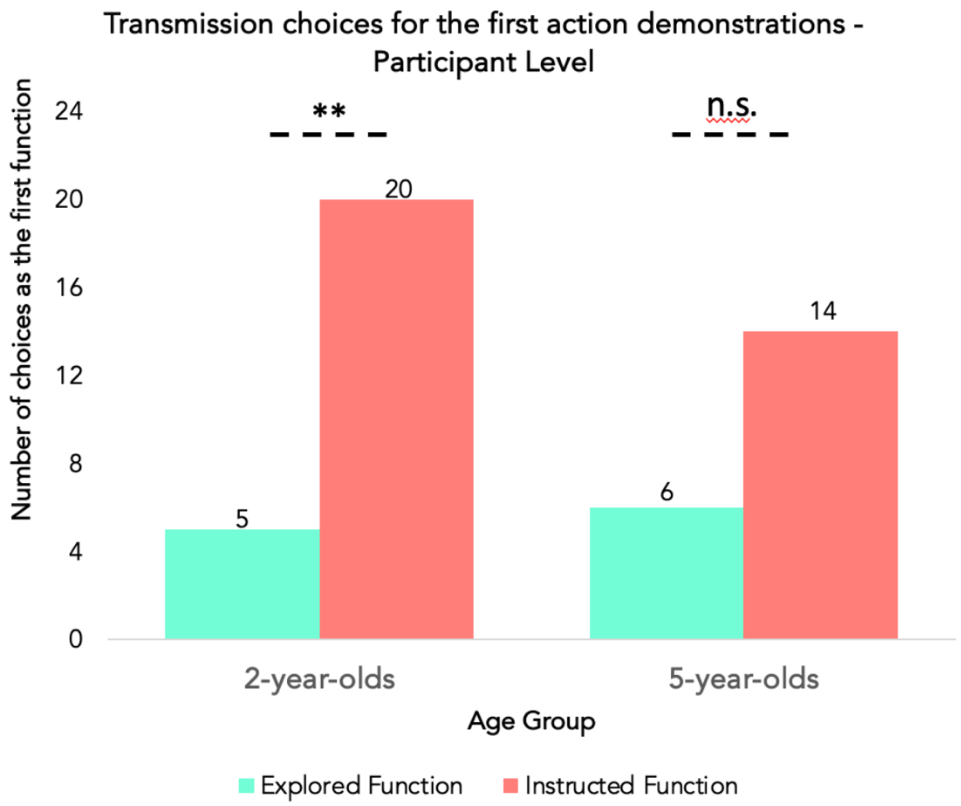

Figure 3. Transmission of choices for the first action demonstration.

This figure shows transmission choices for the first action demonstrations from the participants who made a preferential choice between transmitting Explored or Instructed function in one or both trials.

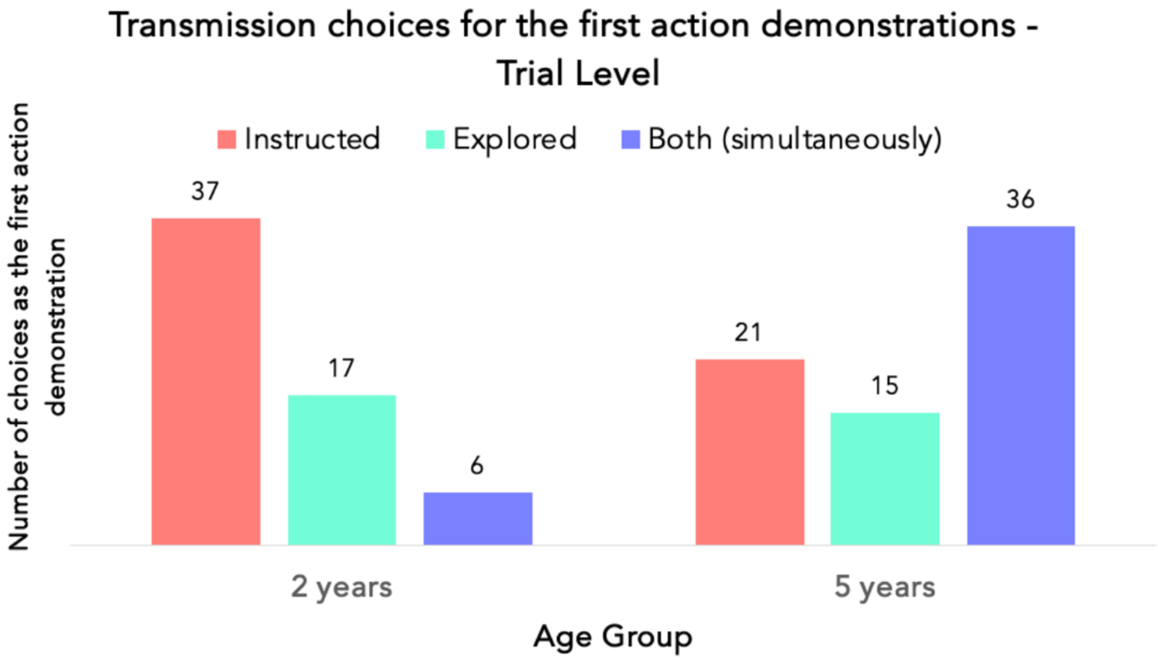

Figure 4. Transmission choices for the first action demonstrations.

This figure focuses on each block that was contributed by children across both age groups and shows the transmission choices that children made in each eligible Transmission trial. In total, 2-year-olds contributed 60 trials out of 82; whereas 5-year-olds contributed 72 trials out of 82 trials. Complementary analyses ran using this trial level data is presented in Supplementary Information which reflected the conclusions reported here. For more detailed information of the descriptive statistics please refer to Tables S1-S3 in Supplementary Information.

3.5. Discussion

In this study, we aimed to investigate whether 2-year-old toddlers and 5-year-old children would display a preference for transmitting information learned from others or through their self-exploration, and whether any potential preference would persist across different age groups. We argued that selectivity for either information type could be explained with the salience-based account (e.g., Bazhydai, Silverstein et al., 2020; Yurovsky & Frank, 2017) where each cue associated with the learning environment is assigned a weight, and a combination of these weighted cues would determine which information is prioritized when the newly acquired information is selected for further transmission. We found that despite learning equally well through self-exploration and instruction, 2-year-old toddlers preferentially transmitted instructed over self-explored information to a naïve learner in a teaching-like situation (Experiment 1). By contrast, 5-year-old children did not show a preference for transmitting either type of information (Experiment 2).

Zooming in on the role of different cues in the learning context (i.e., salience of being taught vs. salience of self-exploration), the results of this study are compatible with the cue-combination framework; however, we did not observe the stability of this preference across the two age groups. It is possible that 2-year-olds weighted cues associated with the learning context more so that learning through a social partner's instruction was more salient than learning through self-led, independent exploration. The different pattern that we observed in 5-year-old children might be due to the changes in weighting of self-exploration because in parallel with getting more experience with learning through others' explicit guidance and instruction, children also become more experienced in self-exploration. Older children engage in more sophisticated forms of exploration and the complexity of the information that they learn through self-exploration increases drastically (e.g., Meder et al., 2021; Pelz & Kidd, 2020; see De Simone & Ruggeri, 2022, for a review). Thus, instead of the learning context (i.e., how they initially acquired information), the information that is more complex or difficult might have become more salient and influenced how the acquired information was prioritized for transmission. Given that in this study we kept other cues relevant to the information equally salient such as the complexity, functionality, and appeal of the objects for both instructed and self-explored information, the weight assigned to the social aspect of the learning context alone might not have been sufficient to influence 5-year-olds' preference for transmitting instructed information as observed in 2-year-olds. This interpretation is also compatible with Ronfard and colleagues' (2016) findings, where 4- to 6-year-olds' preference for transmitting self-explored or instructed information was modulated by the complexity of the method of extracting the reward, and when the information features were equal (i.e., equally easy), children simply did not show a preference for teaching either method.

It should be noted that although the results for the 2-year-olds might also be compatible with a richer explanation ascribing "special status" to information acquired through others' instructions (Vredenburgh et al., 2020), the finding that 5-year-olds did not show such preference makes this interpretation unlikely. If instructed information indeed had a special status for further transmission, we would expect this advantage to persist, if not become even more pronounced with age (e.g., Höhl et al., 2019; Marsh et al., 2014; McGuigan et al., 2007; Flynn & Smith, 2012). The argument for the early competitive advantage for socially acquired information has also been widely debated (e.g., Heyes, 2012a; 2012b) with recent findings showing that both 2- and 5-year-old children learn equally well from social demonstrations as well as individual exploration across different cultures (i.e., UK & China) (Atkinson et al., 2021, see also Kean, 2023 for similar findings with Capuchin monkeys). We therefore conclude that while our findings are also in line with the richer interpretation arguing for a special status for instructed information, they are better explained by the salience-based cue combination account.

Some methodological considerations of our study warrant further discussion. First, we base our interpretation of the findings on the primary outcome measure (i.e., the first function activated in the transmission phase). The "first" responses such as first tap on a touchscreen (e.g., Frank et al., 2021), first visual fixation or look (e.g., Ferry et al., 2010; Gliga et al., 2009; Libertus et al., 2013), first object choice (e.g., Diesendruck & Markson, 2001), first touch (e.g., Libertus et al., 2013), first grip (e.g., Butterworth et al., 1997), first point (e.g., Liszkowski et al., 2008), first reach (e.g., Clearfield, 2006), and first action (e.g., Brugger et al., 2007), among others, have been widely used on cognitive tasks with infants and young children. "First" responses are considered to be the most sensitive measures as the responses are yet to be influenced by any input or feedback that participants might receive while completing the task (Diesendruck & Markson, 2001; Evey & Merriman, 1998). Additionally, a recent finding suggests that children's actions on a causal learning task might be influenced by their first responses (Sobel et al., 2022). Additionally, the traditionally used measures of selectivity in young children such as the first reach or look towards the boxes would have been problematic in the context of our research question because, while they could be indicators of selective attention allocation or an overall preference for engagement, these would not demarcate a preference specifically for transmitting information unless children pressed the buttons to demonstrate what the boxes did. It should be noted that while it is not possible to explain what the "first" responses might signify for children (ease of transmission, importance, etc.), choosing one option over the other first consistently can be a marker of preference. We are therefore confident that our main measure provides crucial information despite not converging with our secondary measure (i.e., the frequency of activating each function).

Second, the simplicity of the objects might have undermined the influence of the self-exploration; while this might be possible for older children, we designed this study taking 2-year-olds into account, reasoning that making the boxes more complex might have masked toddlers' abilities and preferences to act on the objects. Although we did not quantify it, we have anecdotal evidence to suggest that children's first reaction to a box in both groups differed slightly when they explored the box: some tried to find other functions, some were interested in the physical features of the boxes (e.g., the colour of the box, button and light, the surface of the box, whether the button rotates, etc.), and some were curious about the content of the box and tried to open it. Hence, even with a simple box like we used in this study, self-led actions on the boxed could provide varied and valuable information. Finally, unexpectedly, we found that 5-year-old children, unlike 2-year-olds, pressed both buttons simultaneously in almost half of the eligible trials, decreasing the number of trials that we could include in our analysis which might have had an influence on the results. To overcome this potential limitation, future research could employ a design where it is not possible for both buttons to be activated at the same time such as by using a remote-controlled audio player or potentially making the transmission decision a "forced choice". While such alternative designs might be helpful, they also introduce superficial constraints leading children to make an explicit trade-off and diminishing ecological validity.

While these results should be interpreted with caution, they present a starting point for generating further research questions and opening avenues for discussions about how selectivity in information transmission is conceptualised and how it is influenced by different learning contexts. Additionally, we contribute to the relatively limited literature on the development of teaching behaviour in children younger than 4 years, by showing that 2-year-olds actively propagate information to others, and their transmission is influenced by how they initially acquired this information. While the increase in the interest for studying children's ability to transmit information is important for developing fruitful theoretical discussions, findings that are limited to older children (e.g., Baer & Friedman, 2018; Danovitch et al., 2023; Gweon & Schulz, 2019; Pueschel et al., 2022) might also lead to relying on richer explanations that assume complex socio-cognitive skills while dismissing leaner approaches. Even though more sophisticated socio-cognitive capacities such as theory of mind, executive functions, and social motivation to be helpful (e.g., Davis-Unger & Carlson, 2008a, 2008b; Strauss and Ziv, 2002) might be essential for effective and more tailored teaching by allowing teachers to consider the learners' epistemic states and maximize the utility of information to be provided (e.g., Aboody et al., 2022, Bridgers et al., 2020), they may not be a prerequisite for the emergence and early development of information transmission (Corriveau et al., 2017). We argue that the proposed salience-based cue combination account might be helpful for understanding the developmental trajectory in preferential information transmission. For instance, considering the performance of 5-year-olds in our study, the salience of the cost (how difficult, complex, or opaque, and lack thereof) might become more pronounced rather than the salience of learning context. As they get older, children might simply be better at appraising different aspects of information enabled by different socio-cognitive skills. Coupled with their increased experiences as learners and teachers, this combination of skills might eventually lead them to reprioritize the cues assigned to the learning context as well as the information itself.

There is still a myriad of questions remaining to be answered with respect to several aspects of children's preferential information transmission, and what type of information is prioritized for further transmission. For instance, it is possible that the salience of learning from exploration decreased because the self-explored object was selected by the experimenter and not by the learner. Here, if the salience of self-explored information comes from its relation to own interest and attention, this might have undermined the role of self-exploration. While this was an issue we considered, we intentionally avoided letting children choose the object in this manner because it might have led to a preference just by virtue of having chosen one box over the other (e.g., Silver et al., 2020). Future studies could include a set of 3 identical objects, where children are given a choice to explore one of the 3 objects and then could be shown one of the remaining two objects. Children can then be asked which of these objects they would choose to teach (the toy they selected, or the one chosen by the experimenter).

While this would not completely account for the potential confound we mentioned above (i.e., preference being affected by the initial choice), it could enhance the role of self-exploration.[5] A carefully controlled set of studies should take our results further by focusing on different social (e.g., receiving direct instruction, observing a knowledgeable adult, ritualistic or normative component of the information and learning process) and non-social (e.g., salience of the different object features, level of complexity) salient cues that might potentially influence children's choices to have a better view of the factors that motivate what children preferentially share with others.

In summary, our study suggests that toddlers preferentially share information that they have previously learned through others' instructions compared to their own exploration, whereas such preference is not present in 5-year-old children, all other things being equal. We suggest that early preference for transmitting socially acquired information observed in toddlers might be due to its inherent saliency enhanced by several aspects of the learning context such as the use of ostensive cues. As children get older, saliency of the self-led learning might increase leading them to re-prioritize what information to transmit to other people, potentially also considering other aspects, such as efficiency, complexity, or appeal of information for others. Our findings contribute to the growing body of literature on the under-investigated field of children's teaching in early childhood.

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3.7. Supplementary Information

Descriptive Statistics

Table S1. The number of contributed blocks in each age group.

Contributed Blocks			
Age Group	Both Blocks	First Block Only	Second Block Only
2-year-old	22	6	10
5-year-old	31	3	7

Table S2. The number of children who pressed both functions in each age group.

Both Function (Simultaneous Choice)		
Age Group	Two Blocks	One Block
2-year-old	0	6
5-year-old	11	14

Table S3. The distribution of children's first choice as instructed function

Instructed Function			
Age Group	Two Blocks	One Block	Zero Blocks
2-year-old	6	25	7
5-year-old	1	19	22

Table S4. The number of activations of each function across orders and age groups in the learning phase.

Age group	**Order**	**Function**	**N**	**Mean**	**SD**
2-year-olds	Explored-first	Explored function	27	4.67	2.92
		Instructed function	27	5.03	5.22
	Instructed-first	Explored function	28	5.36	5.61
		Instructed Function	28	2.76	1.60
5-year-olds	Explored-first	Explored function	15	9.00	9.21
		Instructed function	15	10.73	10.07
	Instructed-first	Explored function	21	15.90	14.52
		Instructed Function	21	9.38	7.83

Table S5. The number of activations of each function in across orders and age groups in the transmission phase.

Age group	Order	Function	Mean	SD
2-year-olds	Explored-first	Explored function	2.70	2.28
		Instructed function	3.48	2.75
	Instructed-first	Explored function	3.09	4.88
		Instructed Function	3.39	5.23
5-year-olds	Explored-first	Explored function	6.93	8.68
		Instructed function	6.27	7.98
	Instructed-first	Explored function	4.81	6.88
		Instructed Function	4.67	5.77

Table S6. The number of activations of each function was chosen as first function across orders and age groups in the transmission phase.

Age Group	Order	First Function	Counts
2-year-olds	Explored-first	Explored	5
		Instructed	20
	Instructed-first	Explored	11
		Instructed	17
5-year-olds	Explored-first	Explored	8
		Instructed	7
	Instructed-first	Explored	7
		Instructed	14

Control Checks (Order & Box Set)

For our main analyses, we made use of the participant-level data by following the analysis plan that was used in previous studies (e.g., Bazhydai, Silverstein et al., 2020; Vredenburgh et al., 2015). As described in detail in the main methods section, participants contributed data in a varying extent. If they contributed two trials, their choice across both trials were averaged and was used as their final score; if they contributed data from only one of the trials, their choice in the eligible trial was used as their final score. We report all main analyses of interests in the manuscript.

We also wanted to explore the potential effects of box sets presented and the order of presentation on both children's first choices and their total activation of each function. For this, we used the long-format (trial-level data). Below, we present the analyses of these results by experiment.

Experiment 1- Toddlers (2-years)

Learning Phase:

The aim of these analyses was to account for the potential effects of the box set (sound boxes vs. light boxes) and the order of presentation (instructed-first vs. explored first) on toddlers' activation of each function in the learning phase. First, we compared whether the number of activations for each function differed depending on whether the type of box set given using a repeated-measures ANOVA. There was no effect for the number of activations ($p = .11$); however, there was an effect of the box set with the light boxes being activated more often than the sound boxes, $F(1,58) = 23.76$, $p < .001$. There was no interaction between the mode of acquisition for each function and the box set ($p = .76$). The difference between the activation numbers across box sets is expected given the nature of the boxes. Each activation on the sound boxes takes approximately 3 seconds, thus the number of activations that can be done within the trial duration was limited; however, each activation on the light box was momentary; thus, could be activated more often than the sound boxes. Second, we compared whether the number of activations for each function differed depending on whether they were presented with the instruction-first or exploration-first orders using a repeated measures ANOVA. There was no effect of the mode of acquisition ($p = .16$) or the order of presentation ($p = .16$). However, there was an interaction between the number of activations for each function and the order of presentation, with the instructed function being activated less when in the instruction-first order compared to the explored-first order, $F(1,58) = 7.33$, $p = .009$, $\eta p^2 = .11$.

Transmission Phase:

Here, we first examined the potential effects of the box set (sound boxes vs. light boxes) and the order of presentation (instructed-first vs. explored first) on the first function toddlers showed in the teaching phase using two separate independent samples t-test. We found that there was no effect box set or order on the first function that toddlers showed to the naïve learner (p = .85, p = .15 respectively).

Then, we explored the potential effects of the box set (sound boxes vs. light boxes) and the order of presentation (instructed-first vs. explored first), as we did in the learning phase using two repeated measures ANOVAs. First, we compared whether the number of activations for each function differed depending on whether the type of box set given. There was no effect for the mode of acquisition (p = .07); however, there was an effect of the box set with the light boxes being activated more often than the sound boxes, $F(1,58)$ = 4.68, p = .035. There was no interaction between the number of activations for each function and the box set (p = .72). Second, we compared whether the number of activations for each function differed depending on whether they were presented with the instruction-first or exploration-first orders. There was no effect of the mode of acquisition (p = .06), the order of presentation (p = .88) or the interaction between both (p = .40).

Experiment 2 - Children (5-years)

Learning Phase:

We repeated the same analyses that we did with the toddlers to account for the potential effects of the box set (sound boxes vs. light boxes) and the order of presentation (instructed-first vs. explored first) on children's activation of each function in the learning phase. First, we compared whether the number of activations for each function differed depending on whether the type of box set given. There was a main effect for the number of activations ($F(1,70)$ = 4.69, p = .034) with explored function being activated more than the instructed function, and there was a main effect of the box set with the light boxes being activated more often than the sound boxes, $F(1,70)$ = 58.66, p < .001. However, there was no interaction between the mode of acquisition for each function and the box set (p = .14). The difference between the activation numbers across box sets is expected given the nature of the boxes. Each activation on the sound boxes takes approximately 3 seconds, thus the number of activations that can be done within the trial duration was limited; however, each activation on the light box was momentary; thus, could be activated more often than the sound boxes. Second, we compared whether the number of activations for each function differed depending on whether they were presented with the instruction-first or exploration-first orders. There was no effect of the mode of acquisition (p = .05) or the order of presentation (p = .07). However, there was an interaction between the number of activations for each function and the order of presentation, with the explored function being activated more when in the instruction-first order compared to the explored-first order, $F(1,70) = 7.38$, $p = .008$, $\eta p^2 = .10$.

Transmission Phase:

Here, we first examined the potential effects of the box set (sound boxes vs. light boxes) and the order of presentation (instructed-first vs. explored first) on the first function toddlers showed in the teaching phase. We found that there was no effect box set or order on the first function that toddlers showed to the naïve learner (p = .10, p = .21 respectively). Then, we explored the potential effects of the box set (sound boxes vs. light boxes) and the order of presentation (instructed-first vs. explored first), as we did in the learning phase. First, we compared whether the number of activations for each function differed depending on whether the type of box set given. There was no effect for the mode of acquisition of activations (p = .53); however, there was an effect of the box set with the light boxes being activated more often than the sound boxes, $F(1,70)$ = 22.23, p < .001. There was no interaction between the number of activations for each function and the box set (p = .32). Second, we compared whether the number of activations for each function differed depending on whether they were presented with the instruction-first or exploration-first orders. There was no effect of the mode of acquisition (p = .46), the order of presentation (p = .75) or the interaction between both (p = .19)

Complementary Analyses using Mixed-Effects Models

Note that while these analyses theoretically can be more appropriate given the issues regarding the data structure and the model was too complex for the data. We observed almost singular fit in some of these analyses and the models were overdispersed.

Experiment 1

Some children contributed data for both trials, whereas others contributed data for only one trial. Within these eligible trials, some children in both age groups demonstrated both functions as the first function by pressing on them simultaneously, while this behaviour was possible, we did not expect children to act this way.
Since we were interested in children's preferential transmission, we focused on the trials where children made a distinct choice between choosing the "Instructed" function (coded as "1") or "Explored" function (coded as "0").

Analyses: For the statistical analyses, we used *Jamovi* (the jamovi project, 2023), an *R*-based (R Core Team, 2022) statistical software program. Generalised Linear Mixed Effects Models and Linear Mixed Effects Models were conducted using *GAMLj3* module (Galucci, 2019). For the tests where the normality assumptions were not met, we reported the non-parametric version of the tests. For all successive tests, we applied a Bonferroni correction.

Results

Exclusions: We excluded data on a trial basis so that if a participant contributed data from one trial, they were kept in the data. Two participants failed this criterion. Data from one more participant was lost due to camera failure. In total, 20 trials were excluded for the following reasons: not activating both functions at least once during the learning phase (15 trials), not showing anything to E2 in the transmission phase (4 trials), parental interference (1). Further, we disregarded 6 trials which were eligible to be included in the overall data but not analysed because the children pressed both functions simultaneously: thus, not exhibiting a distinct choice between the functions.

Learning Phase: As a control check, we conducted a paired-samples t-test to analyse whether toddlers equally activated the instructed vs explored functions in each trial. As expected, the results showed that there was no significant difference in how they activated the instructed function (M = 4.09, SD = 3.33) and the explored function (M = 5.09, SD = 4.47), $W(53)$ = 664, p = .10, *Rank biserial correlation* = .283.

Transmission Phase:

First function: Our main measure of transmission selectivity was the first function shown to E2. Eighteen children contributed data from both trials, whereas 18 children contributed data from only one trial. For this measure, we conducted a generalised mixed-effects model using *"glmer"* function with binomial family and *"logit"* link function using *“lme4”* package in *GAMLj3* module. A random intercept model was specified to predict the *first function* with participants being the random effect variable (*first function* ~ 1 + (1 | Participant), family = binomial). The binomial logistic regression model converged with a satisfactory fit (*AIC* = 71.273, *BIC* = 75.251). The intercept in the logistic regression model predicting first function was estimated to be 0.778 (*SE* = 0.293, *z* = 2.65, *p* = 0.008, *OR* = 2.18). This indicated that the log-odds of choosing instructed function were 0.778 times more likely than choosing explored function. We, then fitted a binomial logistic regression model where the *first function* was predicted by the order of being presented with the function (explored-first vs. instructed-first), the effect type (lights vs. tunes) and the order of contributed block (1^{st} vs. 2^{nd} Block) (Model2: first function ~ 1 + order of presentation + effect type + block order (1|Participant), family = binomial) to control for the potential role of these variables. The binomial logistic regression model converged with a satisfactory fit (*AIC* = 73.940, *BIC* = 83.885). The intercept in the logistic regression model predicting *first choice* was estimated to be 0.879 (*SE* = 0.315, *z* = 2.795, *p* = 0.005). This indicated that when all other predictor variables were accounted for, the log-odds of choosing instructed function were 0.879 times more likely than choosing explored function. However, none of the other predictor variables significantly predicted the first choice (block order *p* = .719, order of presentation *p* = .105, effect type *p* = 0.223). It should be noted that both models were over dispersed, and a negative binomial distribution was not possible for this particular data, thus we additionally conducted an exact binomial test which showed that children were more likely to choose instructed function (*n* = 37) compared to explored function (*n* = 17) as their first choice for transmission, *p* = .009.

Frequency of activation: For this measure, we created a difference score by subtracting the frequency of activating explored function from the frequency of explored function. For this measure, we conducted a linear mixed-effects model using *“lmer”* function (gaussian distribution, *“REML”* estimation and *“bobyqa”* optimizer) using *“lme4”* package through *GAMLj3* module. A random intercept model was specified to predict the *first function* with participants being the random effect variable (*frequency of activation* ~ 1 + (1 | Participant), family = binomial). The model converged with a satisfactory fit (*AIC* = 245, *BIC* = 251). Children were not likely to transmit the instructed function more frequently than the explored function (*Estimate* = 0.565, *SE* =

0.325 $t(36.3) = 1.74$, $p = .091$). We, then fitted another model where the *frequency of activation* was predicted by the order of being presented with the function (explored-first vs. instructed-first), the effect type (lights vs. tunes) and the order of contributed block (1st vs. 2nd Block) (Model2: frequency of activation ~ 1 + order of presentation + effect type + block order (1|Participant)). The model converged with a satisfactory fit (*AIC* = 248, *BIC* = 260). The model showed that children were not likely to transmit instructed function more frequently than the explored function when all other predictors were accounted for (Estimate = 0.580 *SE* = 0.330, $t(35.9) = 1.759$, $p = 0.087$). None of the other predictor variables significantly predicted the frequency of activation either (block order $p = .878$, order of presentation $p = .479$, effect type $p = 0.829$)

Experiment 2

Results

Exclusions: Exclusion criteria were identical to Experiment 1. In total 10 trials were excluded for the following reasons: not activating both functions at least once during learning phase (8 trials), experimenter error or equipment failure (2 trials). Further, we disregarded 36 trials which were eligible to be included in the overall data but not analysed because the children pressed both functions simultaneously: thus, not exhibiting a distinct choice between the functions.

Learning Phase: Children activated the explored function (*M* = 13.02, *SD* = 12.89) more frequently than the instructed function (*M* = 10.00, *SD* = 8.72), $W(35) = .461$, $p = .017$, *Rank biserial correlation* = 0.463.

Transmission Phase:

First function: Nine children contributed data for both trials, and 18 children contributed data from only one trial. For this measure, we conducted a generalised mixed-effects model using *"glmer"* function with binomial family and *"logit"* link function in *"lme4"* package through *GAMLj3* module. A random intercept model was specified to predict the *first function* with participants being the random effect variable (*first function* ~ 1 + (1 | Participant), family = binomial). The binomial logistic regression model converged with a satisfactory fit (*AIC* = 52.902, *BIC* = 56.069). The intercept in the logistic regression model predicting first function was estimated to be 0.336 (*SE* = 0.338, $z = 0.995$, $p = 0.320$, *OR* = 1.40). This indicated that the log-odds of choosing instructed function were 0.336 times more likely than choosing explored function; however, this was not significantly different. We, then fitted a binomial logistic regression model where the *first function* was predicted by the order of being presented with the function (explored-first vs. instructed-first), the effect type (lights vs. tunes) and the order of contributed block (1st vs. 2nd Block) (Model2: first function ~ 1 + order of presentation + effect type + block order (1|Participant), family = binomial) to account for the potential influence of these variables. The binomial logistic regression model converged with a satisfactory fit (*AIC* = 53.710, *BIC* = 61.627). The intercept in the logistic regression model predicting *first choice* was estimated to be 0.392 (*SE* = 0.376, *z* = 1.042, *p* = 0.297). This indicated that the log-odds of choosing instructed function were 0. 392 times more likely than choosing explored function, however, this was not statistically significant. None of the other predictor variables significantly predicted the first choice (block order *p* = .898, order of presentation *p* = .202, effect type *p* = 0.065). It should be noted that both models were over dispersed, and a negative binomial distribution was not possible for this data, thus we additionally conducted an exact binomial test which showed that children were more likely to choose instructed function (*n* = 21) compared to explored function (*n* = 15) as their first choice for transmission, *p* = .405.

Frequency of activation: For this measure, we created a difference score by subtracting the frequency of activating explored function from the frequency of explored function. For this measure, we conducted a linear mixed-effects model using *"lmer"* function (gaussian distribution, *"REML"* estimation and *"bobyqa"* optimizer) in *"lme4"* package through *GAMLj3* module. A random intercept model was specified to predict the *first function* with participants being the random effect variable (*frequency of activation* ~ 1 + (1 | Participant), family = binomial). The model converged with a satisfactory fit (*AIC* = 168.9, *BIC* = 173.7), though it should be noted that the fit was almost singular. Children were not likely to transmit the instructed function more frequently than the explored function (*Estimate* = -0.361, *SE* = 0.393 *t*(35) = -0.920, *p* = .364). We, then fitted another model where the *frequency of activation* was predicted by the order of being presented with the function (explored-first vs. instructed-first), the effect type (lights vs. tunes) and the order of contributed block (1st vs. 2nd Block) (Model2: frequency of activation ~ 1 + order of presentation + effect type + block order

(1|Participant)). The model converged with a satisfactory fit (*AIC* = 167.9, *BIC* = 177.4), though it should be noted that the fit was almost singular. The model showed that children were not likely to transmit instructed function more frequently than the explored function when all other predictors were accounted for (Estimate = -0.362 *SE* = 0.401, *t(32)* = -0.902, *p* = 0.374). None of the other predictor variables significantly predicted the frequency of activation either (block order *p* = .370, order of presentation *p* = .403, effect type *p* = 0.210).

Cross-group comparisons in Transmission Phase:

First function: To compare across age groups, a random intercept model was specified as follows: *first function* was predicted by age group with participants being the random effect variable (*first function* ~ age group + (1 | Participant), family = binomial). The intercept in the logistic regression model predicting first function was estimated to be 0.557 (*SE* = .224, *z* = 2.491, *p* = 0.013, *OR = 1.746*). This indicated that the log-odds of choosing instructed function were 0.557 times more likely than choosing explored function. However, age group was not revealed as a significant predictor (*Estimate* = -0.441, *SE* = .447, *z* = -0.986, *p* = 0.324, *OR* = .643). We, then fitted a binomial logistic regression model where the *first function* was predicted by the age group, the order of being presented with the function (explored-first vs. instructed-first), the effect type (lights vs. tunes) and the order of contributed block (1^{st} vs. 2^{nd} Block) (Model2: First Choice ~ age group + order of presentation + effect type + block order + (1| Participant), family = binomial). The intercept in the logistic regression model predicting *first choice* was estimated to be 0.626 (*SE* = 0.235, *z* = 2.668, *p* = 0.008). This indicated that when all other predictor variables were accounted for, the log-odds of choosing instructed function were 0.626 times more likely than choosing explored function. However, none of the other predictor variables significantly predicted the first choice (age group *p* = .363, block order *p* = .899, order of presentation *p* = .565, effect type *p* = .098).

Frequency of activation: For this measure, we conducted a linear mixed-effects model using *"lmer"* function (gaussian distribution, *"REML"* estimation and "bobyqa" optimizer) in *"lme4"* package through *GAMLj3* module. A random intercept model was specified to predict the *frequency of activation* with participants being the random effect variable (*frequency of activation* ~ 1 + (1 | Participant)). The binomial logistic regression model converged with a satisfactory fit (*AIC* = 412, *BIC* = 419). Children were not likely to transmit the instructed function more frequently than the explored function (*Estimate* = 0.193, *SE* = 0.259 *t*(58.3) = 0.745, *p* = .459). We, then fitted another model where the *frequency of activation* was predicted by the age group, the order of being presented with the function (explored-first vs. instructed-first), the effect type (lights vs. tunes) and the order of contributed block (1st vs. 2nd Block) (Model2: frequency of activation ~ 1 + age group + order of presentation + effect type + block order (1|Participant)). The model converged with a satisfactory fit (*AIC* = 414, *BIC* = 432), though it should be noted that the fit was almost singular. The model showed that children were not likely to transmit instructed function more frequently than the explored function when all other predictors were accounted for (Estimate = 0.128 *SE* = 0.261, *t(57.9)* = 0.492, *p* = .625). None of the other predictor variables significantly predicted the frequency of activation either (age group p = .087, block order *p* = .544, order of presentation *p* = .865, effect type *p* = 0.437).

Additional Analyses – 5-year-olds without "participants" as random effect

Frequency of activation: For this measure, we created a difference score by subtracting the frequency of activating explored function from the frequency of explored function. For this measure, we conducted a linear regression model using *"lm"* function (gaussian distribution and "identity" link function) in *"glm"* package through *GAMLj3* module. An intercept model was specified to predict the *first* (*frequency of activation* ~ 1). The regression model converged with a satisfactory fit (*AIC* = 166.86, *BIC* = 170.02). Children were not likely to transmit the instructed function more frequently than the explored function (*Estimate* = -0.361, *SE* = .393 *z*= -.920, *p* = .358, OR = .697). We, then fitted another model where the *frequency of activation* was predicted by the order of being presented with the function (explored-first vs. instructed-first), the effect type (lights vs. tunes) and the order of contributed block (1st vs. 2nd Block) (Model2: frequency of activation ~ 1 + order of presentation + effect type + block order). The regression model converged with a satisfactory fit (*AIC* = 169.76, *BIC* = 177.67) The model showed that children were not likely to transmit instructed function more frequently than the explored function when all other predictors were accounted for (Estimate = -0.362 *SE* = 0.401, *z* = -.902, *p* = 0.367, *OR* = .696). None of the other predictor variables significantly predicted the frequency of activation either (block order *p* = .363, order of presentation *p* = .397, effect type *p* = 0.201).

Additional Analyses – Interactions

We have added the relevant interaction into the model and below we report the results of this model in the tables below:

Table S7. Generalised Linear Mixed Model for First Function Measure

Model Type	Logistic Model	Model for binary y
Model	lme4::glmer	First function ~ 1 + Block + Order + BoxSet + `Age Group` + Block:Order + Order:`Age Group` + BoxSet:`Age Group` + Order:Block:`Age Group` + (1 | Participant)
Distribution	Binomial	Dichotomous event distribution of y
Link function	Logit	Log of the odd of y
Direction	P(y=1)/P(y=0)	P(T_FirstChoice_Binary = 1) / P(T_FirstChoice_Binary = 0)
Sample size	90	
Converged	yes	
C.I. method	Wald	

Table S8. Fixed Effects Omnibus Tests

	X^2	*df*	*p*
Block Order	4.29e-6	1.00	0.998
Order of Presentation	0.0331	1.00	0.856
Effect Type	**4.8321**	**1.00**	**0.028**
Age Group	0.4630	1.00	0.496
Block Order ✻ Order of Presentation	1.0157	1.00	0.314
Order of Presentation ✻ Age Group	**3.8837**	**1.00**	**0.049**
Effect Type ✻ Age Group	0.3304	1.00	0.565
Block ✻ Order ✻ Age Group	2.1325	2.00	0.344

As expected, children activated the Sound boxes and Light boxes differently, this outcome was expected as they Light boxes had momentary effects, thus could have been activated more often than the Sound boxes.

We also observed that the interaction between order of presentation and age group was on the verge of significance meaning 5-year-old children transmitted instructed function as the first function more frequently when they were presented with the instructed function first. However, since the p-value is .049, the interpretation made based on this result may not be informative.

Table S9. Parameter Estimates (Fixed Coefficients)

				Exp(B) 95% Confidence Intervals			
Effect	**Estimate**	**SE**	**Exp(B)**	**Lower**	**Upper**	**z**	**p**
(Intercept)	**0.69645**	**0.257**	**2.007**	**1.21263**	**3.32**	**2.71019**	**0.007**
Block Order: 2 - 1	-0.00104	0.501	0.999	0.37454	2.66	-0.00207	0.998
Order of Presentation: Instructed-first - Explored-first	-0.09720	0.534	0.907	0.31860	2.58	-0.18203	0.856
Effect Type: Sound - Light	**1.16964**	**0.532**	**3.221**	**1.13516**	**9.14**	**2.19821**	**0.028**
Age Group: 5 - 2	-0.34971	0.514	0.705	0.25742	1.93	-0.68044	0.496
Block Order (2-1) ✻ Order of Presentation (Instructed-first – Explored-first)	1.01482	1.007	2.759	0.38339	19.85	1.00784	0.314

Table S9. Parameter Estimates (Fixed Coefficients)

				Exp(B) 95% Confidence Intervals			
Effect	**Estimate**	**SE**	**Exp(B)**	**Lower**	**Upper**	**z**	**p**
Order of Presentation (Instructed-first – Explored-first) ✻Age Group (5-2)	**2.10473**	**1.068**	**8.205**	**1.01154**	**66.55**	**1.97071**	**0.049**
Effect Type (Sound-Light) ✻Age Group (5-2)	0.61165	1.064	1.843	0.22899	14.84	0.57477	0.565
Block Order (2-1) ✻ Order of Presentation (Explored-first) ✻Age Group (5-2)	-1.95288	1.524	0.142	0.00716	2.81	-1.28183	0.200
Block Order (2-1) ✻ Order of presentation (Instructed-first) ✻ (5 - 2)	0.92500	1.308	2.522	0.19422	32.74	0.70715	0.479

Table S10. Linear Mixed-Effect Model for “Frequency of Activation” Measure

Model Type	Mixed Model	Linear Mixed model for continuous y
Model	lmer	T_IF_Count_Diff ~ 1 + `Age Group` + Block + Order + BoxSet + `Age Group`:Order + Block:Order + `Age Group`:BoxSet + `Age Group`:Block:Order + (1 | Participant)
Distribution	Gaussian	Normal distribution of residuals
Direction	y	Dependent variable scores
Optimizer	bobyqa	
DF method	Satterthwaite	
Sample size	90	
Converged	yes	
Y transform	none	
C.I. method	Wald	

Table S11. Fixed Effects Omnibus Tests

	F	df	df (res)	p
Age Group	2.360	1	57.0	0.130
Block	0.489	1	53.4	0.487
Order	1.470	1	68.7	0.229
Box Set	1.472	1	47.0	0.231
Age Group ✻ Order	1.067	1	79.7	0.305
Block ✻ Order	**6.134**	**1**	**48.8**	**0.017**
Age Group ✻ Box Set	0.573	1	47.0	0.453
Age Group ✻ Block ✻ Order	**3.622**	**2**	**75.9**	**0.031**

Table S12. Parameter Estimates (Fixed coefficients)

			95% Confidence Intervals				
Effect	**Estimate**	**SE**	**Lower**	**Upper**	**df**	**t**	**p**
(Intercept)	0.110	0.252	-0.393	0.613	57.0	0.436	0.665
Age Group: 5 - 2	-0.776	0.505	-1.781	0.230	57.0	-1.536	0.130
Block Order: 2 - 1	0.336	0.480	-0.620	1.291	53.4	0.700	0.487
Order of Presentation: Instructed-first - Explored-first	0.106	0.501	-0.891	1.104	49.8	0.212	0.833
Effect Type: Sound - Light	0.599	0.494	-0.384	1.582	47.0	1.213	0.231
Age Group (5 - 2) ✻ Order of Presentation (Instructed-first - Explored-first)	1.120	1.002	-0.876	3.115	49.8	1.117	0.269
Block Order (2 - 1) ✻ Order of Presentation (Instructed-first - Explored-first)	-0.513	1.006	-2.517	1.490	56.9	-0.510	0.612
Age Group (5 - 2) ✻ Effect Type (Sound - Light)	0.748	0.988	-1.218	2.714	47.0	0.757	0.453

Table S12. Parameter Estimates (Fixed coefficients)

			95% Confidence Intervals				
Effect	Estimate	SE	Lower	Upper	df	t	p
Age Group (5 - 2) ✻ Effect Type (2 - 1) ✻ Order of Presentation: Explored-first	-2.274	1.476	-5.213	0.665	80.0	- 1.540	0.127
Age Group (5 - 2) ✻ Block Order (2 - 1) ✻ Order of Presentation: Instructed-first	**2.961**	**1.300**	**0.373**	**5.550**	**80.0**	**2.278**	**0.025**

4. Chapter 4: Exploring Communication in Toddlerhood: Developmental Trajectories and Patterns of Communicative Interactions in the Second Year of Life

4.1. Linking Statement

The previous empirical chapters reported two experimental studies on preferential choices in early information transmission with a focus on the role of generalisability and the salience of the learning context. This next chapter pivots to broader yet crucial aspects of early information transmission in young children's communicative interactions in their daily life at home. In this chapter, we acknowledge young children as active communicators who initiate various communicative interactions to achieve various goals from requesting objects to sharing attention and information and help seeking to – more importantly for this thesis – information giving.

Our knowledge regarding children's early information transmission attempts as part of their communicative repertoire is currently limited. This is why here we embarked on a journey to investigate how children in the second year of their lives communicate with social partners and the prevalence of information transmission in their interactions. In this investigation, I made use of a data sets collected cross-sectionally from 3 age groups (13-, 18-, 23-months). Our approach in this chapter was primarily exploratory to broadly investigate the types of communications initiated by children. The findings of this study improve our understanding of the nuances of early communicative development, and more specifically, child-initiated communication leading to information transmission.

This chapter is currently being prepared for a journal submission:

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Exploring Communication in Toddlerhood: Developmental Trajectories and Patterns of Communicative Interactions in the Second Year of Life

4.2. Abstract

Children are effective communicators of knowledge from very early on. They actively initiate interactions with others and reciprocate with others' bids for communicative interactions. In this study, we investigated toddler's interactions with their caregivers in their natural settings across the second year of life. We coded one-hour-long video recordings of home observations from different age groups (13-, 18- and 23- months, N = 47) using a novel coding scheme to document the type of interactions that caregivers and toddlers initiate to meet a range of communicative goals. By employing an event-based approach, we identified events that were later categorized with respect to the communicative goals that they initially intended to achieve such as sharing interest, attention, or emotion, requesting an object or an action, seeking information or help and giving information. We then focused on the prevalence of (different types of) information transmission by toddlers in these interactions. We found that toddlers increasingly transmit information to others across the second year of life; however, these interactions constituted only a fraction of the events (approximately 2 %) among all communicative intentions. These findings both inform us about the early communicative interactions between toddlers and caregivers and provide valuable insights about the developmental trajectory of toddlers' ability to transmit information.

Keywords:

- information transmission
- communicative intentions
- deictic gestures
- social interactions

4.3. Introduction

Children exhibit remarkable proficiency in navigating the intricacies of the social world right from the early stages of life. In infancy and toddlerhood, children adeptly employ strategies to enhance their social interactions and communication skills. Advancements in gesture production, language skills, increased mobility, and heightened socio-cognitive awareness shape their social engagement. These developments influence their roles in potential interaction leading them to engage with others in diverse ways and employ various strategies (e.g., Karasik et al., 2011; Schneider & Iverson, 2022), including actively initiating interactions to elicit specific responses from others.

Infants communicate through a combination of non-verbal behaviours, such as gestures and action demonstrations, and verbal behaviours, such as non-speech vocalizations and language, to communicate with the people around them. Among non-verbal behaviours, deictic gestures (i.e., pointing, holdouts, giving and reaching) play a crucial role in early communicative endeavours (e.g., Bates et al., 1975; Boundy et al., 2016, 2019; Cameron-Faulkner et al., 2015). Around 4 months of age, infants actively use their hands to interact with objects and by 6 months, they reach for objects beyond their grasp (e.g., Bates et al., 1975; Rochat et al., 1999), especially when others are present, often alternating their gaze between the object and social partners (Caselli, 1990, Ramenzoni & Liszkowski, 2016). Nine- and 10-month-old infants start using holdouts and giving gestures with a potential intention to socially engage with others such as sharing interest or attention with them (Boundy et al., 2016, 2019; Cameron-Faulkner et al., 2015). These behaviours have been increasingly evaluated as precursors to index-finger pointing – a hallmark of development associated with important linguistic and socio-cognitive outcomes (Aureli et al., 2013; Blake et al., 1994; Carpenter et al., 1998).

Pointing, one of the most prominent deictic gestures used by infants, serves as a powerful tool for initiating interactions. Around 12 months of age, infants start producing points (Tomasello et al., 2007), and their pointing elicits diverse responses from their caregivers and other social partners. Infant-initiated interactions triggered through pointing can be classified as aiming to request an object (e.g., Moore & D'Entremont, 2001), to share or attract attention and interest (e.g., Liszkowski et al., 2004), to seek information or help (e.g., Begus & Southgate, 2012; Kishimoto, et al, 2007; for a review, see Southgate et al, 2007), and to give information (e.g., Liszkowski et al., 2006, 2008). In each of these, the type of caregiver response elicited may differ qualitatively (e.g., handing the infant the desired object, providing the desired information/help). It can thus be argued that infants have at least a rudimentary sensitivity with respect to the role of their own actions on their social partners' subsequent behaviour to be able to direct the responses they would receive from others.

Infants' intentions in communicative bids have been a topic of interest particularly in the context of pointing and almost exclusively with respect to two main communicative intentions: imperative (i.e., using an adult as a means to achieve a goal) and declarative (i.e., drawing attention to an interesting object or sharing interest with others) (e.g., Bates et al., 1975; Camaioni, 1997; Cameron-Faulkner, 2020). Recently, however, research on infants' communicative intentions has extended to information-seeking and informative interactions (Southgate et al., 2007; Tomasello et al., 2007). Infants have been shown to demonstrate information seeking behaviours that elicit informative responses from their caregivers through pointing even before they master language (for reviews see, Begus & Southgate, 2018; Butler 2020; Lucca, 2020). By displaying inquisitive tendencies, infants start babbling (e.g., Goldstein et al., 2010), engage in actions such as showing or holding out objects towards others, giving and taking objects (e.g., Boundy et al., 2016), and social referencing, employing it to both seek social input (Striano et al., 2006) and gather information to resolve uncertainties (Bazhydai et al., 2020; Goupil et al., 2016). Once available to them as a communicative tool, they actively utilize pointing to inquire about objects that captured their attention (Begus & Southgate, 2012; Begus et al., 2014; Lucca & Wilbourn, 2018, 2019). The range of these prelinguistic behaviours, then, paves the way for the eventual development of sophisticated social information seeking using verbal questions. Informative intentions, on the other hand, were previously investigated as a subcategory of declarative intentions along with expressive ones (Tomasello et al., 2007). Previous research found that infants also inform others about the location of an object they were previously looking for but lacked visual access by pointing towards that object (e.g., Liszkowski et al., 2006, 2008; Meng & Hashiya, 2014).

Despite the focus on pointing gestures in the study of early communicative development (e.g., Carpendale & Lewis, 2006; Kuhn et al., 2014; LeBarton et al., 2015; Lucca, 2020), earlier pre-pointing gestures also have been linked to developmental outcomes such as better expressive language (e.g., Choi et al., 2021). Further, recent studies suggest a developmental continuum in infants' gestures and highlight the role of pre-pointing gestures such as gives, hold-outs, and reaches on the range of infants' communicative intentions (Boundy et al., 2019; Carpendale et al., 2021; Donnellan et al., 2020; Karadağ el al., 2024b; Moreno-Núñez et al., 2020; Perucchini et al., 2021; Salter & Carpenter, 2022; see Guevara & Rodríguez, 2023, for a review).

Early communicative intentions have been investigated in different ways. For instance, information giving and information seeking intentions have mostly been explored in lab-based experimental studies (e.g., Bazhydai et al., 2020; Begus & Southgate, 2012; Liszkowski et al., 2006, 2008) compared to other intentions which have been also investigated in more naturalistic contexts (e.g., Cochet and Vauclair, 2010a; Rowe & Leech, 2019). Additionally, these previous findings point to some inconsistencies between experimental longitudinal designs (Aureli et al., 2013, 2017; Camaioni et al., 2004; Carpenter et al., 1998; Perucchini et al., 2020) and more naturalistic studies (Cochet & Vauclair, 2010a) where spontaneously generated behaviours are observed. For instance, in lab-based studies, Camaioni et al. (2004) found imperative pointing emerged at 11 months, preceding declarative pointing, whereas Aureli et al. (2013, 2017) observed both intentions at 9 months, increasing similarly from 12 to 15 months, and these results were also reflected in the findings of Perucchini et al. (2020). In more naturalistic studies, Cochet and Vauclair (2010a, 2010b) reported higher frequencies of declarative pointing in the second and third years, with age correlation for declarative pointing. Thus, comprehensive studies of various communicative intentions are needed to reconcile the mixed findings and build upon them to provide a more complete picture of their developmental unfolding.

To the best of our knowledge, only one study, by Karadağ and colleagues (2024b), investigated all four communicative intentions identified in the literature through a wide range of verbal and non-verbal behaviours initiated by infants and captured through natural home observations. Their findings showed that at 18 months, Turkish infants actively initiated different interactions intended to achieve different communicative goals (e.g., requestive, expressive, information/help-seeking, informative); infants most often initiated expressive interactions, followed by requestive and information/help-seeking interactions. Finally, even though the authors observed informative interactions, these were very rare in comparison to other interaction types and constituted less than 1% of all interactions initiated. The scarcity of information giving interactions is somewhat surprising given the results of the previous, albeit lab-based experimental, studies which suggested that information transmission is an early emerging ability at as young as 12 months (e.g., Liszkowski et al., 2008). Thus, we set out to investigate the early communicative interactions initiated by toddlers longitudinally across the second year of life, with a special focus on the types of informative interactions.

In recent years, more infancy research has shifted toward naturalistic settings, allowing observation and analysis of infant behaviour in the context where most learning occurs – their homes. This approach provides ecologically valid data, accounting for individual differences influenced by factors like familial SES, communicative input from caregivers, and physical constraints of the infant environment (such as house size, available toys and objects at home) (e.g., Herzberg et al., 2022; Suarez-Rivera et al., 2022; Swirbul et al., 2022). Unlike brief lab-based studies, observing infant-caregiver interactions over extended periods where these interactions tend to occur in short bursts (e.g., Herzberg et al., 2022; Slone et al., 2019) has the potential to capture nuances of early information giving.

Traditional experimental paradigms where a somewhat artificial teaching-like context is created to elicit this process may overlook the nuances of how children come to represent knowledge and information exchange between individuals (e.g., Bazhydai, Silverstein et al., 2020; Flynn & Whiten, 2012; Flynn, 2008; Karadağ et al., 2024a; Liszkowski et al., 2008; Vredenburgh et al., 2015).

Limitations in studying information transmission during early childhood may arise from different factors. Firstly, defining teaching often emphasizes intention, knowledge change and mentally representing others' epistemic states (Caro & Hauser, 1992; Strauss et al., 2002) which suits older children but poses challenges when studying infants and toddlers. Secondly, study designs are influenced by how teaching is operationalized and interpreted. For instance, if we expect children to understand words like "teach" or "learn" and represent what teaching or learning entails (Astington & Pelletier, 1998; Sobel & Letourneau, 2016; Strauss et al., 2002; Ziv & Frye, 2004; Ziv et al., 2008), our designs will be restricted both by children's foundational socio-cognitive skills such as language, and their experience with teaching-like contexts. Finally demands of lab-based tasks where children interact with strangers in an unfamiliar setting, differ substantially from real-life situations. For these reasons, the study of teaching has mainly focused on children from a certain age, mostly 4 years and upwards.

Understanding early manifestations of information transmission is crucial for a comprehensive view of teaching. One traditionally dominant view establishes that the teacher judges the knowledge states of the learners, and if the teacher identifies a "knowledge gap" between the learner and themselves, they teach the learner with the motivation to remedy the knowledge gap (e.g., Strauss & Ziv, 2012, Kruger & Tomasello, 1996). In this conceptualisation, possessing the ability to represent others' minds and ascribing beliefs, knowledge or lack thereof, desires, and intentions to others (i.e., theory of mind and metacognitive awareness) is a prerequisite (Gweon, 2021; Strauss & Ziv, 2012, Kruger & Tomasello, 1996). Studies conducted with preschool-aged children lend support to this view, showing that being able to accurately and efficiently represent others' mental states results in more sophisticated and successful teaching strategies (e.g., Bensalah & Caillies, 2020; Davis-Unger & Carlson, 2008a, 2008b; Strauss et al., 2002; Ziv et al., 2016). Nonetheless, it may not apply to the early manifestations of teaching we observe in infants and young children. From the literature, it is known that infants and toddlers share information with others spontaneously even though the scope of this information is limited to information pertaining to the child and what happens in the world around them in the here-and-now (O'Neill, 1996, Knudsen & Liszkowski, 2012; Liszkowski et al., 2008; Behne et al., 2014; see Harris et al., 2020, for review).

Relatedly, some aspects of theory of mind and metacognition emerge early and are ubiquitous such as representing intentions, knowledge and goals of others which may be relevant for being able to share information with others. However, the sole existence of these capacities does not necessitate that the young children use these capacities when deciding to teach or to take the other person into account if they want to share information with them (Bazhydai & Harris, 2021; Bazhydai & Karadağ, 2022). For instance, in an interaction where an infant-caregiver dyad engages in a chore such as tidying up toys, when the infant points towards toys left under the table but not noticed by the parent, there is an information flow between the two parties. While this may not be construed as teaching as such, the infant shares information that is not accessible to the parent at the time, and thus in this context, the infant is more knowledgeable than the parent. Relatedly, early engagement with establishing communicative interactions such as this thus might lie at the heart of the ontogeny of information transmission.

While information transmission is crucial for human cognition (Strauss & Ziv, 2012) and cultural progress (Caldwell et al., 2019), children's abilities in this domain have been understudied until recent decades. Strauss and Ziv (2012) provide an insightful taxonomy of teaching, where early information giving displayed by infants and toddlers such as providing information about the locations of objects are evaluated as *proto-teaching* due to the episodic nature of the information provided. Between the ages of 3 to 5, children engage in what they call *emergent teaching*, initially focusing on procedural aspects when giving information using demonstrations, and later their teaching becomes more comprehensive: 5-year-olds provide detailed explanations, state rules and correct errors alongside providing demonstrations. As children begin schooling, their socio-cognitive development and experiences in formal schooling contribute to their proficiency as they engage in *contingent teaching* activities allowing them to tailor their teaching to the needs of the learners (Gweon 2021; Ronfard et al., 2018; Strauss & Ziv, 2012). This trajectory is not surprising, but it may be incomplete because the early manifestations of children's information transmission remain somewhat elusive. Despite emerging insightful findings (e.g., Ashley & Tomasello, 1998; Bazhydai, Silverstein et al., 2020; Flynn & Whiten, 2012; Karadağ et al., 2024a, 2024b; Liszkowski et al 2006; 2008; Meng & Hashiya, 2014; Vredenburgh et al., 2015), our understanding of this development in the first years of life is limited.

4.4. The Current Study

Young children are active in their interactions with others and their environment. This enables flexibility for them to initiate different types of interactions to meet diverse communicative goals, such as sharing attention, requesting objects, seeking or giving information. Among these goals the one that received the least attention in prior research is information giving. The current study therefore addresses the broad distribution of communicative interactions at three time points in the second year of life, and then focuses on the characteristics and prevalence of information giving interactions. We posed two research questions: (1) What are the developmental trajectories of four types of child-initiated communicative interactions across 3 time points in the second year of life in natural settings? (2) What is the distribution of elicited and non-elicited information giving among all informative interactions across the second year of life? Given the inconsistencies in the prior literature and a lack of studies of this type, this research was largely exploratory. Nevertheless, our predictions were as follows: Across the second year, children will spontaneously engage with their caregivers more to either share their interest or to request something from them compared to information seeking and information giving. We expected infants to both initiate information giving interactions and to respond by giving information to caregiver-initiated information seeking; however, both types of information giving events were expected to be infrequent compared to other communicative intentions. Finally, we expected information giving to increase over the course of the second year.

4.4. Method

4.4.1. Dataset

We used "The Science of Everyday Play" (Tamis-LeMonda & Adolph, 2017) video dataset accessible to researchers registered on Databrary (https://nyu.databrary.org/volume/563). The primary dataset included home observation recordings of 63 toddlers in the second year of their lives. The nature of this dataset is cross-sectional: toddlers from three different age groups (13-, 18-, and 23-month-olds) were recruited. Each toddler was recorded during two two-hour home visits.

For the purposes of the current study, we selected the first hour of the first visit for each age group (48/63 was available). This was done to account for external factors that might influence toddler behaviour differently, such that the novelty due to the presence of others and being observed and followed at home would be consistent.

4.4.2. Participants

Data from 48 toddlers whose caregivers originally consented for the reuse of their first visit videos by another researcher was used in this study. Data was collected from predominantly White, middle class, New York based families. There were 16 toddlers in the 13-month age group (*Mage* = 13.00 months, *SD* = 0.18, *Range* = 12.7 - 13.2 months), 13 toddlers in the 18-month age group (*Mage* = 18.00 months, *SD* = 0.19, *Range* = 17.6 - 18.2 months), and 18 toddlers in the 23-month age group (*Mage* = 22.9 months, *SD* = .18, *Range* = 22.8 - 23.3 months). One toddler from the 13-month group was later identified to follow an atypical trajectory that affected their gesture use; thus, we dropped the coded data from this participant, resulting in a final sample of 47 toddlers.

We received ethics approval from the Faculty of Science and Technology Research Ethics Committee at Lancaster University for the behavioural coding and re-analysis of the primary dataset.

4.4.3 Primary video data collection procedure

When collecting the Science of Play video dataset, the following procedure was followed (Tamis-LeMonda & Adolph, 2017). The visits were made when the toddler and at least one of the caregivers were at home; some toddlers had other family members or house staff at home though these were not quantified. The toddlers and their caregivers were recorded using a portable video-camera, and the observer mostly remained unresponsive to toddler's communicative bids toward them to avoid interfering with the natural behaviour of the dyad. Additionally, during these visits, the caregivers were instructed to continue their daily lives as they normally would and not to interact with the observers unless there were situations where they could not avoid the interaction (such as when they requested recording to be stopped for privacy reasons during feeding or changing their children). However, if the toddlers referenced the observers such as by pointing towards them or asking them to do something with them, the parents acknowledged these requests and explained why the observer cannot engage (e.g., she will eat later, she is recording, etc.).

During home observations, toddler-caregiver dyads engaged in various activities in their everyday environment. These activities included mealtime (where children were fed, or they had snacks and drinks), screen-based activities (where they watched TV together with their parents or looked at photographs or videos from their parents' phones or tablets), playtime (where the dyad played with toys, listened to music, and danced together, played physical games such as *catch the ball*, etc). Additionally, the home observations encompassed household activities where the caregivers carried out their daily chores in the presence of their children or by involving them in these tasks such as when they were cooking, folding the laundry, tidying up the toys, unloading the dishwasher, or making coffee. Finally, among the most common play activities were reading books with the caregivers, drawing and colouring, playing with blocks, making puzzles, listening to music, and dancing.

4.4.4. Behavioural Coding

We adapted a coding scheme developed by Karadağ et al (2024b), coding infant behaviours in an event-based manner (e.g., Bornstein et al., 2020). The camera always followed the toddler, and we coded toddlers' interactions when they were in the presence of or in communication with another person. An event was defined as an interaction that started with a trigger behaviour from the toddler, such as pointing to an object, and ended when the query associated with the trigger behaviour was resolved or when either the parent or the toddler disengaged from communication. All behaviours initiated within 3 seconds following the toddler-initiated trigger behaviour were coded. This time frame was chosen based on the previous literature on contingency in mother-infant interactions (e.g., Kuchirko et al., 2018; Tamis-LeMonda et al., 1998; Tamis-Lemonda et al., 2013). In this study, unlike in the previous coding protocol that looked at a broader range of behaviours (Karadağ et al., 2024b), we only focused on toddlers' use of deictic gestures as the most prevalent non-verbal behaviours to initiate an interaction.

A trigger behaviour (i.e., toddlers' pointing, giving, reaching, holding out gestures) was coded as marking either toddler- or caregiver-initiated interaction. In the following cases, the interaction was coded as toddler-initiated: 1) if the toddler behaviour did not occur within three seconds of the last adult-initiated behaviour (e.g., the mother asks the toddler to look at something, the toddler points 10 seconds later); 2) if the toddler disengaged from the previous interaction with a new trigger behaviour (e.g., the mother asks the toddler to look at the window and the toddler gives an object to the mother). If the toddler behaviour occurred within the three seconds of the last adult-initiated behaviour (e.g., the mother asks the toddler to give her an object, and the toddler responds within three seconds), the event was instead coded as caregiver-initiated. In rare cases where the three seconds prior to the trigger behaviour were not informative in terms of identifying the initiator of the interaction (e.g., toddler pointed to an object, but it was in response to the parent's question four seconds ago), we extended the time frame to five- seconds (e.g. when the child walked towards and gave an object their mother; due to the walking pace of the child 3 seconds before the giving action was not informative to define who initiated this behaviour whether the mother requested the object or the child wanted to give the object to the mother).

The coding was completed in two steps: The first step included identification of the events and event-related characteristics; the second step included the coding of the perceived communicative intent of the events.

First Step Coding:

The main aim of this step was to identify trigger events that fit the criteria as specified above. Once we identified a particular event, we coded three different tiers for each event. The first tier was called "Initiator" and it represented whether the interaction was initiated by the caregiver or the toddler. The second tier was called "Bid Success" and it represented if the bid had been responded to appropriately or not (e.g., successful bid: the infant pointed to some object to request it, the mother looked at it but responded as "No, you can't get it"/ "Here, it is."; failed bid: the toddler pointed to some object to request it, the mother did not notice nor acknowledge the point, instead showed something else and said "Look at this!"). It is important to emphasize that a bid was evaluated as successful even if it did not achieve what it set out to achieve (e.g., receiving an object after pointing to that object to get it). We reasoned that if the communication between the communicative partners continue to flow and the interlocuters acknowledge each other, whether the initial aim of the bid was achieved or not is irrelevant (Clark, 1996; Grice, 1975). The third tier was called "Trigger Behaviour", and it represented the type of behaviour that was used by the toddler to initiate the interaction or to respond to caregiver's bid (Figure 1).

Trigger behaviours were chosen based on the previous literature on early non-verbal communicative interactions initiated by toddlers. We coded instances where infants produced pointing (to an object, location, or a person), hold-out, giving and reaching gestures. We defined these behaviours as follows:

Pointing: Using either index-finger or full hand toward a particular object or a social other. In addition, we included behaviours in this category that were not precisely "pointing" but functioned as pointing (such as a toddler sitting on a couch looking at their parent and tapping on the couch with both hands to request their mothers to sit with them).

Hold-out: Picking an object in one or both hands and holding it out toward the social partner.

Giving: Holding an object in one or both hands and dropping/handing over the object in the social partner's hand/lap, placing the object near the other, or placing an object to a location requested by the partner (such as when tidying toys, putting toys in a basket that the parent is holding towards the child).

Reaching: Extending one or both arms toward an object or a social partner including cases where children reached up to the parent to be picked up, to take an object from the parent and to aid their own mobility.

The instances of these deictic gestures were not coded in the following cases: 1) when the toddler was alone, 2) when the toddler behaviour was directed to the observer (e.g., they looked at and gestured toward the observer, and did not acknowledge the parent), 3) when the toddler and the caregiver were in the same room but the caregiver was not in view of the camera recording and the interaction between the toddler and the caregiver could not be reliably predicted (e.g., the toddler gestured toward the caregiver, but the coder could not see or hear the caregiver), 4) when the toddler and the caregiver were together (sitting on a play mat in close proximity) but the toddler behaviour was not directed to the caregiver (they are examining objects or reaching to objects without acknowledging the parent).

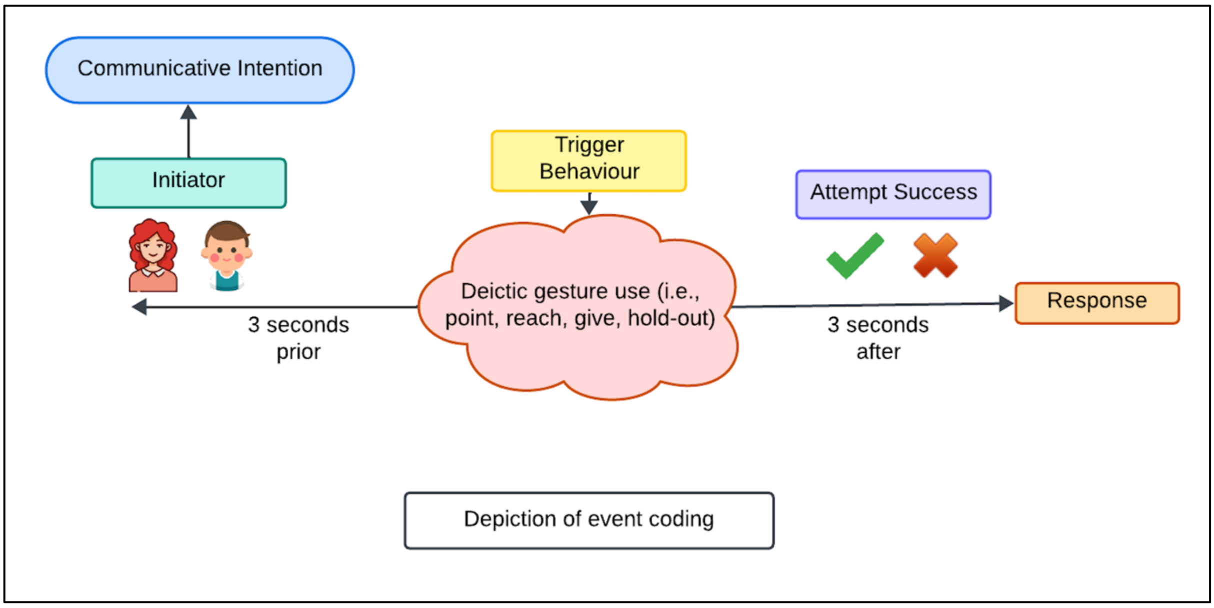

Figure 1. Depiction of event coding.

<u>Second Step Coding:</u>

Once all events and event-related characteristics were reliably identified in the video dataset, all the videos were coded again to identify the perceived intention of the interactions (Figure 2). This was coded in one tier which was called "Interaction Type" and could be *requestive*, i.e., requesting an object or an action from the social partner, *expressive*, i.e., aiming to either share emotion about an object or an action, or attract, share or sustain attention of a social partner, *information/ help seeking,* i.e., aiming to seek information or help from the social partner, and *information giving*, i.e., aiming to transmit information to the social partner.

In order to fully characterise and understand the development of information giving in the second year of life, information giving events were classified into two categories as non-elicited/spontaneous information transmission and elicited information transmission. The first category included events where toddlers shared information that was opaque to their caregivers spontaneously, such as telling them about something that happened in their absence, exchanging looks with their caregiver and pointing to something that only they can see or information about their own mental and physical states (e.g., pointing to their finger and saying "hurt"). For the second category, we coded toddlers' information giving responses to their parents' genuine information-seeking questions where the response to the posed question was not immediately clear to the parent. For instance, if a parent asked the toddler "Where is X?" and if the parent did not have visual access to the X at that moment, or if the parent asked the toddler "Which one do you want? This one or this one?" by holding two objects towards the toddler, the toddlers' responses to these questions were coded as information-giving as the toddler had an opportunity to provide specific information to the parent. However, not all parents' questions aimed to seek information. For example, if the parent asked, "Could you please hold this?", the toddler's response to this question was not coded as information-giving because the question was not a genuine information-seeking attempt but rather a polite request from the caregiver. Similarly, if the parent and toddler shared the same visual field and the parent asked a question about aspects of the context that were accessible to both (e.g., the parent and toddler are looking at a picture book and the parents asks, "Where is the ball?", "How many are there?"), the toddlers' responses were not coded as information-giving because of the pedagogical nature of such questions where the parent aimed to guide the toddler's learning rather than learn from the toddler (e.g., Yu et al., 2019).

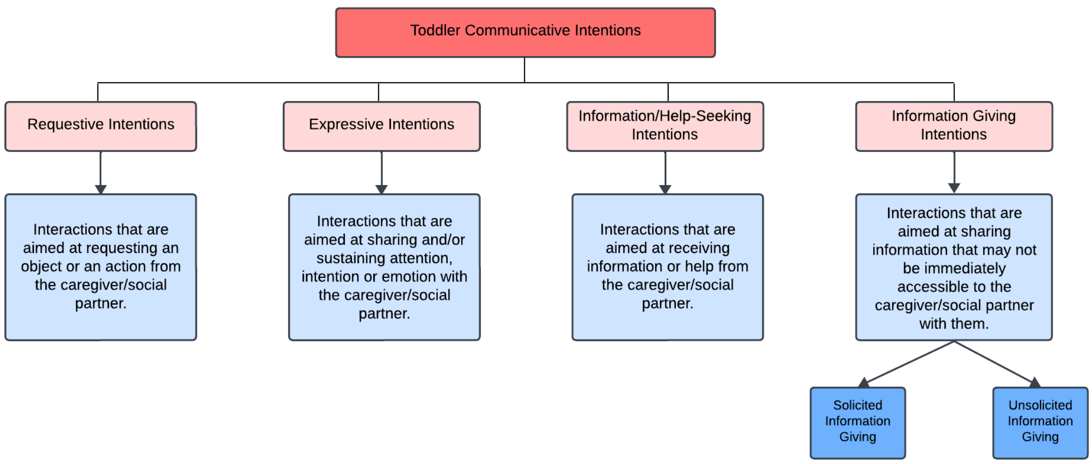

Figure 2. Types of interactions classified by the perceived intention of the interaction.

Finally, the intentions of the interactions were assigned based on the initiator of that event. If the toddler showed a give gesture because the parents asked for an object from the toddler by holding their hands toward them, this interaction was coded as *requestive* because the gesture of the infant was initiated by the parent. Besides describing an overall distribution, we did not analyse the parent-initiated interactions in this study.

4.4.5. Training Coders and Interrater Reliability

The videos were coded using ELAN (ELAN, 2023; Wittenburg et al., 2006). Following the coding procedure, we conducted a reliability analysis in two steps with two different secondary blind coders. The first author acted as the secondary coder in the first step and as the main coder in the second step. First, the coders identified the events based on the developed event definitions while watching the first hour of a free-flowing video. Following the identification of the event, coders moved onto coding other event related characteristics such as initiators, attempt success and trigger behaviours. In the second step, a new blind coder was trained to code the type of interactions for the reliability analyses.

We randomly selected 25% of the data to be coded for reliability. In the first step, after the coders coded the videos independently, they discussed each case that was coded by only one of them to make sure the coded interactions followed the criteria of this study. In this agreed-upon list of events, 77% of all events were reliably identified by both coders[6]. Categorical variables showed substantial to excellent agreement (all kappas ranged between .67 to .89, % agreement rate ranged between 84% - 93%) and Intraclass correlations calculated for the continuous variable ($r = .77$) showed good reliability. In the second step, coders showed substantial agreement (kappa = .75, % agreement = 85%). After sufficient reliability was reached, the remaining data were coded independently by the primary coder.

4.5. Results

4.5.1. Event characteristics

[6] Given the nature of the data, we were not able to calculate a Kappa value for the event detection.

Overall, we identified a total of 4440 events (*M* = 54.44, *SD* = 38.2, *Range*: 30-208). Approximately 64% of all events coded were initiated by the toddlers with one of the trigger behaviours, in the remaining 36% of the events, toddlers' use of the trigger behaviours was as a response to parents' bids (caregiver-initiated). Since the focus of the current paper is toddler-initiated behaviours, our reporting below is based on toddler-initiated events (except for "elicited information giving" which occurred as response to parent's information-seeking questions/attempts and allows us to characterise this communicative intention more fully as manifested in infants' everyday environments).

In total, we identified 2817 events initiated by the toddlers (*M* = 55.41 per one-hour, *SD* = 38.99, *Range*: 17-175). An event lasted 3.23 s on average. Among these, 98% were coded as successful (*n* = 2754). Toddlers used all four trigger behaviours to varying degrees with reaches being the most frequent, followed by points, gives, and holdouts (see Table 1).

Table 1. Distribution of trigger behaviours in toddler-initiated interactions.

Trigger Behaviour	Number of Events	% of Total Events
Reach	913	32.4%
Point	856	30.4%
Give	619	22.0%
Hold-out	429	15.2%

Across all age groups, all four types of events based on perceived communicative intent were initiated at least once. *Expressive* events were initiated most frequently, followed by *Requestive* and *Information/Help Seeking* interactions. Even though rare compared to other intentions, children also initiated *Information Giving (Non-elicited)* events (See Table 2).

Table 2. Distribution of communicative intentions in toddler-initiated interactions.

Interaction Type	Number of Events	% of Total Events
Expressive	1407	49.9 %
Requestive	1128	40.0 %

Information/Help Seeking	235	8.3 %
Information Giving	**47**	**1.7 %**

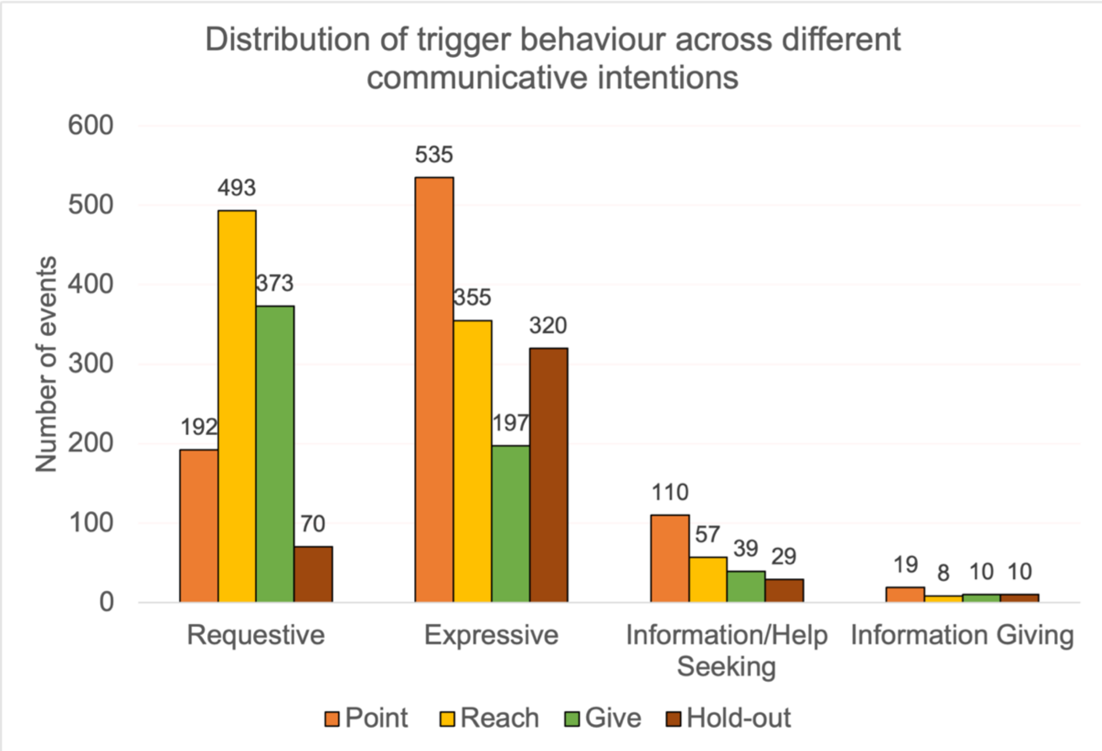

Figure 3. Distribution of trigger behaviours across different communicative intentions. As evident in Figure 2, pointing was most frequently used to initiate expressive events, and the most prevalent among information/help seeking events, whereas requestive events were most frequently initiated with a reach and a give.

4.5.2. Developmental trajectory of toddler-initiated communicative intentions

We present the proportion of each type of interactions initiated by toddlers across age groups in Table 3. Since the assumption of normality was not met, by using the proportions we conducted four Kruskal-Wallis tests to investigate the role of age across each communicative intention while applying Bonferroni correction for multiple tests, the results of these tests did not show a significant difference across age groups, all *ps* were bigger than the Bonferroni adjusted critical alpha value of .0125 (requestive $p = .022$, expressive $p = .202$, information/help seeking $p = .875$, information giving $p = .260$).

Table 3. Proportions of communicative interactions initiated by each age group.

	Age Group	Mean	SD	N
Requestive	13-month	0.47	0.16	16
	18-month	0.43	0.12	13
	23-month	0.35	0.09	18
	Total	**0.42**	**0.14**	**47**
Expressive	13-month	0.47	0.15	16
	18-month	0.50	0.14	13
	23-month	0.54	0.09	18
	Total	**0.50**	**0.13**	**47**
Information/Help Seeking	13-month	0.05	0.03	16
	18-month	0.06	0.08	13
	23-month	0.08	0.10	18
	Total	**0.07**	**0.08**	**47**
Information Giving	13-month	0.006	0.01	16
	18-month	0.009	0.01	13
	23-month	0.02	0.03	18
	Total	**0.01**	**0.2**	**47**

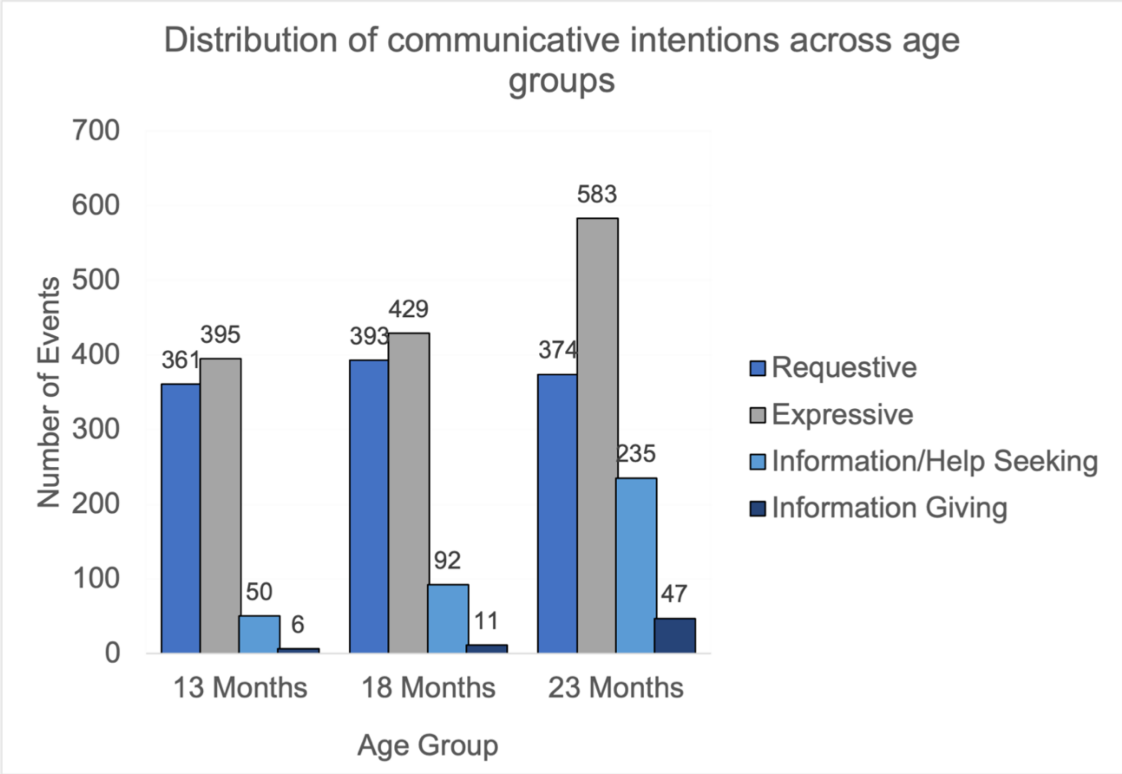

Figure 4. Total number of events initiated for each communicative intention across age groups.

4.5.3. Toddlers' information giving

To collectively account for all events that we characterised as information giving in our coding scheme, we created a new variable - combined information giving where we summed up the number of elicited information giving events and the number of non-elicited information giving events. Based on this combined teaching measure, 40 out of 47 toddlers in the sample displayed at least one informative event during an hour-long interaction with their caregivers. Eighteen out of 47 toddlers showed at least one toddler-initiated (non-elicited) information giving event and 38 out of 47 toddlers showed at least one elicited information giving event.

4.5.6. Developmental trajectory of information giving behaviour

To investigate the predictive relationship between age and information giving, we ran linear regression analyses for each type of information giving, and the combined information giving score, while accounting for age as a continuous variable. Despite showing a steady increase across age groups, the continuous age variable did not significantly predict the number of non-elicited information giving events β = .284, ($t(45) = 1.989$, $p = 0.053$, two-tailed). Similarly, continuous age variable did not predict the number of elicited information giving events β = .252, ($t(45) = 1.749$, $p = .087$, two-tailed). However, age significantly predicted the number of combined information giving events β = .306 ($t(45) = 2.159$, $p = .036$, two-tailed). We additionally calculated correlations between age as a continuous variable and each type of information giving as well as combined information giving scores. We found that age was positively correlated with non-elicited information giving $r(45) = .284$, $p = .026$ (one-tailed), with elicited information giving $r(45) = .252$, $p = .044$ (one-tailed), and with combined information giving score $r(45) = .306$, $p = .018$ (one-tailed).

Table 4. Mean number of different information giving events different age groups.

	Age Group	**Mean**	**SD**	**Min**	**Max**
Non-elicited Information Giving	13	0.38	0.81	0	3
	18	0.85	1.07	0	3
	23	1.667	2.83	0	11
	Total	**1.00**	**1.94**	**0**	**11**
Elicited Information Giving	13	2.31	2.57	0	8
	18	5.46	3.64	1	13
	23	4.67	4.26	0	13
	Total	**4.09**	**3.75**	**0**	**13**
Combined Information Giving	13	2.69	2.92	0	8
	18	6.31	3.86	1	13
	23	6.33	6.21	0	24
	Total	**5.09**	**4.89**	**0**	**24**

4.6. Discussion

In this study, we had two overarching aims: First, we investigated the developmental trajectory of key toddler-initiated communicative intentions across three time points cross-sectionally in the second year of life. Second, we focused on the information giving intention to characterise the distribution of both elicited (i.e., initiated by the caregivers) and non-elicited information giving events. In this study, we found that toddlers actively initiated communicative interactions with a range of communicative intentions (requestive, expressive, information/help seeking, information giving) using all four deictic gestures. Almost all of the communicative bids from toddlers received an appropriate response from the parent. Additionally, although it was much less frequent in occurrence, we also found that 1/3 of the toddlers initiated at least one non-elicited information giving events, and when this was combined with the elicited information giving which occurred as a response to parents' information seeking requests, 85% of all children displayed information giving there was a positive relation with toddler's age and the number of information giving events, as toddlers got older, their information giving increased. The findings of the current study build upon and extend the findings from previous literature (e.g., Salo et al., 2019, Karadağ et al., 2024b, see Guevara & Rodriguez, 2023 for reviews) in several ways., By incorporating the less often studied deictic gestures such as hold-outs, gives and reaches in addition to the more commonly investigated pointing gesture, and by using a wide range of communicative interactions, we provide a fine grained characterization of communicative behaviours across the second year of life using natural observation across three time points in the second year of life. Additionally, we show that while still being much less frequent compared to other communicative interactions, information giving emerges increasingly as part of toddlers' communicative repertoire.

Here, toddlers initiated 55 events on average during an hour-long observation in their home settings, using different deictic gestures. In terms of communicative intentions, toddlers most frequently initiated *expressive* intentions – to share or sustain attention, intention, or emotion with caregivers. The second most frequent communicative intention was *requestive* – to request an object or an action from caregivers. These two intentions accounted for almost 90% of all interaction initiated by the toddlers in this sample. The prevalence of these intentions was similar to what has previously been observed in a similar paradigm (Karadağ et al., 2024b). Additionally, these findings are also in line with the prior literature which mainly focused on imperative and declarative intentions (akin to what we characterized as "requestive" and "expressive") (for reviews, see Tomasello et al, 2007; Guevara & Rodriguez, 2023).

While it was substantially less frequently observed (just over 8% of all interactions, approximately 5 events per hour), toddlers also initiated interactions with the intention of receiving information or help from their caregivers. This finding is also in line with prior studies showing that during the second year of life, information or help seeking is present (e.g., Karadağ et al., 2024b) in natural settings and serves as a part of the emerging repertoire of later curiosity-driven inquiries and explorative behaviours (e.g., Harris & Lane, 2017; Harris et al., 2018; Ronfard et al., 2018). While young children's social information seeking behaviours have attracted attention in the past two decades, most studies that focused on early information seeking were conducted in controlled laboratory settings (e.g., Bazhydai et al., 2020; Begus & Southgate, 2012, Begus et al., 2014; Goupil et al., 2016, Lucca & Wilbourne, 2018) in comparison to a smaller number of studies conducted in natural or naturalistic settings (Boundy et al., 2019; Chouinard, 2007; Olson & Masur, 2013). For instance, Chouinard (2007) conducted a diary study aimed at exploring how preverbal children, who lack the ability to verbally formulate questions, seek information from their caregivers. To accomplish this, the researcher trained parents to distinguish different types of nonverbal behaviours such as gestures and non-speech vocalizations in order to identify instances where their children were attempting to communicate inquiries. Parents, then, used specific forms to track the children's non-verbal attempts at seeking information from their caregivers. Chouinard (2007) found that 12–18-month-old toddlers sought information from adults through the use of gestures as well as information seeking vocalisations. In an experimental study, 16-month-old toddlers were more inclined to seek information about novel objects through pointing from an adult who consistently offered reliable information in the past in comparison to an adult who has been inconsistent or unreliable (Begus & Southgate, 2012). Recently, Karadağ and colleagues (2024b) found that 18-month-old Turkish infants used a wide range of verbal and nonverbal behaviours (e.g., vocalizations, deictic gestures, action demonstrations, non-specific play actions) to initiate interactions with their social partners with the intention to receive information from them. Our findings provide further support that information/help seeking is present as early as 12 months and remains stable across the second year of life. Our results therefore not only complement but extend the previously reported findings on early manifestations of information seeking behaviour.

The second goal of our study was to focus on early information giving that we reasoned would reliably manifest itself in the second year of life. Previous studies conducted in the laboratory settings demonstrated that while infants and toddlers share information following explicit requests or cues regarding the recipients' episodic knowledge states based on visual access through pointing and action demonstrations (Bazhydai, Silverstein et al., 2020; Behne et al., 2014; Liszkowski et al., 2006; 2008; Karadağ et al., 2024a, Vredenburgh et al., 2015), they are less likely to spontaneously initiate such interactions without being prompted in natural settings (Karadağ et al., 2024b). One reason for this might be that in lab settings, the tasks are specifically designed to create a situation where the child is more likely to be "in the know"; however, during the natural flow of daily events in their homes, these sorts of situations are less likely to happen.

Relatedly, considering the complexities involved in categorizing an interaction as informative while adhering to the conceptualisation of previous studies, which underlines the importance of a sort of "knowledge gap" between the interlocutors as an important feature of information giving (see Strauss & Ziv, 2012), this result is not surprising. While interpreting intentions behind communicative interactions that are initiated by toddlers is challenging on its own, it is especially difficult when it comes to providing information to others. In the preceding studies, toddlers' information provision is typically prompted by adults looking for objects through reaching, looking or self-directed questions (e.g., Lizskowski et al., 2006; 2008) or explicitly requesting information from the toddlers (e.g., Bazhydai, Silverstein et al., 2020; Vredenburgh et al., 2015). However, in the absence of these cues or when the adults do not explicitly signal these to the toddlers, categorizing these behaviours as information giving becomes challenging. This difficulty arises because it relies on making rich assumptions such as toddlers having metacognitive awareness (e.g., realizing they possess unique information) and theory of mind skills (e.g., understanding others' needs) when in reality they don't necessarily need (Bazhydai & Harris, 2021) or may not potentially have developed these capacities (Kulke et al., 2018) to give information to others. By taking this caveat into consideration, we also coded information giving where toddlers provided information in response to their caregiver's genuine information seeking questions where the appropriate response to the questions were not immediately accessible to the caregivers such as when they lacked visual access or when the response pertained to the internal states of the toddler (e.g., their preferences). We found that toddlers overall displayed more elicited compared to non-elicited information behaviour and that there was a positive relation between age and different types of information giving; however, given the borderline p-values we observed in our statistical tests, it is difficult to make strong conclusions.

Previous research on early information giving has primarily centred on pointing (e.g., Behne et al., 2014; Knudsen & Lizskowski, 2012a, 2012b; Liszkowski et al., 2006, 2008; Meng & Hashiya, 2014) and has been grounded in two key assumptions. The first assumption posits that even infants possess the ability to efficiently monitor both their own and others' epistemic states, enabling them to discern differences in knowledge levels. Some evidence supports this, with studies suggesting that infants can track their own (Bazhydai et al., 2020; Goupil et al., 2016) and others' (Tomasello & Haberl, 2003; Surian et al., 2007) episodic knowledge states. However, the extent to which these abilities motivate infants' communicative intentions, particularly in the context of information giving, remains insufficiently established. In this study, while we assume that toddlers initiate these interactions with an intention to give information, we do not claim that toddlers consciously reason that they possess unique information that needs to be transferred. Instead, the intention to transmit information (akin to proto-teaching, Strauss & Ziv, 2012) might precede the intention to teach observed in older children, and do not necessarily need to be motivated from components of theory of mind that may arguably not yet be present in toddlers (e.g., Kulke et al., 2018; Poulin-Dubois et al., 2018). Regarding the second assumption, which posits that children exhibit a prosocial motive to provide information when others want or need it, recent findings from instrument helping literature challenge this notion (Dahl & Paulus, 2019; Paulus, 2020). While infants may indeed have a prosocial inclination to help others, recent studies suggest that, in the case of 18-month-old children, their helpful behaviour is not solely driven by the specific needs of the recipient. Instead, their motivation seems to stem from a broader desire to engage in social interactions and be part of social dynamics (Paulus, 2020) as well as from a motivation to complete goal-directed actions that are not completed by others (Michael et al., 2022). Considering these findings, we suggest that incorporating observational studies that take place in toddlers' home environment as they continue their daily routine over extended periods might be useful. By doing so, we can build alternative pathways to understanding the ontogeny of early information transmission without relying on these higher-level assumptions.

Limitations & Future Directions

While the current study provides valuable insights regarding early communicative interactions, specifically information transmission, it is not without limitations. First of all, in this study we used secondary data to investigate our questions. While the video recordings were quite natural and suitable for this investigation, we did not have any control on how the observations were conducted, the sample size or sample characteristic which might have influenced the findings of our study. However, considering that our findings regarding the frequency of different types of communicative intentions were in line with Karadağ et al.'s (2024b) which investigated 18-month-old Turkish infants, with a similar coding scheme and sample size, we do not expect this to be crucial.

Second, the data coded in this study was cross-sectional, while it is still informative in examining whether and how toddlers from different ages groups initiate interaction in natural settings, it does not provide us information regarding toddlers' behaviour in the prior to or following the observed age milestone. Thus, using a longitudinal data from the same toddlers in different time points perhaps up until 4 years of age might be more informative in exploring the developmental trajectory of these interactions, and role, or lack thereof, of higher-level cognitive mechanisms such as ToM or metacognition on these interactions.

Third, identification of intentions might be challenging as each infant and their context is unique. While it was possible for observers to agree on a intention; this was still limiting because it does not necessarily mean that they actually held this intention, thus a level of assumption was allowed to be able to categorize these interactions. More studies both observational and experimental are needed to understand how adults perceive communicative intentions of young children, and what sort of assumptions they hold while interpreting these communicative intentions. Relatedly, here we were unable to account for parental behaviours or characteristics, such as some parents might be more prone to scaffolding child-initiated interactions, others instead hindering such attempts, both overall and for each individual type of intention. Thus, future studies could investigate the role of parental attitudes on the range of communicative interactions initiated by their children to account for potential individual differences across children.

In conclusion, our study was designed to provide a panoramic picture of child-initiated communicative bids with various intentions across the second year of a child's life. We found that children are active communicator, initiating interactions to fulfil various communicative goals including information giving which increasingly becomes pronounced from 13-to 23-months.

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5. Chapter 5: General Discussion

In this thesis, I have investigated early information transmission behaviour by focusing on the type of information children transmit to others in experimental studies conducted in a laboratory setting with 2- and 5-year-old children, and whether toddlers transmit information to their social partners in their natural settings across the second year of life in an observational study. In Chapter 2, I investigated the role of information generalisability in 2-year-olds' information transmission, which some have argued to be a key factor in conceptualizing teaching behaviour (Strauss & Ziv, 2012; Moll, 2022). In Chapter 3, I examined the role of learning context (self-exploration vs. instruction) in 2- and 5-year-old children's further transmission of the previously learned information. In Chapter 4, I documented toddlers' interactions with their caregivers in their natural home environment and documented the information transmission events across 3 time points (13-, 18- and 23 months) using an open-access database stored in Databrary. Below, I summarize each study along with their findings.

Chapter 2 broadly investigated whether sensitivity to the generalisability of information is an early ability influencing 2-year-old children's information transmission, leading them to selectively transmit action-based generalisable information to others. I designed a study where 2-year-old toddlers were presented with three identical-looking boxes differing only in colour. Each box contained two distinct buttons leading to either a generalisable outcome (e.g., playing a novel tune in each box) or a non-generalisable outcome (e.g., vibrating the box, making a non-musical sound, or turning on lights). In the Discovery Phase, toddlers were presented with each box individually and allowed to discover the effects of both buttons in each box. Subsequently, in the Exploration Phase, they were presented with all three boxes simultaneously to engage with them together and given a chance to observe the generalisable and non-generalisable outcomes associated with each button across the boxes. Finally, in the Transmission Phase, a naive recipient entered the room, stating they had not seen the boxes before, and asked the toddler to demonstrate what the boxes do. I measured toddlers' preference for transmission using two outcome variables: the first function activated (initial preference) and the subsequent function activated in a different box after demonstrating a generalisable first function (systematic preference). I found that 2-year-olds did not exhibit an initial preference for selectively transmitting generalisable information to a naive informant. Among the few toddlers who did preferentially transmit generalisable information, I did not observe a systematic preference for transmitting such information. I further compared toddlers' activation patterns in the Exploration and Transmission phases to examine whether children had different preferences when engaging with the objects themselves versus when transmitting them to others. However, I found no difference in how toddlers engaged with the boxes using the same two measures across the phases. In summary, these findings indicated that 2-year-olds do not demonstrate sensitivity to the generalisability of information, neither while exploring objects independently nor when transmitting them to others. These results suggest that older children's well-established sensitivity to information generalisability (e.g., Baer & Friedman, 2018; Gelman et al., 2013; Karadağ et al., in prep; Pueschel et al., 2023) may be a bias that develops later, possibly in conjunction with the development of other socio-cognitive processes such as language, theory of mind, and executive functioning. While 2-year-olds do transmit action-based information to others, they do not exhibit selectivity regarding the generalisability of the information.

In Chapter 3, I investigated whether the mode of acquisition of information that is learned through self-led exploration or direct instruction of others would influence 2-year-old and 5-year-old children's subsequent transmission of this information. The decision to transmit a particular piece of information over the other can be influenced by at least two factors: The first relates to the nature of information itself. For instance, if information A is different from information B in any way, such as their perceptual features (e.g. how they look, how they feel to touch, how they sound), causal and mechanistic properties (e.g. the way they work, how easy/difficult they are to acquire, how opaque or transparent they are) and outcomes associated with the information (e.g. how exciting or boring they are, how useful they are). The second relates to how the information is acquired, whether the learning process was self-led exploration or directed by others through direct instruction. Both factors can be important in determining what children select to further transmit to other individuals. When both information A and B are salient (i.e., equal, or closely matched in all of the dimensions listed above), a potential selectivity for either comes from the relative inherent salience of the learning environment to the children. Whilst there is evidence to support that both learning contexts might influence children's preferences to transmit one information over the other, if their salience is weighted differently, we might expect a preference towards more salient learning contexts.

To test this hypothesis, I designed a study with 2-year-old toddlers and 5-year-old children who had some experience of formal schooling. In the first experiment, the 2-year-olds were presented with two boxes that were almost identical in perceptual features. Each had one different button on different sides of the boxes that played different sounds. In the learning phase, children were taught the function of one of these boxes by the experimenter (i.e. the instructed function) and were given a chance to explore the second box independently (i.e. the explored function). After they learned what each of the boxes did, the experimenter left the room and a new experimenter entered and asked the children to show her what the boxes did. In the second experiment, the same procedure was repeated with 5-year-olds but with slight modifications to make the task more realistic, given that the boxes were quite easy for them to operate. I measured their preference for transmission in two ways: the main measure was the first function transmitted to the learner, and the complementary measure was the total number of activations for each function. I found that 2-year-olds preferred to transmit the instructed function to the learner first significantly more often than the explored function, whereas 5-year-olds transmitted both functions equally. We interpreted these results within a cue saliency framework arguing that as children get older, the way they evaluate and integrate different salient cues present in their learning environment might be undergoing a developmental change as they perceive that one can learn equally well from instruction and self-led exploration. Thus, the increasing salience of exploration might outweigh the salience of instruction, leading them to consider other cues such as the salience cues relating to the information itself. Given that these were also equal in salience, 5-year-olds might have not formed a preference for either function. Regarding the complementary measure, there was no difference in the total number of activations for either function in either age group during transmission. Whilst not being conclusive, these findings suggest that, earlier in development, the salience of instruction might be more prevalent in forming a preference for transmitting information acquired through this means.

Finally, Chapter 4 focused on early information transmission behaviour across the second year of life in toddlers' natural home environments. Even though the amount of research on information transmission is rapidly increasing, the focus of these studies was mainly on the teaching behaviour of preschool and school-aged children in controlled lab environments (e.g., Bridgers et al., 2020; Gweon et al., 2014; Gweon & Schulz, 2019; Sobel & Letourneau, 2016; Strauss et al., 2002) with studies investigating children's teaching behaviour at home remaining limited. In these studies, the age group of children tested also tended to be older (e.g., Howe et al., 2015, 2016), only a few studies included children younger than 4-year-olds as information transmitters in the context of sibling relationships (e.g., Howe, Adrien et al., 2015; Segal et al. 2018). Regardless, lab-based studies conducted with younger children aged between 12 and 24 months show that information transmission – whether it is evaluated as "teaching" or not- might be a relatively early ability (e.g., Bazhydai, Silverstein et al., 2020; Liszkowski et al., 2006, 2008; Knudsen & Liszkowski, 2012). While these findings are valuable for our understanding of the ontogeny of teaching behaviour, they are limited in their implications. Although 12-month-old infants provide information to others through pointing, it is not clear whether this is limited to the contexts that are specifically designed to elicit this behaviour or if spontaneous natural information transmission gradually becomes a tool in toddlers' social-communicative repertoire.

In this study, I aimed to investigate and identify information transmission events in toddlers across their 2nd year of life by using open-access video recordings of 13-, 18- and 23-month-old children. I used a novel coding scheme to identify the main communicative intentions that young children initiate with their social partners in their homes. Here, information transmission was divided into two categories: elicited information transmission which included children's responses to their parents' "genuine" requests for information (i.e., information-seeking questions), and non-elicited information transmission which included cases where the children shared information without being prompted by the other social partner. Information transmission was conceptualised as communicative exchanges where the information shared is not immediately apparent to the receiver because they lacked visual or content access such as informing the parents about things that happened in their absence or things that are not in their visual or attentional focus. I found that toddlers initiated a wide range of events (requestive, expressive, information/help-seeking and information giving) that differed in communicative intentions. Relevant to this thesis, I found that while quite rare (less than 2% of all events initiated by children) in comparison to other communicative intentions, children did initiate interactions to give information to their parents. Further, I found that children also provided information to their parents in response to their genuine information-seeking. Finally, when combined (elicited and non-elicited), there was a positive correlation with the children's age and information-giving across the second year of life.

Taken together, this thesis shows that: (1) While 2-year-olds transmit action-based information to others, they do not seem to prioritise the information that they transmit to others is generalisable, suggesting that sensitivity to generalisability in transmission contexts that has been observed in older children might develop gradually. (2) Two-year-olds' but not 5-year-olds' information transmission might be influenced by how they previously learned information when all other cues about the information were comparable. This might be due to how the salience of cues associated with the information and the learning context is evaluated might change developmentally in conjunction with both socio-cognitive improvements and increased exposure to different learning contexts. (3) From around 13 months, children transmit information in the elicited and non-elicited manner as part of their communicative repertoire and during their natural interactions with their parents. Information giving in natural settings is reliably present across the second year of life and tends to increase with age from 13- to 23 months.

5.1. Theoretical Contributions

Children's role as recipients of information in the knowledge exchange process has been more widely investigated in comparison to the active role they take as transmitters of information. This thesis contributes to the current literature on the developmental origins and selectivity of information transmission in early childhood by focusing on the type of information that children transmit (Chapters 2 & 3) and their spontaneous information transmission in natural settings (Chapter 4). Below, I incorporate the findings of this thesis with what we know about children's information transmission.

5.1.1. The relationship between information transmission and teaching

I have previously discussed the relationship between information transmission and teaching across different chapters in this thesis. The findings of the studies reported in this thesis might be helpful in how this knowledge transfer process is conceptualised. In both of my experimental studies, I found that the majority of children – though not all - transmitted action-based information to others who were presented as ignorant to them by re-enacting previously learned object functions. In my observational study, I found that 1/3 of children spontaneously provided information to their social partners without being prompted for information, and the number of children who provided information increased considerably when children's responses to their parents' information-seeking questions were included. While these findings collectively suggest that even infants and toddlers successfully transmit information that is not immediately accessible to the recipients, does this mean that these children engage in "teaching"? Unfortunately, the answer to this question is not straightforward.

Teaching has been considered in relation to some core components such as the nature of information being transmitted (i.e., transfer of generalisable information is teaching), the ability to represent others' mental states including what one knows and what others know (i.e., teaching happens when the teachers recognise a "knowledge gap"), and a motivation to help others learn (i.e., teaching aims to fill in the knowledge gap between the learner and the teacher) (Gweon 2021; Moll, 2022; Strauss & Ziv, 2012; but also see Bazhydai & Harris, 2021; Brandl et al., 2023; Pasquinelli & Strauss, 2018). I will unpack these supposedly core components in relation to the findings of the studies presented in this thesis and previous studies with young children.

5.1.1.1. The role of generalisability in defining teaching

Generalisability is an important aspect of knowledge that acts as a useful heuristic to bypass the costly and time-consuming trial-and-error process (Prasada, 2000). When transmitting information, it is reasonable to prioritize generalisable information for at least two reasons: It increases the utility of learnt information by making it applicable to different contexts and situations rather than limiting it to the present. It also decreases the future cost of teaching by enabling pupils to apply acquired information in various contexts and situations, thus making them less likely to need or request teaching in the future.

Starting from the age of 4, children associate generalisable information with teaching-like contexts and selectively teach such information (Baer & Friedman, 2018; Gelman et al., 2013; Pueschel et al., 2023b; Karadağ et al., in prep). This preference is not evident in 3-year-old children (Baer & Friedman, 2018; Pueschel et al., 2023b). It is possible that 3-year-old children do not "teach" because the information they convey is not generalisable. On the other hand, studies have shown that 3-year-old children can transmit generalisable information, such as action-based game rules or object functions and thus may "teach". It is also possible that the way information generalisability was measured in some studies (e.g., Baer & Friedman, 2018; Pueschel et al., 2023b) may not be appropriate or applicable to younger children who are still developing their socio-cognitive toolkit, particularly their language skills.

The first experimental chapter in this thesis aimed specifically to investigate whether toddlers would prioritize generalisable information in an action-based task rather than a verbal task that likely depends on their ability to comprehend and produce generic language. Although toddlers successfully transmitted action-based information to others, with only a few children opting not to transmit anything, I found that they did not prioritize generalisable information for further transmission. There can be different explanations as to why this was the case. For instance, it is possible that the concept of generalisability might be developing in relation to language (i.e., being able to produce generic language and associate generic language with kind-based representations), thus, leading to a preference for transmitting generalisable information selectively to others. This would be in line with the findings showing that starting from 4 years children reliably produce generic language and make sophisticated inferences based on others' use of generics (e.g., Gelman et al., 2013, Cimpian & Scott, 2012).

Alternatively, the task used in Chapter 2 might have required a higher degree of abstraction to identify the generalisability of the functions, and the lack of preference in transmission might be due to the lack of understanding of the generalisability of the functions rather than a lack of ability to represent and be selective regarding information generalisability. Regardless, we did not detect any preference for generalisable information. Therefore, if we consider generalisability as a requirement for teaching to occur, it would not be possible to evaluate toddlers' information transmission as teaching.

Nevertheless, it is important to exercise caution when making these distinctions. While generalisability of the information is crucial for teaching, defining teaching based on it may obscure the nuances of its evolution as a mechanism for transmitting information. For example, consider a 5-year-old older sibling noticing their toddler brother walking towards a hot stove and warning them by saying, 'It is very hot, it will burn you'. In this case, the language used by the sibling is specific and the information provided is limited to that moment. Therefore, this event would not be considered teaching by this criterion. However, the brother may use the information received from their sibling to avoid 'hot things' in the future. The recipient of information may generalise the information regardless of whether it was initially transmitted as being generalisable. Alternatively, if we consider game rules or object functions which are considered generalisable information (Strauss & Ziv, 2012; Csibra & Shamsudheen, 2015), would knowing the rules of a specific game such as Hide and Seek necessarily mean that one would know the rules of another game, such as Chutes and Ladders?

In summary, generalisable information provides a solid foundation of knowledge and skills that the next generations can build on and extend, and generalisability is an important component of the ability to teach, after all, it enables individuals to adapt, innovate and thrive in an evolving world. However, evaluating generalisability as a core and defining component of teaching might lead to overlooking the multifaceted nature of how teaching develops and functions as an efficient and high-fidelity information transmission mechanism.

5.1.1.2. Knowing what one knows and does not know

The roles of metacognition and ToM in preschool and school-aged children's representation of teaching, as well as their self-perception as potential teachers, are widely acknowledged as crucial (Strauss et al., 2002; Corriveau et al., 2018; Gweon, 2021; Pasquinelli & Strauss, 2018). While children who have better ToM skills might be better at effectively transmitting information (e.g., Davis-Unger & Carlson, 2008a; Strauss et al., 2002, Ziv et al., 2016, Ye et al., 2021), ToM may not necessarily be a prerequisite for teaching to occur in younger children (Corriveau et al., 2018; Pasquinelli & Strauss, 2018). Although children increasingly view teaching as an intentional communicative act aimed to lead to a change in others' knowledge and beliefs (e.g., Sobel & Letourneau, 2016), whether infants and toddlers show an explicit understanding of how knowledge is distributed among interlocutors in teaching-like contexts is not well known (Bazhydai & Harris, 2020; Ronfard et al., 2018). Moreover, there is an ongoing debate as to whether infants and toddlers in general display metacognitive awareness and ToM skills (e.g., Goupil et al., 2016; Goupil & Koudier, 2016; Kammermeier & Paulus, 2018; Kulke et al., 2018; Scott & Baillargeon, 2009; Ruffman et al., 2012, Ruffman et al., 2023). Despite these, even very young children were reported to transmit information to others, without making a claim about children's own awareness of the reasons for enabling transmission (e.g., Bazhydai, Silverstein et al., 2020; Liszkowski et al., 2008; Vredenburgh et al., 2015).

In all the empirical studies that I reported in this dissertation, we observed different examples of information transmission in very young children between the ages of 13 and 24 months. While in these studies, we assumed that children in the second year of life might be able to track others' knowledge, albeit through the lack of visual access to the information (Chapter 4) and might acknowledge others' lack of information based on their testimonies (e.g., "I have never seen these before", "I don't know how it works") (Chapters 2 and 3), it is not possible to argue that young children explicitly knew that they had useful information that the other person lacked or that their transmission behaviour was guided by an intentional thought process regarding the nature of their communication with others (Bazhydai & Harris, 2021). Even in Chapter 3, where both toddlers and 5-year-old children were tested using the same paradigm, the 5-year-olds who obviously had these skills, did not necessarily need to employ them to be able to appropriately transmit information. Across all studies, young children transmitted information to others appropriately through action demonstrations (Chapters 2 and 3) and deictic gestures (pointing, hold-outs, giving, reaching) (Chapter 4).

If we follow the conceptualisation of teaching as an information transmission mechanism centred on representing others' mental states, it becomes difficult to categorize the behaviour observed in my studies as teaching. However, imagine that the recipient in the studies in Chapters 2 and 3 did not explicitly state their ignorance about what boxes did or how they worked rather hinted that they did not know by trying to open the boxes instead of pressing the buttons, and toddlers pressed the buttons after this observation. Would we consider this as teaching then?

While it is possible that toddlers explicitly reasoned about the recipient's knowledge or, lack thereof, acted intentionally to help them learn about the functionality of the boxes, we do not have any evidence to support that they did. Instead, it is more likely that toddlers' transmission stemmed from merely recognizing what the recipient was attending to at that moment and their subsequent actions, given the limited range of "meaningful actions" available (Pasquinelli & Strauss, 2012). To conclude, I believe that while ToM, metacognitive awareness, or intention to teach might lead to more efficient teaching that is tailored to recipients' goals, beliefs and knowledge levels (Corriveau et al., 2019), these capacities may not be prerequisites for appropriate information transmission even for older children to some extent. Thus, the conceptualisation of teaching based on mentalizing skills might be misleading when considering its developmental trajectory from infancy.

5.1.1.3. Helping others learn

In the previous section, I acknowledged that mentalising ability is a crucial component of later teaching behaviour with preschool-aged children and onwards. However, the paucity of research on the topic with children younger than 4 years puts barriers to our understanding of human teaching, and these are two-fold: One is about the cognitive capacities required for teaching to emerge at an earlier age which I have covered above. The other one is about the motivation with which children teach. Even though older children's selectivity when teaching with respect to what they teach and whom they teach is informative for understanding children's motivations for teaching, these findings do not provide conclusive evidence with respect to what, indeed, motivates their teaching.

The most prominent motivation for teaching is a prosocial one: to help others learn or to provide them with the information they need (Gweon 2021; Strauss, 2022). Given that several aspects of prosocial behaviour such as helping others, sharing resources, cooperating with them, and providing comfort when they are in distress develop early in life (see Dunfield et al., 2011; Paulus, 2014 for reviews), it should not be surprising that children are motivated to teach and transmit information with others because they have a genuine concern for them. However, even so, a close inspection of early prosocial behaviours displayed by young children draws a more complicated and multifaceted picture (Paulus, 2014). For instance, recent findings show that children's helping behaviour may not initially be motivated by a concern for others and their needs but by a motivation to socially interact with them in joint activities, and other-oriented motivations become more prevalent over the course of life from infancy to preschool years (Paulus, 2020; Dahl & Paulus, 2019).

Teaching is considered a prosocial behaviour that encompasses both helping and sharing behaviours (Strauss, 2022). By teaching, one both shares the knowledge they possess with others and helps others acquire knowledge they previously did not possess. Thus, just like helping and sharing, children's teaching might also be motivated by both other-oriented (such as a genuine concern for others) and self-oriented motivations (such as establishing social interactions with others). Although motivation is a crucial component of teaching to understand its bounds and the cognitive mechanisms enabling this complex behaviour (Pasquinelli & Strauss, 2018), the motivation by which teaching occurs does not deflate the value of teaching itself. Teaching might occur to serve others: to remedy a knowledge gap in their epistemic repertoire, to minimize the costly trial-and-error process associated with independent learning, and to enable cohesion in a social group by making sure all members have necessary functional knowledge. On the other hand, teaching might occur to serve the self in diverse ways: to affiliate and socially interact with favourable others, to consolidate one's own knowledge, to complete others' incomplete goal-directed actions, to display one's own competence to others, just to list a few. These motivations do not have to be mutually exclusive either, as some other-oriented acts of teaching might be self-serving. For instance, when one person shares a piece of unknown information with a naïve other, they not only remedy the knowledge gap but also behave in line with the normative expectations of the social group that they belong to and are viewed as a "good" member of the group.

While being somewhat speculative, findings from teaching and helping literature lend support to these motivations. For instance, when 4-year-old children have a chance to choose between managing their reputation by showing previously observed information to an observer and teaching them novel information, children forsake the opportunity to teach (Asaba & Gweon, 2022). In another study, it was found that when 4- to 6-year-old children were asked to choose between an ignorant and a knowledgeable learner to teach novel information, they always chose to teach the knowledgeable learner rather than the ignorant learner (Kim et al., 2015). In instrumental helping studies where it is typically found that that toddlers share information with individuals who do not have perceptual access to the location of an object to complete an action, this pattern has usually been explained in terms of children's motivation to share information with others given their needs. While this is plausible, new evidence points out that this pattern might be driven by 2-year-olds' motivation to complete goal-directed actions that are not completed by others (Michael et al., 2022).

Finally, children are not sponges that simply soak up information, they consolidate their knowledge in diverse ways, including by asking more questions about it and testing the bounds of the received information (e.g., Ronfard et al., 2021). Teaching this new information to others can be considered one of the ways by which one consolidates one's own knowledge. Even though there are only a few developmental findings on this, one study found that prompting 7- to 10-year-old children to teach others leads to better encoding of new information (Marno et al.,

2021) and another showed that prompting 10-year-old children to teach health-related information helped them consolidate their own understanding of the health-related information (Hermida et al., 2021). Nonetheless, extensive research with adults supports the idea that transmitting information can be an effective way of learning (Bargh & Schul, 1980; Gregory et al., 2011; Pi et al., 2021, see Duran 2016, Kobayashi, 2024 for reviews). Finally, findings from educational psychology show that starting from primary school years peer-teaching has positive learning outcomes for both the peer-teacher and the peer-learner (Briggs, 1998).

In the studies that I report in this thesis, while there was a level of assumption to rely on toddlers to track their recipient's lack of knowledge, we did not expect them to make inferences regarding the recipients' knowledge states by establishing knowledge gaps in the recipients through their explicit testimony (e.g., "I don't know what these do", "I don't know how it works") (Chapters 2 and 3) or through perceptual and content access (Chapter 4). It is possible that they were motivated the fill these knowledge gaps; however, in both experimental chapters, some toddlers and children did not show an attempt to transmit information despite the explicit request from the learner. Additionally, if toddlers' transmission was motivated solely by other-oriented concerns, we would expect a behavioural modification in Chapter 2 where children engaged with the objects for themselves (Exploration Phase) and for others (Transmission Phase). Further, in Chapter 3, if the transmission was motivated by the learner's need or lack of knowledge, we would expect indiscriminate information transmission in both toddlers and children across both measures because there was no difference in the type of information per se – but while this was the case for 5-year-olds, it was not the case for toddlers.

Overall, one could argue that transmitting information without concern for others' lack of knowledge may not be construed as teaching because teaching is an intentional activity to cause learning in another person (Strauss et al., 2002), and this very aspect is what distinguishes teaching from ordinary telling (Gweon, 2021). While there is merit to this idea, it does not reflect the whole picture. Teaching is not defined by its outcome; despite the cost of teaching, learning does not necessarily occur because of teaching and the teacher has little control over the outcome, which, in turn, might decrease teachers' motivation to share information unless it is certain that learning will occur. And teaching with the certainty of a successful outcome is an exceedingly rare occurrence. It is highly doubtful that children also make this assumption, i.e., teaching only because the recipient will learn, when they act on to transmit information. Thus, viewing teaching as an information transmission mechanism in this new light without restraining it as an other-serving and need-oriented behaviour opens exciting venues for the study of teaching as the complex and psychologically fascinating topic it is, and not as a mere by-product of learning, and allows us to engage with the ontogeny of teaching in a deeper level.

5.1.2. Teaching as a developmental mechanism of information transmission embedded in social interactions

How does it all come together? Here, I will reiterate a fundamental question I asked at the beginning of this thesis. *What is teaching?* While it would be great to state that I have found the right definition to answer to this question, unfortunately it would be far from the truth. However, I believe I do have an answer and a complementary perspective to offer. In the end, while it presents itself as a straightforward question, I can see that this was not the right question to ask because there is no definitive answer. At least, not yet.

At its core, teaching is a mechanism for knowledge transmission and includes transfer of knowledge for the future use of others when they do not have immediate access to this; however, applying strict criteria (e.g., transmitting generalisable information, clearly understanding that others do not know, motivation to close knowledge gap) to define how teaching should look like in early development might overlook its nuances. Thus, investigating whether and how infants and toddlers transfer knowledge to others, in what ways and an under which conditions is helpful. Research up to date, including the findings of this thesis implies that information transmission is ubiquitous in humans starting from the second year of life – maybe not as a higher-level ability or a cognitive instinct (e.g., Strauss & Ziv, 2012; Pasquinelli & Strauss, 2018) but as a “communicative endeavour” (e.g., Bazhydai & Harris, 2021) or as a “cognitive gadget” for cultural learning (e.g., Brandl et al., 2023) – and the form and function of it continuously changes and becomes more sophisticated throughout development (e.g., Gweon 2021; Corriveau et al., 2018).

After all, information transmission is profoundly ingrained in social interactions and can be affected by several factors related to both the recipient and the transmitter. To have a theoretically richer understanding of teaching, we do not necessarily need to define teaching as a higher-level, complex cognitive ability, rather it is pivotal to recognise the importance of studying teaching as an information transmission mechanism that requires a level of flexibility across development.

5.2. Investigating Children’s Information Transmission in Adult Terms

In this section, I provide an overview of a critical caveat in studying information transmission in very young children: evaluating early behaviour observed in infants and toddlers form a lens of adult-centric concepts. This issue has been an ongoing debate for many years, revolving around the tendency to interpret infant behaviour by drawing a parallel between the behaviour of adults and children (Haith, 1998; Punch, 2002). Some argue that such comparisons tend to assign complex capabilities to infants that they may not arguably possess yet resulting in interpretations that are far too rich and potentially misleading (Haith, 1998; Heyes, 2014; Munataka, 2000; Paulus, 2022; Punch 2002). In the context of the current studies, one could argue that we do not necessarily know whether toddlers evaluated their actions as information transmission (Chapter 2 and 3) and it was their intention to provide information to their parents (Chapter 4).

Assigning intentions or socio-cognitive capacities to young children especially when we have practically no way of knowing what exactly they are reasoning should be approached with a pinch of salt. For instance, in information transmission and teaching studies, how do we know that they view their actions as information transmission or teaching but not as playful or communicative endeavours? While it is possible to directly assess this with older children who have developed a concept of teaching, have had experiences with formal and informal teaching practices and have developed necessary socio-cognitive skills especially language, how can we be certain that younger children engage to increase knowledge in others, rather than merely to play? Although some level of assumption and interpretation is necessary to be able to investigate this behaviour, the level of explanation that we adopt directly influences our interpretation. Despite the appeal of considering young children as mini adults, equipped with the foundations of every complex capacity waiting to flourish, a more realistic perspective would be to view them as active and dynamic social learners that continuously engage with their environment, refine their skills, become more efficient and selective in the choices that they make.

In the current experimental studies to partially account for this caveat, we took some precautions, for instance, in both Chapter 2 and 3, the learner was presented as overtly ignorant through their testimony which did not rely on toddlers' ability to make inferences about their knowledge states. We used simple designs to investigate information transmission in a way that required minimum cognitive capacities. Additionally, in Chapter 2, we aimed to investigate whether toddlers modify their behaviour based on an ignorant experimenter's request for information in the Transmission Phase which was identical to the preceding Exploration Phase except there was no request for information from another person. With respect to preferential engagement with the generalisable information, toddlers did not show any difference, however, it is possible that they might have modified their behaviour to use ostensive cues during transmission (e.g., Calero et al., 2015). While I did not include this as part of this thesis, the coding of ostensive communication (such as establishing eye contact or using verbal prompts or instructions) used by toddlers and 5-year-olds in Chapters 2 and 3 and another study conducted in our lab (Bazhydai, Silverstein et al., 2020) is underway to shed light onto this issue.

5.3. Methodological Contributions

In this section, I will briefly discuss some of the methodological contributions of the experimental studies reported in this thesis. First, in Chapter 2, I translated a preferential transmission task that is dependent on language skills into a non-verbal task to make it more suitable for testing pre-verbal toddlers or toddlers who have just started talking. This task enabled me to investigate whether the well-established preference to transmit generalisable information is present in younger children. Future studies could examine whether there is a correspondence between verbal and non-verbal tasks in eliciting a preference for generalisable information in transmission contexts in older children. It is possible that current form of the non-verbal task might be too abstract for the age group I tested. As part of this thesis, it was not possible to conduct follow up studies with respect to this; however, systematic investigations of this carry both methodological and theoretical significance regarding information transmission.

Second, in Chapter 4, I used a modified and simplified version of a coding scheme we previously developed (Karadağ et al., 2024b) to investigate early child-led communicative interactions with a focus on information transmission in these interactions. This enabled us to observe whether information transmission that is evident in laboratory settings (e.g., Bazhydai, Silverstein et al.., 2020; Liszkowski et al., 2006; 2008) also occurs as a part of young children's early communicative repertoire. The distribution of the type of communicative interactions observed across two different settings (i.e., Turkey vs. US) with different age groups (18 months vs. 13-, 18-, 23- months) was similar and followed the same order with children initiating mostly expressive interactions followed by requestive and information/help seeking interactions. The least prevalent communicative interaction initiated by infants was information giving interactions (less than 1% vs. approximately 2%). While this might be somewhat speculative, it might suggest that information transmission as it was observed in these studies might emerge from children's communicative interactions with others, perhaps influenced by their experience with teaching-like behaviours (see Brandl et al., 2023). One interesting aspect that future research should investigate is the relation between the number of questions asked by the parents and the number of elicited information giving displayed by the children. It is possible that if the parents regularly ask information-seeking questions, children have more experience with sharing information that is not accessible to the others and sought upon by them. From this perspective, information transmission can be viewed as a communicative engagement that is practiced and refined every day as children develop.

Finally, across different studies, I tried to integrate components of open and collaborative science practices into the study of early information transmission. Chapter 2 was designed as a Registered Report and went through peer review based on its methodological rigor before the data collection and analysis had started. Chapter 4 conducted a secondary data analysis using research data from an online video library to understand naturally occurring information transmission behaviour in infants' and toddlers' home settings. In conclusion, this thesis contributed to the way young children's information transmission is investigated by integrating novel approaches.

5.4. General Limitations

While the studies reported in this dissertation have both methodological and theoretical contributions to the study of information transmission, they are not without limitations. Since in each individual chapter, I have provided specific limitations regarding the study reported in that chapter, here I focus on general limitations that might have had a role in the outcome of this work. First, neither in the experimental studies, nor in the observational study, we had full control on the sample characteristics. The research laboratory that I conducted my research is located in a predominantly White, middle class and well-educated region in the Northwest of England. The data used for the secondary data analysis comes from presumably different areas of the New York City and again from well-educated, middle-upper middle-class families. Thus, this relatively skewed sample characteristics might have had an influence in the behaviours I observed in young children (e.g., Singh et al., 2023a, 2023b).

Second, the experimental studies were conducted in an extraordinary time for research immediately after the COVID-19 pandemic. While it is still early to evaluate its impact on early communicative development, compared to previous studies conducted in the lab (with the same age groups and similar designs), I have experienced a higher attrition rate in children's participation. The study might have been too long and overwhelming for children, or their engagement might have been overshadowed by having been born during the pandemic lockdowns and having had diminished social interactions which might have made the lab environment overwhelming for them. Additionally, while being anecdotal, parents who have older children born pre-pandemic reported difference in the social behaviour of their children who were born during the pandemic with often referring to their children as "typical pandemic baby" to explain their shy and distant nature. Moreover, the parents that I was able to recruit were mostly the ones that were enthusiastic about being in the social domain again and expressed a desire to compensate for the lack of social contact and communication they experienced during the pandemic. While it is difficult to predict how exactly these differences might have been influential, they are nonetheless important to consider.

Third, in both Chapter 2 and Chapter 3, I designed the objects based on our expectations of 2-year-old's motor skills as well as their evaluation of the salience or attractiveness of the objects presented to them. For instance, in Chapter 2, in the initial design of the study, to make buttons as distinct as possible, I manipulated not only how they looked but also how they were operated leading to a decision to use a push button and a toggle switch. However, once I started testing, I noticed that 2-year-olds either lacked the finger strength to activate the toggle switch or they were not able to figure out how it worked which led them to only press the push button.

While the button was not particularly smaller or more difficult to operate than the push button, I quickly realised that it was not suitable for this age group. Since activating both buttons in each box at least once was an inclusion criterion, I had to replace toggle switches with another push button which looked distinct from the initial push button both in colour and shape. However, since the functionality of the buttons were the same, this might have had an influence on toddlers' information transmission if they focused on how the buttons worked rather than the outcomes with which each button was associated. Additionally, children showed variability in their reactions to different types of effects such as vibration while eventually lead us to make modifications to the presentation order. Similarly, in Chapter 3, I did not explicitly measure if toddlers perceived the boxes as attractive, nor did I experimentally manipulate the learning context but rather relied on their inherent salience. Future studies should integrate a systematic baseline assumption check to control for the potential effects of these factors.

Finally, this thesis did not investigate the role of individual differences in children's communicative behaviour more generally and information transmission behaviour more specifically. While the data from all three studies shows that there are considerable differences across toddlers in terms of the number and intention of interactions that they initiated, I did not investigate other areas of individual differences, for instance the role of parental attitudes towards children's communicative and information giving efforts, the role of children's curiosity and explorative tendencies, and the role of causal understanding on information transmission. For instance, in Chapter 2, the buttons were conditionally functional such that when one button was activated, the other button did not work. To be able to observe the effect of each button, toddlers had to wait for the effect of the previously activated button to again activate the previously "unactivated" button. This procedure proved slightly difficult for some toddlers as they were not able to grasp the causal structure of the boxes, which led to providing more guidance and prompts than was originally anticipated. Thus, the relative complexity of the causal mechanism associated with the boxes might have interfered with some toddler's representation of the generalisability of the information and might have masked a potential preference for transmitting generalisable information. However, I believe this is not very likely because when children were given more discrete prompts (e.g., saying "what about the other button?" referring to the previously unactivated button), they did not have any problems with activating both buttons in the remaining boxes.

5.5. Future Directions

Children's role in active knowledge exchange as teachers or information transmitters has recently attracted the interest it rightfully deserves. While there are many insightful studies and new approaches to studying teaching as an information transmission mechanism, there is still a lot that we do not know about information transmission. In each respective chapter, as well as the discussion section, I have offered different suggestions for future research to follow up the findings of these studies. In this section, I will provide more general suggestions that require further investigation for better conceptualisation and understanding of the developmental trajectory of information transmission.

The first area of research requiring further deliberation is the early ontogeny of information transmission. By now, I have established that different forms of information transmission are evident in the second year of life as early as 12-months (Akagi, 2012; Bazhydai et al., 2020; Flynn, 2008; Liszkowski et al., 2006; 2008; Knudsen & Liszkowski, 2012, Meng & Hashiya, 2014, O'Neill, 1996; Vredenburg et al., 2015). Observing this behaviour at 12 months does not necessarily mean that information transmission emerges at exactly this point. Integrating precursors of pointing gestures such as hold-outs and gives (e.g., Boundy et al., 2016; 2019) might help us further track when information giving interactions, whether elicited or non-elicited, starts in the first year of life.

Second, future research could also explore children's perceptions of information acquisition and transmission as well their perceptions of themselves as potential teachers. Previously, Sobel & Letourneau (2015, 2016) laid the groundwork by exploring how 4- to 6-year-old children reflect on their learning and teaching processes. Building on these findings, in a study not forming part of this thesis, we are extending these questions to 10-year-old children, seeking their explicit reflections about learning and teaching, the factors that would influence transmission decisions, and how information can be transmitted to others by asking them questions in a multiple-choice format (i.e., If you wanted to learn about something new, where could you look for information?, What makes you want to learn something?, How can you learn?, If you want to teach something, how can you teach it?, What do you need to keep in mind when you teach someone?). We hope to provide direct evidence from children about their thinking about knowledge exchange processes – redirecting the emphasis from the researchers' interpretation to children's own perspectives.

Third, the motivation component of information transmission has been somewhat overlooked in the literature. As previously mentioned, the main motivation of the transmission has been considered to remedy a gap in others' knowledge (e.g., Strauss et al., 2002). However, more recently, studies demonstrated different motivations can be at play when children transmit information (e.g., Asaba & Gweon, 2022; Kim et al., 2015) thus the motivation underpinning information transmission has been highlighted (Pasquinelli & Strauss, 2018). Future research could explore different potential motivations that might drive children's information transmission such as socio-normative motivations (enforcing social norms and values to contribute to social cohesion and order), prosocial motivations (helping others gain new knowledge and skills), cognitive motivations (leveraging the experience of teaching to improve one's own future learning) and self-serving motivations (establishing oneself as a respected and knowledgeable member of the social group). Additionally, it would be interesting to investigate whether these motivations remain stable across development or change throughout the development akin to changes observed in prosocial behaviours.

Finally, although research on transmission assumes an important role for the prosocial motivation to help others gain new knowledge and skills (e.g., Strauss, 2022) based on studies on other prosocial motivations such as instrumental helping and sharing, to my knowledge, there is currently no research on whether children see teaching as a prosocial and normative behaviour. It is well-established that from the preschool years, sometimes even earlier, children expect others to provide help for those in need and make inferences based on these expectations. It is unclear whether children hold similar expectations for information transmission (e.g., Hepach et al., 2012; Hepach et al., 2017; Paulus, 2014, Paulus et al., 2017). For instance, would children expect an individual to transmit information to another person on a normative level, and negatively evaluate the knowledgeable individual when they prefer not to transmit information? Would they punish people who do not transmit information when someone needs information? These are all very interesting but overlooked aspects that require deeper engagement in the context of information transmission.

While there are more questions that can be explored in future research, here I focused on relatively understudied aspects. Below I further provide additional areas of interest to enhance the literature on child-led information transmission (see Box 1).

More open questions:

- Do children view information transmission as a social norm, like helping or sharing? If so, what would its trajectory look like developmentally, similar to helping, sharing, or comforting?
- What kind of information is more likely to be selected by children for further transmission, e.g., expected or unexpected, familiar or novel, negatively or positively valenced?
- Which aspects of learning context would influence children's subsequent information transmission?
- Would children transmit mistruth or gossip?
- What is the role of the recipients in children's decision to transmit information?
- How early do children start considering the characteristics of the learner when they transmit information?
- What would happen when the self-serving motivations and other-serving motivations are conflicted (e.g., transmitting information that would help transmitter consolidate their own knowledge vs. transmitting information that is novel thus more useful to the recipient)?

Box 1. Open questions regarding children's information transmission.

5.6. Conclusion

The current thesis aimed to explore the ontogeny of information transmission in young children with a focus on the type of information that young children prefer to transmit to others, and information transmission that occurs naturally in children's everyday surroundings. The first experimental study provided an investigation of toddlers' action-based information transmission, by probing the importance of information generalisability in guiding selectivity. To my knowledge, this was the first study to establish that during toddlerhood, a preference for transmitting generalisable information is not yet available. Findings of this study provide insight into the role of information generalisability in early information transmission. In the second experimental study, my enquiry focused on whether children who are in two distinct developmental stages, 2- and 5-years old, transmit information preferentially based on how they previously learned about it. I found that whether 2-year-old toddlers preferred to transmit information that they previously learnt from others, this was not the case for 5-year-old children. These findings are generative in investigating the role of different cues associated with the information as well as the learning context, and how they interact with the developmental process to drive children's preferential information transmission. In the final study, I observed young children's communicative interaction in their natural settings to have a better understanding of how information transmission might emerge and develop early in life. These findings suggest that information transmission might emerge as part of children's socio-communicative interactions with their social partners. Overall, this thesis aimed to provide a coherent narrative on the ontogeny of information transmission in young children. Here, my findings provide indirect support for conceptualisation of teaching as an information transmission mechanism embedded in social interactions.

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