# Are Implicit and Explicit Metacognition Related to Young Children's Selective Social Learning?

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Abstract

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Selective social learning is our ability to learn efficiently from our environment. Previous research has suggested that complex mechanisms such as metacognition, or one's ability to reflect upon their thoughts, and theory of mind (i.e., the ability to reflect upon others' mental states) scaffold the emergence of selective social learning. Metacognition can be separated into implicit (indirect demonstrations of knowledge; e.g., gestures, requesting help) and explicit skills (explicitly express knowledge; e.g., confidence about knowledge). Implicit and explicit metacognition have an inconsistent relationship in the literature. Past work has shown that implicit metacognition as well as theory of mind can predict selective social learning. This study sought to further explore those links by broadening the tasks used in addition to comparing different metacognition tasks (which used different implicit and explicit metrics) to test their concurrent validity. We hypothesized that 1) implicit metacognition would predict selective social learning and that 2) the explicit metacognitive measures would be correlated, as would the implicit metacognitive measures. For exploratory purposes, we explored the concurrent relationship between explicit and implicit metacognitive skills with these tasks, which had not yet been attempted. We were unable to replicate a link between implicit metacognition and selective social learning or theory of mind and selective social learning, however trending inter-task correlations between the two explicit metacognitive measures suggest that the latter may be measuring the same skill. Finally, our intra-task correlations were also trending, suggesting better implicit metacognitive skills could possibly be related to better explicit metacognitive skills.

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**Are Implicit and Explicit Metacognition Related to Young Children's Selective Social Learning Skills?**

Social learning is widespread in animals (Call & Carpenter, 2001; Whiten, 2021) and reaches its apogee in human culture. Social learning is defined as learning influenced by observing and interacting with other individuals or their products (Heyes, 1994 as cited in Rendell et al., 2011). Young children, though resourceful, require assistance from others in their environment to learn. For the information obtained to be useful however, it must be gathered from reliable sources, which presupposes an ability to distinguish good sources from unreliable ones (Heyes, 2016). This ability to select from whom to learn is referred to as selective social learning (Sobel & Finiasz, 2020; Tong et al., 2020) and constitutes a complex cognitive ability that fully develops around the fourth year of life, though is present in rudimentary forms in infancy (Poulin-Dubois & Brosseau-Liard, 2016; Sobel & Finiasz, 2020). Selective social learning skills are typically evaluated in session through trust paradigms (Koenig & Harris, 2005a), also referred to as conflicting sources paradigms (Koenig et al., 2004), where children are forced to choose to learn from a reliable or an unreliable source. The reliability of the source can be established in various ways, such as describing the source as being competent (e.g., Johnston et al., 2015) or demonstrating their competence through labelling common objects correctly (e.g., Brosseau-Liard et al., 2015; Koenig et al., 2004; see Mills, 2013 and Tong et al., 2020 for reviews). Common ways to measure selective learning are to ask the child to directly chose a source from whom to learn ("Ask" questions; e.g., DiYanni et al., 2012; DiYanni & Kelemen, 2008; Elashi & Mills, 2014; Fusaro & Harris, 2008) or to ask the child to endorse information provided by one of the conflicting sources ("Endorse" questions; Resendes et al., 2021; Brosseau-Liard et al., 2015; Koenig et al., 2004; Koenig & Harris, 2005b; Lucas et al., 2013; Sobel & Finiasz, 2020). The former questions are more metacognitive, as they require children to reflect upon informants' knowledge state to make a judgement, whereas the latter may introduce an implicit linguistic component, wherein children must also make a judgement about the plausibility of the label's existence given what they understand of their language (Sobel & Finiasz, 2020). Some have argued that Ask questions are more difficult because children may have conflicting interests when explicitly selecting from whom to learn (e.g., who do I want to affiliate with?; Tong et al., 2019). Further distinctions exist between these types of questions, including their different developmental trajectories. Where children perform fairly consistently on Endorse questions over toddlerhood, their performance on Ask questions improves substantially over these same years (Sobel & Finiasz, 2020). Children who ask and endorse the labels of reliable sources over unreliable sources are thought to have better developed selective learning abilities.

Though cues related to other's knowledge and expertise, i.e., epistemic cues, are most informative when learning from others, toddlers were found to prioritize certain non-epistemic, or social cues (e.g., benevolence, familiarity, in-group/out-group status; Corriveau & Harris, 2009; Elashi & Mills, 2014; Johnston et al., 2015), when choosing from whom to learn (see Tong et al., 2020 for a meta-analysis; Lucas et al., 2017). As of 4 years of age however, this prioritizing shifts (Tong et al., 2020). For instance, children above 4 years of age more consistently prioritized a source's previously demonstrated knowledge or expertise over their benevolence (Johnston et al., 2015), suggesting they are becoming more adept learners and can shift between learning strategies. This is in line with the two-stage theory of transmission of information proposed by Henrich and Broesch (2011), which suggests children below a certain age will default to learning from individuals with social-cultural links to themselves (e.g., family members) and will later transition to learning from those they deem as being more knowledgeable.

The results discussed above imply that an important shift in thinking occurs between the age of 3 and 4, where children actively change their learning strategy, opting for accurate sources rather than relying on socially-motivated heuristics, such as a propensity to trust others (Jaswal & Kondrad, 2016), when epistemic cues are provided along with social cues. How and why this shift occurs is under investigation and many theories have been advanced (e.g., Hermes et al., 2018; Heyes, 2016; Heyes et al., 2020; Landrum et al., 2015). Some rely on the development of lower-order and early-developing asocial cognitive abilities such as executive function (i.e., inhibition; Jaswal et al., 2014; Jaswal et al., 2016) to explain this improvement whereas others have turned to higher-order cognitive mechanisms.

Beginning with lower-order mechanisms, Jaswal and colleagues (2014) found that children between 2.5 and 3.5 years-old were more likely to endorse an unreliable source over a reliable one despite this source having been repeatedly incorrect, suggesting an inability to inhibit a default response to trust others, which did not occur in older children. Such results reflect a lean view of selective social learning development, where these broad mechanisms would be responsible for both social and asocial learning alike. Hermes and colleagues (2018) coupled these results with findings of older children being able to inhibit said response to propose a dual-process theory of selective social learning, as has been proposed for many social and cognitive mechanisms (for review, see Smith & DeCoster, 2000). This framework suggests that infants are endowed with certain heuristics that allow them to learn from their environment efficiently, but later develop, following growth of executive functions, a second system which can override the commonly used heuristics when necessary (Heyes, 2012); the former system is fast and mostly unconscious whereas the second is more deliberative (Hermes et al., 2018). These two systems can coexist and be called upon in different circumstances, which, Hermes and colleagues argue, explains the seemingly opposing results found in the literature, where children of the same age have been shown to make decisions both based on social cues and epistemic cues. Similar claims have been made in the language development field, which cites similar transition periods in verb tense overregularization, where children temporarily default to regular conjugation rules with irregular verbs before deliberately employing the later memorized terms (Marcus et al., 1992).

Where some have theorized executive function to be the main mechanism of development for a more deliberative social learning process, others have suggested frameworks in which more complex mechanisms may be partially responsible for this newly acquired ability. Heyes (2016), for instance, argues that though some selective learning strategies would be based in associative learning (e.g., "copy when uncertain"), others would be rooted in explicit metacognitive processes (e.g., "who do I learn from"), otherwise described as the ability to reflect, identify, and disseminate our own thoughts (Heyes, 2020). This ability would therefore be directly involved in at least a subset socially-motivated decision-making such as, for instance, deliberating on the trustworthiness of a source (Tenney et al., 2007; Diaconescu et al., 2014). Similarly, Landrum and colleagues (2015) suggest that learning effectively from others presupposes being able to reflect on their intentions, a key component of theory of mind (i.e., mind-reading), which broadly refers to individuals' ability to reflect upon other people's mental states.

The above-mentioned frameworks have provided testable hypotheses regarding predictors of selective social learning, where, for instance, better metacognitive abilities and better theory of mind abilities should predict more efficient social learning. Research has indeed supported the involvement of metacognition in infancy (Goupil & Kouider, 2016; Kuzyk et al., 2020) and toddlerhood (Resendes et al., 2021) as well as theory of mind in toddlerhood (Brosseau-Liard et al., 2015; DiYanni & Kelemen, 2008; Koenig & Harris, 2005b; Moses & Baldwin, 2005; Sobel & Kushnir, 2013) in the development of selective social learning. The two aforementioned higher-order cognitive skills are the subject of this study.

**Metacognition**

Metacognition, as alluded to above, is widely defined as the ability to reason about one's own cognitive processes (Flavell, 1979; Schneider, 2008; Sobel & Finiasz, 2020; Sodian et al., 2012). Many taxonomies have been proposed to distinguish types of metacognition (e.g., Schneider, 2008; Efklides, 2011), however most include some distinction between knowing about cognition and cognitive strategies (i.e., declarative metacognition) and actively thinking about one's own thoughts and knowledge (i.e., procedural metacognition). The latter can be further divided into monitoring and control components that allow individuals to monitor the strength of their knowledge (e.g., confident or not confident) and self-regulate accordingly (i.e., asking for help when unsure or declining to answer a question; Goupil et al., 2016; Schneider, 2008; Schneider & Lockl, 2013; Nelson & Narens, 1994). The distinction between these two components is difficult to make and inconsistent across the literature (Roebers, 2017), it is therefore important to keep this in mind when interpreting this study in the broader literature.

Heyes (2020) argues that metacognition is the result of a socially-motivated evolutionary process, where over thousands of years individuals with better metacognitive abilities were better able to survive through cooperation with others. As this skill develops, most likely via experiencing metacognitively-demanding tasks and receiving feedback from our environment

(Efklides, 2011; Roebers, 2017; Heyes, 2020), we are better able to discriminate between different internal experiences (e.g., between fear and excitement), better able to identify them (i.e., give them a label), and finally, to broadcast it to others in our environment (e.g., explicitly referring to our internal states in conversations with others; Heyes, 2020). The latter ability, also referred to as metacognitive control (Schneider & Lock, 2013; Schneider, 2008; Nelson & Narens, 1994), is more cognitively taxing, and thus may result in what Heyes' refers to as "cognitive offloading", or physical manifestations of metacognitive states (e.g., engaging in gestures which are culturally associated with metacognitive states such as uncertainty). Uncertainty gestures (Kim et al., 2016) are an example of cognitive offloading, which can be quantified as a manifestation of metacognitive awareness. How one can act upon this metacognitive awareness or discuss it with others is where the distinction between implicit and explicit metacognition comes in.

Explicit metacognition develops in early toddlerhood, where children have been shown to reliably judge their own knowledge by the age of five (Heyes, 2020; Goupil & Kouider, 2019). As its name implies, explicit metacognition is the ability to think explicitly about one's thoughts and share them with others (i.e., do I know this or not?). Implicit metacognition, on the other hand, is the ability to indirectly reflect on or express one's thoughts (i.e., do I need help with this task or not?; Flavell, 2003) or measurable properties of said reflections (i.e., how long it takes to answer a question; Heyes, 2016). Explicit metacognitive abilities have been extensively studied in school-aged children and its study is on the rise in younger populations.

Explicit metacognitive abilities have been measured in children in several ways. Confidence judgements are a common way to assess if children can reason about their knowledge (e.g., Roderer & Roebers, 2010). Children are asked how confident they are about an answer using a Likert scale whose levels are typically represented by images of a face or a child expressing various levels of confidence (e.g., Geurten & Bastin, 2019; Paulus et al., 2013; Roderer & Roebers, 2014). An example of a task using confidence judgements is the associative learning paradigm, or paired-associates paradigm, where children learn associations between pairs of objects and are asked to both recall the pairing as well as make a judgement on how confident they are about their answer (Paulus et al., 2013; Resendes et al., 2021). For instance, Paulus et al. (2013) had 3- to 5-year-old children learn about different animals and their favourite type of food or favourite activity. During the test trials, children were presented with the animal along with its associated food or activity as well as a distractor from the opposite semantic category (e.g., a food if the animal was paired with an activity). After the accuracy trials, they were asked to rate their confidence level using a Likert-scale composed of five images depicting a young child expressing increasing levels of confidence. They found that as the children got older, they became more accurate at discerning when they were correct or incorrect, based on their confidence judgement (i.e., they were more confident on accurate trials and less confident on inaccurate trials).

Other tasks that use confidence judgements are perceptual identification paradigms, where toddlers or children are asked to recognize ambiguous stimuli, and if they are confident about what they identified. Bernard and colleagues (2015) had 3- to 5-year-old toddlers view blurred images of varying levels of difficulty, accurately name that object, then rate how confident they were about their identifications. They found no difference between the groups in the actual identification of the images according to difficulty, however found that older children most often acknowledged uncertainty on incorrect trials. Similarly, forced-choice visual discrimination tasks have also been used in conjunction to confidence judgements, where children are shown a blurry stimulus and asked to choose between the clear version of this stimulus and a similar distractor image when asked to identify the blurry image (Geurten & Bastin, 2019). Despite the children performing well above chance on the task, they found that children did not select high confidence judgements more often on correct trials than on incorrect trials. A possible advantage of the latter tasks is that they are not dependent upon memory abilities, which are themselves still developing until well into the teenage years (Schneider & Lockl, 2013). In other words, these tasks do not measure metamemory abilities, but rather measure metacognitive judgement abilities.

Confidence judgements are not the only measure of explicit metacognition in childhood. Certain opt-out tasks allow children to express their confidence in a binary fashion, by being presented with an uncertain event and being asked whether they know the outcome. For instance, Kim and colleagues (2016) presented children with a box in which they would hide toys. In Full Knowledge trials, they would show children which toy went in the box. In Ignorance trials, they would not. Finally, in Partial Knowledge trials, they would present the child with two toys and told them only one of them would be put in the box. The experimenter would then ask the child whether or not they knew what was in the box and asked them to name the toy. The results suggest that 3- and 4-year-old children had the most difficulty with the Partial Knowledge trials, where many claimed they knew what was in the box despite not having been shown which toy was hidden, but had little difficulty correctly expressing their knowledge in Full Knowledge (around 80% correct) and Ignorance trials (around 80% correct). In a similar design, Filevich and colleagues (2020) found that children who were able to correctly identify their knowledge state during a Partial knowledge trial had more cortical thickness within the left medial orbitofrontal cortex, a region that contributes heavily to the default mode network, or the group of brain regions responsible for introspective thought in adulthood (Filevich et al., 2020). Overall, the results from the aforementioned studies suggest explicit metacognitive skills can be reliably detected at around 4 years of age with many different tasks, however no study to our knowledge has attempted to compare these measures in a within-subjects design. This would allow the field to establish concurrent validity amongst commonly used measures, thus providing evidence that they are measuring the same ability; should the relationship between the two be low, this could suggest the tasks are measuring different metacognitive abilities, leading us to revise our current understanding of metacognition.

Implicit metacognition has seen a recent surge in interest as infants as young at 12 to 18 months have been shown to display some rudimentary reflective abilities (e.g., Goupil & Kouider, 2016). Indeed, Goupil and Kouider (2016) have shown that 18-month-olds display implicit metacognitive monitoring via a persistence measure, wherein children persisted longer when looking for a hidden toy when they were correct about its location. Twenty-month-olds have also been shown to selectively ask for help via non-verbal communication when unsure about the location of a hidden object (Goupil et al., 2016), suggesting infants display both implicit monitoring and control. In older children, this implicit awareness of knowledge has been measured with tasks such as was designed by Kloo and colleagues (2017). The latter found that children were able to distinguish when they were given helpful or unhelpful hints in a task and correctly ask for additional hints before answering a question. Hence, though they were not asked about their knowledge directly, they were able to implicitly monitor their knowledge state and act upon it.

Many implicit measures of metacognition have been developed in the hopes of detecting such abilities earlier than previously expected. Many of these tasks were borrowed from animal research (e.g., see Crystal & Foote, 2009 for a discussion on metacognition in animals; Call, 2010; Smith & Washburn, 2005; Carruthers, 2009) which had to innovate ways to measure cognition monitoring with this non-verbal population. In addition, they address a fundamental flaw in explicit tasks that require children to respond verbally, wherein children with a better understanding of declarative metacognition (i.e., knowing about knowing; using mentalistic language; Schneider, 2008) may artificially perform better in these tasks (Baer et al., 2021). Eye-tracking was amongst the first attempts at detecting implicit metacognitive skills in humans. Paulus and colleagues (2013) indeed found that though their younger sample (3.5-year-olds) exhibited no measurable explicit metacognitive abilities, they consistently looked longer at the low confidence images when answering, suggesting they were not confident but might not have been able to inhibit their high confidence answers. Similarly, eye-tracking is allowing researchers to gain insight into what children attend to when uncertain and in need of information to answer correctly (Leckey et al., 2021). Recent efforts have focused on measuring behaviors suggesting metacognitive skills such as asking for help or for a hint when one is unsure about their knowledge (Geurten and Bastin, 2019; Kloo et al., 2017; Resendes et al., 2021), displaying uncertainty gestures such as lifting their shoulders or shaking their heads (Kim et al., 2016; James et al., 2021), or measuring other aspects of behaviour such as how long infants persist in searching in  a particular location for a hidden toy as an index of how certain they are it is hidden there (e.g., Goupil & Kouider, 2016; Kuzyk et al., 2020). For instance, Kuzyk and colleagues (2020) measured persistence time as an implicit monitoring measure of metacognitive skills and found that infants with poorer monitoring were more likely to learn from an ignorant informant.

Implicit and explicit metacognition have an unclear relationship with one another in toddlerhood. Roderer and Roebers (2010) report a concurrent relationship in 7- to 9- year-olds when implicit metacognition is measured via eye-tracking and explicit metacognition via confidence judgement, however few correlations have been performed in younger populations despite many studies measuring both abilities. For example, Geurten & Bastin (2019) report that their sample ask for a clue more often after inaccurate trials of their visual discrimination task than after accurate ones, but as a sample, these children do not select high confidence more often after accurate trials than after inaccurate trials. This might suggest that the abilities are unrelated, however, we do not know if individually children who performed best in the explicit task also performed best in the implicit task.

Measuring implicit metacognition and explicit metacognition present similar difficulties, wherein the variety of tasks being used in the field should make us question whether they are measuring the same construct. It is therefore important to consider this when attempting to replicate relationships between skills with various tasks.

**Theory of Mind**

Theory of mind is the ability to reason about other's mental states, including thoughts, intentions, beliefs, and feelings (Ruffman, 2014; Wellman, 2014). Given the similarities between theory of mind and metacognition, some have questioned the distinctiveness of these skills (see Carruthers, 2009 for a review on the link between mindreading and metacognition). Indeed, both perform similar functions, i.e., reflecting upon one's own thoughts vs. other's thoughts, which led some to theorize that both abilities might be governed by the same underlying cognitive mechanisms (e.g., Carruthers, 2009). This would have implied finding a strong concurrent relationship between the two skills; both abilities have however repeatedly been found to be dissociable (Baer et al., 2021; Bernard et al., 2015; Kim et al., 2020). Furthermore, Feurer and colleagues (2015) found that early procedural metacognitive skills predicted later theory of mind abilities, where this relationship was heavily influenced by language development, suggesting the latter ability precedes the former, which may in turn scaffold selective social learning skills. Interestingly, Schneider (2008) found the opposite, where theory of mind abilities assessed 2 years prior predicted better metacognitive knowledge and vocabulary. This not only provides evidence for dissociation between mindreading and metacognition, but also supports different developmental trajectories for different metacognition skills, i.e., though procedural metacognition emerges before theory of mind, perhaps theory of mind emerges before declarative metacognition (see Carruthers, 2009 for a comprehensive review of theories).

Much like metacognition, explicit and implicit theory of mind abilities have been detected, where implicit abilities have been detected with non-verbal tasks in kids as young as 15 months of age (e.g., Onishi & Baillargeon, 2005; for a review see Scott & Baillargeon, 2017) and explicit abilities in children as young as 4-years old (Wimmer & Perner, 1983; Wellman, Cross & Watson, 2001). Explicit abilities are typically measured in lab using a variety of tasks involving answering questions about other people's inner experiences (Wellman & Liu, 2004). False-belief tasks are often used as a single pass/fail test of theory of mind abilities, where children are asked to reflect upon another individual's inaccurate knowledge. The latter however have been rightly criticized for their low ecological validity and reductionist view of theory of mind, which encompasses concepts beyond false-belief. The Children's Social Understanding Questionnaire (CSUS; Tahiroglu et al., 2014), a parent report questionnaire about theory of mind abilities, was developed following these criticisms. It demands that parents reflect on their children's understanding of others' emotions, knowledge, perception, beliefs, intentions, and desires. This questionnaire, therefore, seeks to broaden our ability to measure theory of mind in a lab setting and widen the variability in scores we can observe.

**Links between selective social learning, metacognition, and theory of mind**

Much has been discussed in the field regarding the emergence of complex social abilities, including how early in human evolution they emerged and whether they are present in infancy. For instance, Heyes (2019) advances that theory of mind and metacognition are ‘cognitive gadgets’, or, simply put, abilities that evolved out of need to make sense of an increasingly complex social context. Indeed, adults’ social reasoning has been shown to be related to explicit metacognitive skills in certain circumstances (e.g., adults being able to report learning strategies to experimenters; Heyes, 2016), but results in the field so far do not support this statement in children under 4 years of age. This link must therefore emerge later in development. This transition may happen in stages. Indeed, previous work in our lab has shown that implicit metacognitive monitoring skills predict whether infants will learn from an incompetent informant (Kuzyk et al., 2020) and that later in development, implicit metacognitive control and monitoring predict selective social learning better than explicit metacognitive control in toddlers (Resendes et al., 2021). In other words, toddlers’ ability to act according to indirect monitoring of their knowledge (i.e., asking for hints when they lack knowledge) but not their ability to explicitly reflect upon their confidence is correlated to their ability to learn new information from accurate sources. Taken together, these results suggest that implicit metacognition comes online before explicit metacognition and scaffolds selective social learning early in life. Given the above established relationship in adulthood between explicit metacognition and selective social learning mechanisms, the question remains as to when these skills become related, if at all.

Relatedly, other studies have found that theory of mind may play a role in the development of selective social learning, where scores on a theory of mind battery sometimes predicted better selective social learning (Brosseau-Liard et al., 2015; DiYanni et al., 2012; DiYanni & Kelemen, 2008; Elashi & Mills, 2014; Fusaro & Harris, 2008; Palmquist & Fierro, 2018; Vanderbilt et al., 2011) or did not (Brosseau-Liard et al., 2018; Cossette et al., 2020; Pasquini et al., 2007). To our knowledge, only two studies used the Children's Social Understanding Scale to measure theory of mind (Brosseau-Liard et al., 2018; Resendes et al., 2021) and only the latter found a relationship between selective word learning and the Belief subscale of the questionnaire. Overall, the field provides ample theoretical and empirical evidence that selective social learning may be driven by a number of complex mechanisms in toddlerhood and infancy.

**Present study**

The present study has two overarching goals. First, we want to further explore the relationships between metacognition, selective social learning, and theory of mind by replicating and expanding upon previous findings with new tasks, given the failure to link selective social learning with explicit metacognition to date. Though it is possible that this failure is due to a lack of relationship, we do not believe the field has exhausted avenues of exploration; the tasks we used are, we believe, simpler and target the abilities we are attempting to measure more directly, giving us better chances of measuring a relationship if it exists. We used two tasks which have previously been used in the field, the first of which is an opt-out task and the second a confidence judgement task. Explicit metacognition was measured in the opt-out task by asking the children whether they knew the content of a box, and in the confidence judgement task by asking them how confident they were about their answers. Implicit metacognition was quantified in the opt-out task by counting the uncertainty gestures the children made and in the confidence judgement task by asking them if they wanted a clue when answering a question.

Based on previous research, we first hypothesize that we will find a stronger relationship between each measure of implicit metacognition and selective social learning than between each measure of explicit metacognition and selective social learning (Kuzyk et al., 2020; Resendes et al., 2021).

Our second goal is to examine whether opt-out metacognition task performance relates to that of confidence judgement metacognition tasks in an attempt to evaluate how strongly these tasks are related. We hypothesize that our explicit measures of metacognition will be correlated to each other and that our implicit measures of metacognition will be correlated to each other.

For exploratory purposes, we will also attempt to replicate relationships between theory of mind and selective social learning, and theory of mind and metacognition. Specifically, we would expect theory of mind to predict selective social learning, and theory of mind to be related to metacognition. In addition, given the research in older children (Roderer & Roebers, 2010), we would expect explicit and implicit metacognition to be related when concurrently measured.

## Methods

### Participants

Participants were recruited through birth lists from areas near the university as well as lists of past participants. Following power analyses conducted on G*Power 3.1.9.7 (5 total predictors and 3 tested predictors; $\alpha = .05$, power = .8), our recruited sample should consist of 69 participants (assuming an expected effect size of $f^2 = .17$ based on previous research; Resendes et al., 2021). Out of 74 children who were tested, 11 had to be excluded due to undisclosed language development delays (N = 1), insufficient proficiency in either French or English (N = 3), excessive parental interference (N = 1), or excessive fussiness (N = 6). Fussiness was operationalized by calculating engagement ratings for each task. How much children looked at the experimenter, listened to instructions, cooperated with instructions, and answered without requiring several prompts was rated from 1 (Never) to 5 (Always). Engagement ratings below 3/5 were considered excessively distracted and were excluded from our group analyses (see table 1). Two independent scorers who were blind to our hypotheses scored. Out of eleven exclusions, two were due to low engagement ratings.

**Table 1**

*Engagement Ratings According to Task*

| | Selective Social Learning | Opt-out metacognition | Confidence metacognition |
|---|---|---|---|
| Mean | 4.78 | 4.70 | 4.16 |
| SD | 0.26 | 0.34 | 0.54 |

The final sample therefore contained 63 participants (female N = 35) with a mean age of 47.1 ± 3.03 months. Given the restricted age range, we did not control for age in our analyses. Fifty-six parents whose children were included in the final sample answered our optional demographic questionnaire. Parents reported a median yearly income was between 100 000 $ and 150 000 $ and the majority of our sample identified as Canadian (60.3%). Other cultural identities reported were European (23.8%), East and Southern Asian (15.9%), Caribbean (9.5%), African (7.9%), Latin/Central/South American (4.8%), and Middle Eastern (4.8%). Parents filling out the form could choose more than one cultural affiliation, resulting in 44.6% of our sample identifying with two or more cultures.

**Materials and procedure**

There were three tasks administered, the order of which was counterbalanced by participant. The Selective Social Learning (SSL) task was always administered first to warm-up the children as it is particularly engaging, and the two Metacognition (MC) tasks were presented in opposing orders, where the opt-out was presented first in half of the participants' cases and second in the other half. This resulted in two possible task presentation orders. All tasks were administered over the online video conference platform Zoom, where the children were typically seated beside or in front of their parent. Parent intervention was minimal, though sometimes necessary when the child was not responsive, as the experimenter could not always keep them on task.

French and English protocols were developed for each task. Parents chose the language in which their child was tested. In total, 29 participants were tested in French and the remaining 34 were tested in English. Analyses of variance were run with and without language as a between-subjects factor and results were not altered, we therefore analyzed the sample as an integral group.

**Selective Social Learning Task (SSL)**

This task was adapted from Koenig, Clement, and Harris (2004) and Pasquini and colleagues (2007). We used the procedure from Resendes and colleagues (2021). French and English protocols were developed. Two girl puppets ("Sophie" and "Clara") name objects for children. During the familiarization trials, they named familiar objects for the children. One of the puppets named the objects accurately and the other did not (e.g., call a 'ball' a 'shoe'; see Table 2 for complete list of labels). The experimenter then asked the child if they knew which puppet had said something wrong or right ("Explicit Judgement question"). Whether we asked about the correct or incorrect puppet was counterbalanced across participants. During the test trials, odd-looking unfamiliar objects were presented to the children. Participants were asked if they knew what this object was and if they wanted to ask one of the puppets for help labelling them ("Ask" question). Each puppet then proceeded to label it with competing nonsense words ("Endorse" question; e.g., "toma" or "mido"). Finally, the experimenter asked the children a second time which puppet they thought said something wrong or right (second Explicit Judgement phase).

**Table 2**

*Objects and Associated Labels for the Selective Social Learning Task*

| Object | Correct Label | Incorrect Label |
|---|---|---|
| Familiarization phase | | |
| Car | Car | Book |
| Ball | Ball | Shoe |
| Cup | Cup | Dog |
| Test phase | | |
| Roll of blue string | Toma | Mido |
| White bulb of a turkey baster | Fep | Dax |
| Red funnel | Bosa | Dawnoo |

The order in which the puppets spoke alternated, meaning the same puppet never spoke first twice in a row. The order in which each puppet spoke first for each phase was counterbalanced (i.e., Sophie spoke first for some and second for others in the familiarization phase and for the test phase) as well as the start position for each puppet (i.e., Sophie began on the right hand for some participants and on the left for others) and which puppet was reliable (i.e., Sophie or Clara). The position of the puppets was switched between each object presented to ensure the children were relying on the identity of the puppet to endorse a label rather than the position of the puppet (e.g., "the one on the left is always wrong"). This resulted in 16 counterbalancing conditions. Counterbalance conditions were assigned in order across genders to ensure equal distribution.

**Metacognition Tasks (MC)**

***Opt-Out***

This task was adapted from Kim and colleagues (2016). The experimenter brought out an empty black shoebox and showed it to the child. Three scenarios would then subsequently play out in counterbalanced order. In the "Full Knowledge" trials, the experimenter showed a toy to the child, saying "I am going to put this toy inside the box". The experimenter, in full view of the child, put the toy inside the box and closed the lid, saying "Now, I have put the toy inside the box". In the "Partial Knowledge" trials, the experimenter showed two toys to the child and explained that "[he/she] [is] going to put only one of these toys inside the box". The experimenter then occluded the screen with a thick piece of cardboard. He or she removed the cardboard after the toy was hidden and said: "I have now put one of the toys inside the box". In the "Ignorance" trials, the experimenter told the child that he or she would "put a toy inside the box" without showing a specific toy. They would occlude the screen once again, putting a different toy inside the box, remove the cardboard and state "I have now put a different toy inside the box." Once one of these scenarios played out, the experimenter asked the child "Do you know what's inside the box or do you not know?" If the child answered that they knew, the experimenter would ask them what the object was and if they really knew or if they were just guessing. If they did not know, they were asked if they knew why they did not know. To ensure the children knew what the toys were, and thus not answering that they did not know because they could not identify the toy, the experimenter would ask them before each trial what each toy was (other than for the ignorant trials, where he or she asked the child after the toy was shown). The experimenter would also play a little with the toys to engage the children, as typically in this task they would have a chance to play with them themselves. We counterbalanced the order in which the participants saw the Ignorance, Partial Knowledge, and Full Knowledge trials, meaning there were six possible orders the children could be exposed to.

### ***Confidence Task***

This task was adapted from Geurten and Bastin (2019) and run on the computer program *Psychopy3* (see Appendix for example trial). Children were seated in front of the computer and the experimenter shared their screen with them. The parents then dragged the window with the experimenter's face to the top of the screen between two colourful lines where it would not occlude the task. The parent was asked to remain seated near the child (either beside or behind). The experimenter explained to the participants that they were going to help identify pictures. The experimenter began three practice trials to ensure the children understood the task.

**Familiarization trials.** Three familiarization trials occurred, where children saw each of the phases described below. After each of the three familiarization trials, the children were given feedback on their answers to help them understand the task. They were given feedback on both the explicit and implicit judgement phases. For instance, if they selected the wrong image yet said that they were very confident, the experimenter would explain that "here you selected the wrong image, but you said that you were very confident about it. Perhaps you were not so sure here." Similarly, for the implicit judgement phase, if the children chose the wrong image but did not ask for a clue, the experimenter would explain that "Here, you chose the wrong image, but you did not ask for a clue. Here, you could have ask for a clue to help you recognize the blurry image."

**Stimulus presentation.** They were first presented with a blurry image that appeared for 1 second on the screen. This was followed 300 ms later by two simultaneously presented images, one target (i.e., the unblurred image) and one distractor (highly similar image). Both images were surrounded by different borders, one blue and one purple, to help the children point out the one they wanted to choose (i.e., "the blue one" or the "purple one"). The experimenter then asked the children if they could tell them which image resembled the blurry one the most. The experimenter would then select the option on their keyboard.

**Explicit metacognitive monitoring phase.** An image of a boy smiling and another of a boy frowning with a hand on his head and the other pointing to his mouth would appear on the screen side by side. The experimenter asked the child whether they were really sure of their answer like the boy who was smiling or not so sure of their answer like the other boy. They would then be prompted to point or touch their screen if they were too shy to answer verbally.

**Implicit metacognitive control phase.** An image of a question mark appeared in the middle of the screen with the words 'yes' in green and 'no' in red on either side. The experimenter asked the child whether they knew what a clue was. They then explained that a clue was information that could help them recognize the blurry image. The experimenter then explained that if they felt like they had made a mistake, they could ask for a clue. The experimenter then selected the answer on their keyboard. If the children requested a clue, they would be shown an image semantically related to the blurry image (e.g., a Christmas tree if the blurry image was a gift).

**Change phase.** Following the presentation of the clue, the children were given the opportunity to change their answer. The experimenter asked them if they still thought the answer was the one they selected, or if they wanted to switch to the other image. The experimenter selected the option chosen by the participants on their keyboard.

**Test trials.** No feedback was administered during the test trials. The implicit and explicit judgement phases were administered in a counterbalanced fashion, where half the participants always saw the explicit judgement phase before the implicit judgement phase, and the other half of the participants saw the implicit judgement phase before the explicit judgement phase. In the latter condition, the clue was only shown after the explicit judgement phase, as not to influence their choice of confidence. Sixteen trials were typically administered, but the experiment was cut short if the child was no longer cooperative. This was half the trials than were administered in the original study, which was judged reasonable given the administration of the other tasks would lengthen the study considerably and exacerbate children's' attention span.

**Theory of Mind**

To measure theory of mind, rather than relying on another lab-based lengthy task, we relied on the Children's Social Understanding Scale, or CSUS, a 42-item parent-report of children's common behaviors and patterns of thinking (Tahiroglu et al., 2014; Brosseau-Liard & Poulin-Dubois, 2019). Each statement was rated on a scale from 1 (very untrue) to 4 (very true). Total scores are calculated by adding Likert ratings for each question and dividing by the number of questions answered. This presented many advantages including shortening the session length and allowed for more variability between the scores than lab tasks, which are typically pass/fail. This questionnaire also offers a more comprehensive image of theory of mind, including their ability to reason about emotions, beliefs, knowledge, perception, desire, and intentions. The creators report an excellent internal validity ($\alpha = .94$) and a mean score of 3.14/4 for all combined scales, indicating their sample had overall very good theory of mind skills. This questionnaire was then translated into French by Brosseau-Liard & Poulin-Dubois (2019). This translation shows similar validity and reliability to its English counterpart. The CSUS has repeatedly shown its reliability across translations (e.g., Białecka-Pikul & Stępień-Nycz, 2019; Brosseau-Liard & Poulin-Dubois, 2019) and most recently has demonstrated inter-rater reliability across parents (Gluck et al., 2021).

## Results

### Planned Analyses

First, our results will be compared to chance performance to confirm whether our sample is displaying the abilities that we are measuring with our tasks. Next, we will compare our sample's performances to previous studies to provide evidence for or against the success of the replication. Afterwards, we will use correlations to investigate links between task performances. Finally, regression analyses will be performed to quantify the strength of the direct link between metacognitive skills and selective social learning.

### Data analysis

Data analyses were conducted on JAMOVI (v.1.1.9) and SPSS (v.27). A single univariate outlier ($N = 1$) in our explicit metacognitive monitoring task was identified following visual inspection of the data (± 3.29 standard deviations from the mean; Tabachnick & Fidell, 2019). Analyses were run with and without this outlier and it did not change our conclusions, thus it was kept. No multivariate outliers were identified using Tabachnick and Fidell's (2019) criteria of exclusion (i.e., no Mahalanobis distances with p-values below .001 when variables of interest are regressed on identification number). Less than 5% of the data was missing; we further proceeded to assume the latter were missing at random (MAR) and excluded cases pairwise from analyses.

Independence of data points could be assumed and normality for the individual variables was within recommended values (i.e., |3| for skewness and |10| for kurtosis; Kline, 2011)

## Selective Social Learning Task

### *Scoring*

Children were given one point every time they chose to ask the accurate puppet for their label, every time they endorsed the label advanced by the accurate puppet, and when they correctly identified which puppet had been accurate. There were 3 "Ask" and "Endorse" trials each, meaning scores could vary between 0 and 3, and 2 "Explicit Judgement" trials, meaning scores could vary between 0 and 2. To allow for increased variability amongst scores, we added scores on the Ask and Endorse questions for a possible total of 6. Proportion of correct responses were calculated from these scores. Preliminary independent sample t-tests were run to determine if there were any differences between the languages. No significant differences were present, therefore the sample was analyzed together.

### *Chance Analyses*

Sixty-three children were included in the one-sample t-tests performed, however one child did not complete the Explicit Judgement trials. Chance was operationalized at 50%, as children had to choose between two options (i.e., competent or incompetent puppet) for all three question-types. Children performed above chance for Ask, Endorse, and Explicit Judgement questions (see Table 3).

**Table 3**

*Descriptives and Chance Analyses for the Selective Social Learning Task*

| | Ask Questions | Endorse Questions | Explicit Judgement |
|---|---|---|---|
| N | 63 | 63 | 62 |
| Mean | .59 | .62 | .65 |
| SD | .31 | .33 | .33 |
| t | 2.32 | 2.89 | 3.62 |
| Df | 62 | 62 | 61 |
| Sig (p < .05) | .024 | .005 | < .001 |
| 95% CI | [.01, .17] | [.04, .20] | [.07, .24] |
| Cohen's d | 0.29 | 0.36 | 0.46 |

*Note.* One child did not complete the Explicit Judgement trials

***Replication***

Past research has indicated that children who perform better on the Explicit Judgement trials perform better on the Endorse and Ask questions. To confirm whether we replicated this pattern, we ran independent sample t-tests comparing children who obtained two correct trials on Explicit Judgement trials (Above Chance, $N = 26$) to those who obtained one or no correct trials (Equal to or Below Chance, $N = 36$). These analyses revealed a significant difference of performance on the Ask questions ($t(60) = 2.67$, $p = .010$, 95%CI [−.05, .35], $d = 0.69$; see Figure 1) but not on the Endorse questions ($t(60) = 1.41$, $p = .163$, 95%CI [−.05, .29], $d = 0.36$; see Figure 2). Notably however, children who performed at chance on the Explicit Judgement questions also performed at chance on the Endorse questions suggesting there was indeed a deficit in performance in this sub-group (see Table 4 for complete chance analyses).

**Table 4**

*Performance on Ask and Endorse Questions According to Performance on Explicit Judgement Questions*

| | **Above chance performance on explicit jugement questions** | | **Below chance performance on explicit jugement questions** | |
|---|---|---|---|---|
| | Endorse | Ask | Endorse | Ask |
| N | 26 | 26 | 36 | 36 |
| Mean | .69 | .71 | .57 | .51 |
| SD | .34 | .33 | .31 | .27 |
| t | 2.89 | 3.32 | 1.41 | .21 |
| Df | 25 | 25 | 35 | 35 |
| Sig (p < .05) | .008 | .003 | .167 | .838 |
| 95% CI | [.06; .33] | [.06; .33] | [-.03; .18] | [-.08; .10] |
| Cohen's d | 0.57 | 0.65 | 0.24 | 0.03 |

**Figure 1**

*Performance on Ask Trials According to Performance on Explicit Judgement Questions*

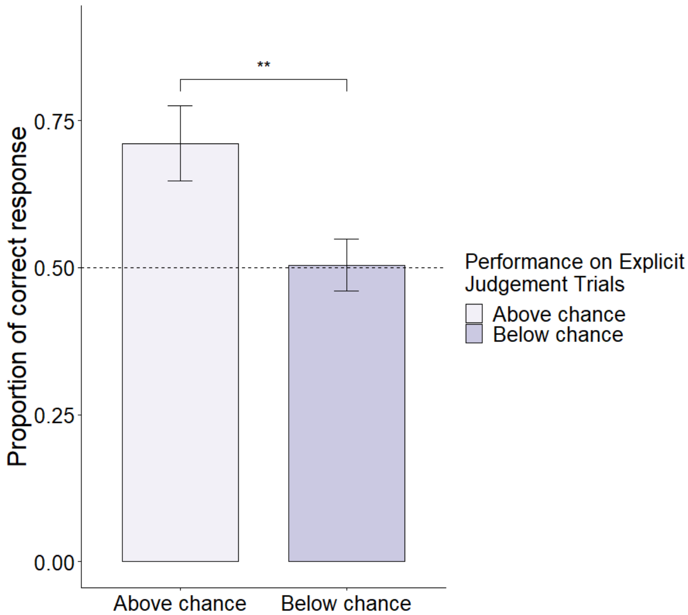
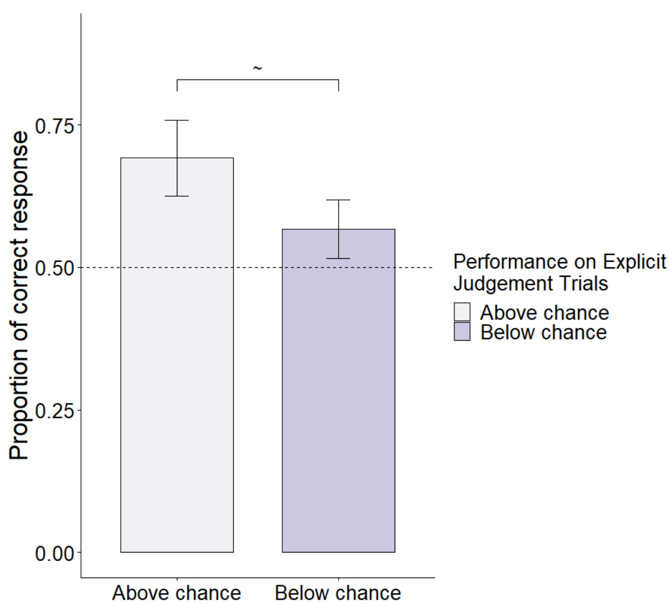



**Figure 2**

*Performance on Endorse Questions According to Performance on Explicit Judgement Trials*



## Metacognition

### *Opt-Out Task*

**Scoring.** The children were awarded 1 point if they correctly claimed to know which toy was in the box in the Full Knowledge condition or if they correctly claimed not to know what was in the box in the Partial Knowledge or the Ignorant conditions. Each type of trial was presented twice, meaning scores could vary between 0 and 6. Proportions of correct scores were calculated from these scores and became our explicit measure for the opt-out task which could be used for individual differences. Two independent scorers scored this task. Scorers agreed on 96.35% of the trials according to a sample subset of 16 participants. Three types of uncertainty gestures were coded as an implicit measure of metacognition, specifically head tilting, shrugging shoulders, and shaking the head. Two independent raters coded the gestures and were found to agree on 81.25% of the trials from a sample subset of 16 participants (Cohen's kappa = .55). Presence of any type of gesture for each trial was coded, such as scores could vary between 0 and 2 for each type of trial. To construct an overall individual measure of implicit metacognition for this task, we created a difference score by averaging the number of Ignorance and Partial Knowledge trials which contained uncertainty gestures and subtracted from it the number of uncertainty gestures exhibited during the Full Knowledge trials. Our rationale was that we would expect children with implicit metacognitive skills to exhibit more uncertainty gestures in the Partial knowledge and ignorance trial than in the full knowledge trials, as they are aware of which toy is put in the box in the latter trials. Such difference scores have previously been used in developmental research with similar purposes (e.g., Vanderbilt et al., 2011). This meant that the scores could vary between −2 and 2.

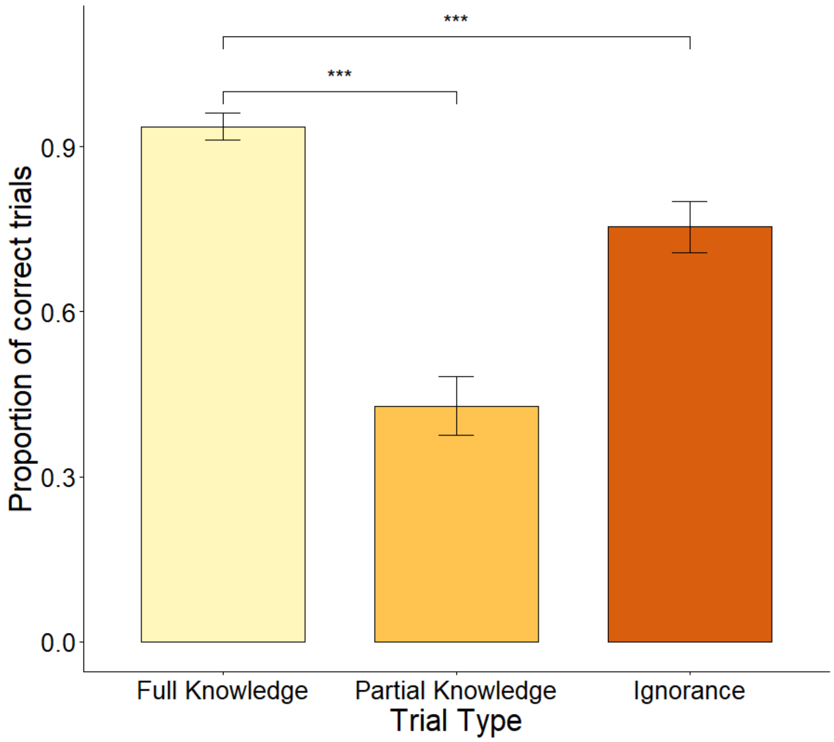
**Replication.** Kim and colleagues (2016) reported their results according to trial type, therefore to compare our results to theirs, we will do the same here. We performed a repeated measures ANOVA with trial type (Full Knowledge, Partial Knowledge, and Ignorance) as a within subject factor. We found a main effect of trial type ($F(2, 124) = 37.0$, $p < .001$, $\eta^2 = .28$), where children perform worse on the Partial Knowledge trials than on the Full Knowledge ($t(124) = 8.49$, $p < .001$) and Ignorance trials ($t(124) = 5.44$, $p < .001$; see Figure 3).

Similarly, we ran a repeated measures ANOVA with trial type (Full Knowledge, Partial Knowledge, and Ignorance) as a within-subjects factor on the proportion of trials with uncertainty gestures. We found a main effect of trial type ($F(2, 124) = 16.88$, $p <.001$, $\eta^2 = .11$), where our sample engaged in more gestures in the Partial Knowledge ($t(124) = -3.76$, $p < .001$) and Ignorance trials ($t(124) = -5.72$, $p < .001$) as compared to the Full Knowledge trials (see Figure 4). There was a trending difference between the gestures present in the Partial Knowledge and Ignorance trials ($t(124) = -1.96$, $p = .053$).

**Explicit metacognitive monitoring measure.** Sixty-three children were included in the following one sample t-test. Chance was once again operationalized as 50%, as children were given the option to either "know" or "not know" what is in the box. Our sample performed well above chance ($t(62) = 8.09$, $p < .001$, 95%CI [.16, .26], $d = 1.02$) with a mean of 70.6 ± 20.2%.

**Figure 3**

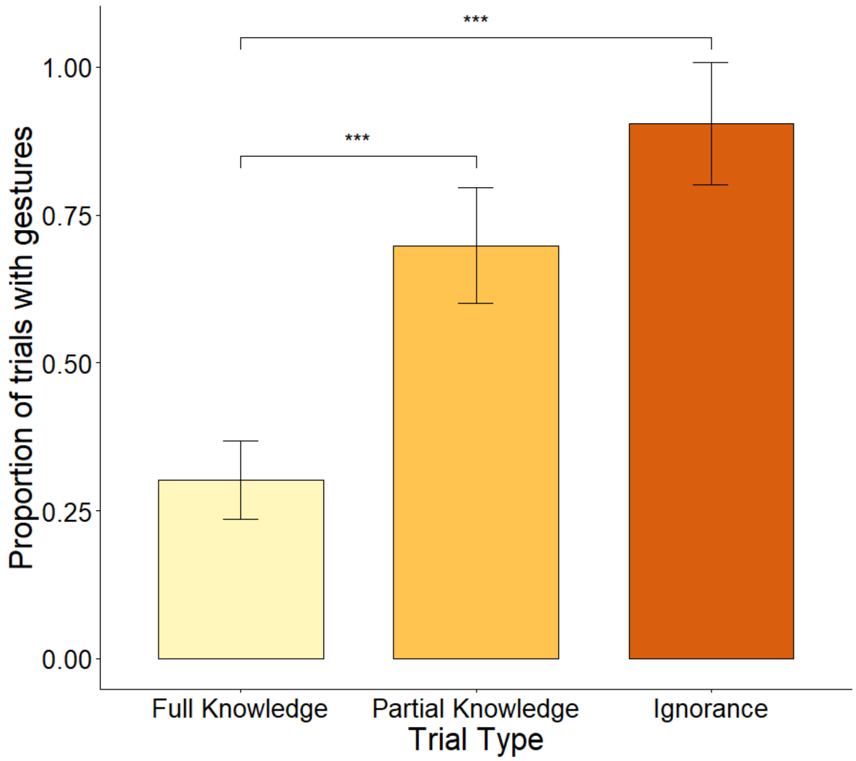
*Proportion of Correct Trials According to Trial Type*




**Implicit metacognitive monitoring measure (Gestures).** Sixty-three children were included in the following one sample t-test. Chance was operationalized as 0, as the difference score was calculated by subtracting the presence or absence of gestures in the Full Knowledge trials from the averaged presence or absence of gestures in the Partial and Ignorance trials, creating scores that would vary from −2 to 2. Our sample once again performed well above chance ($t(62) = 5.80$, $p < .001$, 95%CI [.33, .67], $d = 0.73$, min = −1, max = 2) with a mean of .5 ± .68.

**Figure 4**

*Proportion of Trials with Gestures According to Trial Type*



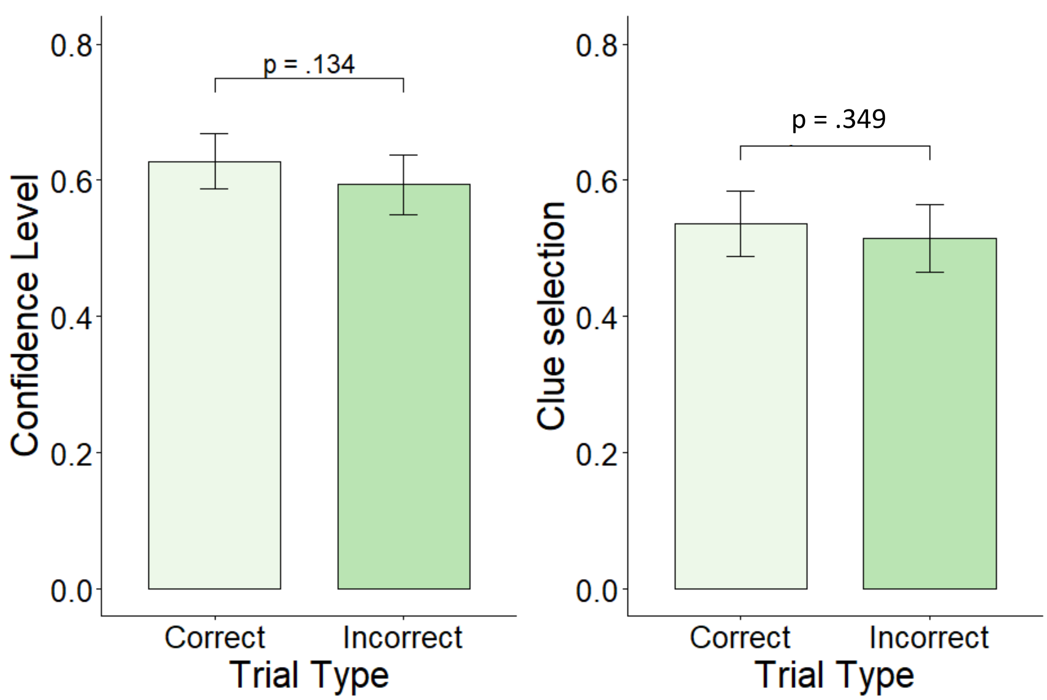

***Confidence Judgement Task***

**Scoring.** Proportions of confidence and clue selection according to correct or incorrect trials were initially calculated. Then, difference scores were calculated for both the explicit and implicit trials. For the explicit trials, the proportion of confident judgements on incorrect trials was subtracted from the proportion of confident judgements on correct trials. For the implicit trials, the proportion of clue asking on correct trials was subtracted from the proportion of clue asking on incorrect trials. Both measures could vary between −1 and 1, where −1 would indicate no MC skills and 1 would reflect perfect MC skills.

**Replication.** Geurten and Bastin (2019) compared confidence judgements as well as clue selection in trials which children had been correct versus incorrect trials. Sixty-three children were included in the following analyses. The children performed on average 15.8 ± 3.68 trials, as the task was terminated early for children who were no longer cooperative or excessively distracted. We ran a repeated measures ANOVA with trial type (correct or incorrect) as a within subjects factor on confidence levels as well as on cue selection rates. We found no main effect of trial type on confidence levels ($F(1, 62) = 2.30$, $p = .134$, $\eta^2 = .00$; see Figure 5) or cue selection rates ($F(1, 62) = 0.89$, $p = .349$, $\eta^2 = .00$; see Figure X). Our sample overall performed below chance on the visual discrimination task ($t(62) = 1.57$, $p = .123$, 95%CI [−.01, .06], $d = .197$).

**Figure 5**

*Proportion of Trials Including High Confidence Judgements or Clue Selection According to Trial Type*



**Chance analyses.** Sixty-three children were included in the following one-sample t-tests. Chance was operationalized as 0, as the difference scores could vary between −1 and 1. Our sample performed at chance on the explicit metacognitive measure (confidence differential score) and on the implicit metacognitive measure (clue selection differential score; see Table 5).

***Table 5***

*Descriptives for the Confidence Judgement Task*

| | Confidence judgements | | Clue selection | | Confidence differential score | Clue selection differential score |
|---|---|---|---|---|---|---|
| | Correct trials | Incorrect trials | Correct trials | Incorrect trials | | |
| N | 63 | 63 | 63 | 63 | 63 | 63 |
| Mean | .63 | .59 | .54 | .51 | .03 | -.02 |
| SD | .32 | .34 | .38 | .40 | .18 | .19 |
| t | 3.14 | 2.17 | 0.77 | 0.28 | 1.52 | -0.94 |
| Df | 62 | 62 | 62 | 62 | 62 | 62 |
| Sig (p < .05) | .003 | .034 | .447 | .777 | .134 | .349 |
| 95% CI | [.05; .21] | [01; .18] | [-.06; .13] | [-.09; .11] | [-.11; .08] | [-.07; .02] |
| Cohen's d | 0.40 | 0.27 | 0.10 | 0.04 | .19 | −.12 |

**Children's Social Understanding Scale**

As mentioned above, we gave the Children's Social Understanding Questionnaire (CSUS) to all parents of our participants. Participants filled it out in either French or English according to the language with which they were most comfortable. Sixty-two out of sixty-three parents of children included in our final sample completed the questionnaire. Below in Table 6, we report mean scores and standard deviations for all separate scale and grand total. These results are similar to Tahiroglu and colleagues' (2014) initial results (e.g., total mean = 3.14), suggesting our children are developmentally similar to the initial sample. The questionnaire's internal consistency was very good in this sample ($N$ = 24, list-wise deletion according to all variables in procedure; Cronbach's alpha = 0.89).

**Table 6**

*Mean scores on the separate scales of the CSUS*

| | Total | Emotion | Desire | Knowledge | Belief | Intention | Perception |
|---|---|---|---|---|---|---|---|
| *N* | 62 | 62 | 62 | 62 | 62 | 62 | 62 |
| Mean (*SD*) | 3.11 (0.35) | 3.25 (0.40) | 3.14 (0.46) | 3.23 (0.44) | 3.03 (0.60) | 3.12 (0.52) | 2.89 (0.36) |

**Intertask Correlations**

The first goal of this thesis was to examine the link between selective social learning and metacognition. We thus ran correlations on our measures of selective social learning, metacognition, and theory of mind (see Table 7). Explicit Judgement trials were not included as they inquire after the children's memory of the accuracy of the puppet rather than their own thoughts on who they want to learn from. We also included our two measures of explicit metacognition and implicit metacognition, as our second hypothesis concerned correlations between tasks. We found a significant relation between the implicit and explicit MC measures of the confidence judgement task ($r = .263$, $p = .037$), between the explicit and implicit MC measures of the opt-out task ($r = .252$, $p = .047$), between the two selective social learning measures ($r = .328$, $p = .009$), and finally between the Ask question scores and the confidence judgement composite ($r = -.334$, $p = .008$). We also find trending relationships between the selective social learning scores and confidence judgement measure of the visual discrimination task ($r = -.245$) and between the confidence judgements and the total scores of the opt-out task ($r = .238$; i.e., our two explicit metacognition measures). After performing a false discovery rate procedure on these results however, no correlations remained significant.

**Table 7**

*Zero-order Correlations Between Key Measures*

| | | 1. Endorse Questions (SSL) | 2. Ask Questions (SSL) | 3. Explicit Metacognitive Monitoring (Opt-Out) | 4. Implicit Metacognitive Monitoring (Gestures) | 5. Explicit Metacognitive Monitoring (Confidence Judgement) | 6. Implicit Metacognitive Control (Clue Selection) | 7. Children's Social Understanding Scale (ToM) |
|---|---|---|---|---|---|---|---|---|
| 1 | Pearson Correlation (*r*) | — | | | | | | |
| | *N* | 63 | | | | | | |
| 2 | *r* | **.33**** | — | | | | | |
| | Sig. (2-tailed) | .009 | | | | | | |
| | 95% CI | [.09; .53] | | | | | | |
| | *N* | 63 | 63 | | | | | |
| 3 | *r* | −.07 | −.001 | — | | | | |
| | Sig. (2-tailed) | .609 | .996 | | | | | |
| | 95% CI | [−.31;.19] | [−.25;.25] | | | | | |
| | *N* | 63 | 63 | 63 | | | | |
| 4 | *r* | .046 | .10 | **.252*** | — | | | |
| | Sig. (2-tailed) | .72 | .416 | .047 | | | | |
| | 95% CI | [−.20;.29] | [−.15;.34] | [.004; .470] | | | | |
| | *N* | 63 | 63 | 63 | 63 | | | |
| 5 | *r* | −.07 | **−.33**** | *.238* | .028 | — | | |
| | Sig. (2-tailed) | .563 | .008 | .06 | .829 | | | |
| | 95% CI | [−.32;.18] | [−.54;−.09] | [−.01;.46] | [−.22;.27] | | | |
| | *N* | 63 | 63 | 63 | 63 | 63 | | |
| 6 | *r* | .14 | .07 | .10 | −.01 | **.26*** | — | |
| | Sig. (2-tailed) | .266 | .614 | .432 | .965 | .037 | | |
| | 95% CI | [−.11;.38] | [.19;.31] | [−.151;.340] | [−.253;.243] | [.016;.480] | | |
| | *N* | 63 | 63 | 63 | 63 | 63 | 63 | |
| 7 | *r* | −.01 | −.07 | −.02 | −.04 | .13 | −.16 | — |
| | Sig. (2-tailed) | .922 | .593 | .869 | .743 | .317 | .227 | |
| | 95% CI | [−.24;.27] | [−.29;.22] | [−.30;.21] | [−.30;.20] | [−.13;.37] | [−.38;.12] | |
| | *N* | 62 | 62 | 62 | 62 | 62 | 62 | 62 |

*Note.* None of these correlations remained significant after an FDR correction with a false-discovery rate of .05. ** *is significant to .01 level and * is significant at the .05 level without correction.*

Despite the fact that it was the original goal of this study, regression analyses to determine the contribution of metacognition to selective social learning abilities will not be undertaken, as the above-reported correlations suggest that there is no link between selective social learning and metacognition in this sample.

**Discussion**

This study investigated the relationship between metacognition and selective social learning, where implicit and explicit metacognition were each measured with two different tasks. We hypothesized that 1) the two measures of implicit metacognition would predict selective social learning abilities, 2) that the two implicit metacognitive measures would be correlated with each other and the two explicit metacognitive measures would be correlated with each other, and that 3) theory of mind, as measured by a parental questionnaire, would predict selective social learning performance. We failed to find a significant correlation between selective social learning skills and implicit metacognition, nor did we did replicate a link between direct measures of theory of mind and either selective social learning or metacognition. Finally, we observed the expected link between implicit and explicit variable within each metacognitive task before statistical corrections.

Looking at individual task performance, our sample displayed above-chance selective social learning abilities when considering all three question types (59% on Ask Questions; 62% on Endorse questions; 65% on Explicit Judgement Questions), replicating the results of previous studies (averages ranging from 50-78%; Birch et al., 2008; Brosseau-Liard et al., 2015; DiYanni & Kelemen, 2008; Koenig et al., 2004; Koenig & Harris, 2005a; Rakoczy et al., 2008; Scofield & Behrend, 2008). In addition, we found that children who performed above chance on the Explicit Judgement questions also performed better on the Ask trials, replicating past findings (e.g., Koenig et al., 2004). This could suggest some level of involvement of memory processes, as to answer the Explicit Judgement questions correctly, individuals must keep track of the trustworthiness of each informant. Conversely, some suggest it could reflect the natural consequence of attributing explicit traits to informants, i.e., trait attribution, therefore guiding children's social decision-making processes in a way memory cannot do, which some may argue is based on error monitoring or on Bayesian modelling (i.e., updating a hypothesis as evidence is gathered; Fitneva & Dunfield, 2010).

Next, our sample also displayed implicit metacognitive skills according to the opt-out task. As Kim and colleagues' (2016) results suggested, our sample exhibited poorer explicit monitoring when reflecting on an ambiguous knowledge state (i.e., the Partial Knowledge trials) than on unambiguous ones (Full and Ignorance trials), but exhibited good implicit metacognitive monitoring, as they engaged in more uncertainty gestures in trials where they lacked knowledge (i.e., in the Partial knowledge and Ignorance trials).

Regarding the other task measuring explicit monitoring, our sample was not more confident on accurate trials than on inaccurate trials in the confidence judgement task, replicating Geurten and Bastins' (2019) results. However, contrary to what they found, our sample did not select clues on inaccurate trials more often than on accurate trials. Our sample therefore exhibited some signs of implicit metacognitive monitoring but did not exhibit implicit metacognitive control. It is important to note that Geurten and Bastin's (2019) sample performed above chance on the task, whereas ours did not, meaning the task may have been too difficult for our sample. In addition, our sample only performed about 16 trials whereas theirs performed 32. It is possible that a greater number of trials could have given the children more opportunities to improve their overall performance; however, given the length of the online study, an increase of the length of the task was not advisable. Notably, we ran an ANOVA with counterbalance condition as between-subject factor and found no significant impact of counterbalance, suggesting engaging in this task second or third did not impact children's performance. This task had its strengths, however, as children's performance on the picture identification trials was uncorrelated with their performance on either the confidence judgements ($r = -.243$) or the clue selections ($r = -.152$); this suggests that the metacognitive trials were likely measuring a skill unrelated to visual discrimination, which could not be said of the memory task previously used, which was highly correlated to the metacognitive measure (Resendes et al., 2021).

As discussed above, we did not find support for our first hypothesis, as our sample's performance on a selective social learning task did not correlate with implicit metacognitive control. This was true for the older half of our sample and our youngest half. We found a negative correlation between Ask question performance and explicit metacognitive monitoring, which was unexpected and possibly spurious. Some have argued however that performance on Ask questions may be vulnerable to ulterior social goals, such as wanting to affiliate (Reyes-Jaquez & Echols, 2013; Tong et al., 2020), and as such it is possible that children who actively sought to affiliate with the unreliable puppet were also skilled at monitoring their thought processes, as this choice might have been deliberate.

Alternatively, recruitment was challenging, and we were unable to reach our target sample size of 69. Though we had considered a priori power needed for a regression, our sample remained slightly smaller than the target sample size for correlations would have been (N = 68, $r = 0.375$; Resendes et al., 2021). It is therefore also possible that our analyses were under-powered or represent a natural variation in point estimates around an unknown population mean.

As for our second hypothesis, which was that we expected explicit metacognitive measures to be correlated with each other and implicit measures to be correlated with each other, we found a trending relationship between the explicit measures (confidence judgements and opt-out), but not our implicit measures (uncertainty gestures and clue selection) of metacognition. This may reflect the fact that both our explicit metacognitive measures assessed metacognitive monitoring, whereas the two implicit measures differed in one key aspect: clue selection was a measure of implicit metacognitive control whereas uncertainty gestures, one could argue, reflect more of a monitoring component as they required no decision on the part of the child (James et al., 2021). Future studies will be required to clarify this distinction when exploring correlates of these mechanisms. Alternatively, attempting to measure abilities in children is difficult given the amount of error associated with scores, and correlations are only as precise as the variables themselves.

For exploratory purposes, we also conducted intra-task correlations; we found a trending correlation between implicit and explicit metacognitive abilities, suggesting the two abilities might be related at this age. Though it is theoretically likely that these abilities are indeed related, as we have established, there is a developmental curve to metacognition and chronology has not been entirely established between monitoring and control (and implicit and explicit), meaning it is possible that one ability precedes the other, where the second ability has not developed yet, resulting in a window of time where the two abilities are not yet related. The trending correlation we report here supports previously discussed results wherein both abilities were correlated when implicit metacognition when measured via eye-tracking and explicit metacognition with confidence judgements (Roderer & Roebers, 2010). These results should be interpreted with caution, however, as none of these correlations survived an FDR correction and our sample was under-powered.

Finally, we found no significant correlation between theory of mind and either selective social learning or metacognition, failing to replicate the bulk of the past work in this area. To our knowledge, the CSUS has been used in such a context in only two studies and results have been mitigated, where either no relationship was found with selective social learning (Brosseau-Liard et al., 2018) or a specific, very limited relationship with the belief subscale (Resendes et al., 2021). As Brosseau-Liard and colleagues (2018) point out, though previous studies have found a relationship between selective social learning and theory of mind (e.g., DiYanni et al., 2012; Vanderbilt et al., 2011), this effect might be small and replicated with difficulty, especially in smaller samples. It is also possible that the nature of the selective social learning task may have impacted this link, as it is possible that children attribute fewer mental states to puppets online, as this combination may reduce the animacy of these agents beyond what children are able to interpret. As Sobel and Finiasz (2020) point out however, the nature of the informant in selective learning tasks generally do not seem to have impacted results in the field thus far.

Broad methodological factors as well as societal changes may have contributed to these mostly unexpected results. First and foremost, these data were collected online via the video conferencing application Zoom due to the COVID-19 pandemic, meaning the children and experimenter were at their respective homes. Though the experimenter's screen was devoid of distractions, it was impossible to regulate the child's immediate environment beyond asking parents to set-up their screen in a quiet and distraction-free environment. This was not always possible, and though our final sample was rated as being visibly engaged, it is possible that the depth of processing of the information was insufficient to result in robust understanding and engagement. As Strouse & Samson (2021) point out, there is still a quantifiable performance deficit in video tasks in 4-year-olds as compared to in person, even if said deficit decreases with age. We also know that children's peer interactions are an important part of early cognitive and social development (Rogoff et al., 2018). The reduced peer interactions or lack thereof over the several months preceding testing may have delayed the development of the abilities that we were attempting to measure, as the abilities discussed are thought to at least partial stem from interactions with a rich social environment (Cameron & Tenenbaum, 2021).

The results discussed above do not support a rich view of selective social learning, where this ability would stem from complex mechanisms such as the ability to reflect upon one's own thoughts or other's mental states (Heyes, 2020). They do not, however, discount the rich hypothesis entirely as it is possible that a link between these abilities emerges later. Indeed, it is possible that we would find different patterns in children closer to 5-years-old. For example, Vanderbilt and colleagues (2011) tested 3- to 5-year-olds on a selective distrust task and found that only 5-year-olds reliably distrusted an untrustworthy informant over a trustworthy one; their preference in informants as well as results were positively correlated with scores on a theory of mind battery. Older children may therefore exhibit more stable patterns in behaviour.

As Heyes (2016) has hypothesized, the early emergence of early social learning skills may be supported by simpler mechanisms such as associative learning. The transition to being supported by more complex mechanisms would require individuals to learn through social interactions. Although previous work in our lab did not support the implication of a low-level cognitive mechanism such as associative memory or statistical learning to be directly associated with selective social learning abilities in early toddlerhood (Resendes et al., 2021) or in infancy (Crivello et al., 2018, 2021), it remains possible that other low-level mechanisms may remain temporarily involved at that age (e.g., inhibitory skills; Jaswal et al., 2014). Implicit metacognition, as measured by persistence, was found to predict social learning abilities in 18-month-olds above and beyond low-level executive functioning skills (Kuzyk et al., 2020), however, some may argue that persistence is a precursor to metacognitive skills rather than a fully developed skill, and that mechanisms other than metacognition could explain such behaviours (e.g., behavioural cue association; Hampton, 2009). Models have been proposed to consolidate results from the animal research field to better understand whether these implicit measures are more consistent with associative learning mechanisms or metacognitive ones (Smith et al., 2016).

Taken together, the field's findings might be an indicator of the progression of social learning development, wherein the role played by executive function skills is slowly eclipsed by implicit metacognitive skills before then relying on explicit metacognitive skills, as is the case in adults (see Heyes, 2016 for a discussion on explicit metacognition in adulthood). The question then becomes when this shift occurs and what purpose this shift serves. Given the established link between calibration (i.e., explicit metacognition) in school-aged children and school performance (e.g., Hadwin & Webster, 2013), it is possible, for instance, that relying on explicit metacognitive skills facilitates asocial learning more than executive functions alone or implicit metacognitive skills. Future studies could therefore endeavor to compare learning using implicit versus explicit metacognitive strategies.

To conclude, we were unable to replicate a link between selective social learning and implicit metacognitive monitoring and theory of mind or find further links with explicit metacognition. We were able, however, to contribute to the literature by exploring the relationship between explicit and implicit metacognitive processes in early toddlerhood as measured by two different tasks and for the first time, as far as we know, measure the construct and concurrent validity of these metacognitive tasks. Future studies may want to evaluate the concurrent validity of other metacognitive tasks and further our knowledge of the longitudinal development of complex cognitive mechanisms and their interplay.

References

Baer, C., Malik, P., Odic, D. (2021) Are children's judgments of another's accuracy linked to their metacognitive confidence judgments?. *Metacognition Learning,* 16, 485–516. https://doi.org/10.1007/s11409-021-09263-x

Bernard, S., Proust, J., & Clément, F. (2015). Procedural Metacognition and False Belief Understanding in 3- to 5-Year-Old Children. *PLOS ONE*, *10*(10), e0141321. https://doi.org/10.1371/journal.pone.0141321

Białecka-Pikul, M., & Stępień-Nycz, M. (2019). Parent-report measure of Theory of Mind: Adaptation to Polish of the Children's Social Understanding Scale. *European Journal of Developmental Psychology*, *16*(3), 318–326. https://doi.org/10.1080/17405629.2017.1406850

Birch, S. A. J., Vauthier, S. A., & Bloom, P. (2008). Three- and four-year-olds spontaneously use others' past performance to guide their learning. *Cognition*, *107*(3), 1018–1034. https://doi.org/10.1016/j.cognition.2007.12.008

Brosseau-Liard, P. E., Iannuzziello, A., & Varin, J. (2018). Savvy or Haphazard? Comparing Preschoolers' Performance Across Selective Learning Tasks Based on Different Epistemic Indicators. *Journal of Cognition and Development*, *19*(4), 367–388. https://doi.org/10.1080/15248372.2018.1495219

Brosseau-Liard, P., Penney, D., & Poulin-Dubois, D. (2015). Theory of mind selectively predicts preschoolers' knowledge-based selective word learning. *British Journal of Developmental Psychology*, *33*(4), 464–475. https://doi.org/10.1111/bjdp.12107

Brosseau-Liard, P., & Poulin-Dubois, D. (2019). Fiabilité et validité de l'Échelle de compréhension sociale des enfants. *Psychologie Française*, *64*(4), 331–341. https://doi.org/10.1016/j.psfr.2018.01.003

Call, J. (2010). Do apes know that they could be wrong? *Animal Cognition*, *13*(5), 689–700. https://doi.org/10.1007/s10071-010-0317-x

Call, J., & Carpenter, M. (2001). Do apes and children know what they have seen? *Animal Cognition*, *3*(4), 207–220. https://doi.org/10.1007/s100710100078

Cameron, L., & Tenenbaum, H. R. (2021). Lessons from developmental science to mitigate the effects of the COVID-19 restrictions on social development. *Group Processes & Intergroup Relations*, *24*(2), 231–236. https://doi.org/10.1177/1368430220984236

Carruthers, P. (2009). How we know our own minds: The relationship between mindreading and metacognition. *Behavioral and Brain Sciences*, *32*(2), 121–138. https://doi.org/10.1017/S0140525X09000545

Corriveau, K., & Harris, P. L. (2009). Choosing your informant: Weighing familiarity and recent accuracy. *Developmental Science*, *12*(3), 426–437. https://doi.org/10.1111/j.1467-7687.2008.00792.x

Cossette, I., Fobert, S. F., Slinger, M., & Brosseau-Liard, P. E. (2020). Individual Differences in Children's Preferential Learning from Accurate Speakers: Stable but Fragile. *Journal of Cognition and Development*, *21*(3), 348–367. https://doi.org/10.1080/15248372.2020.1727479

Crivello, C., Grossman, S., & Poulin-Dubois, D. (2021). Specifying links between infants' theory of mind, associative learning, and selective trust. *Infancy*, *n/a*(n/a). https://doi.org/10.1111/infa.12407

Crivello, C., Phillips, S., & Poulin-Dubois, D. (2018). Selective social learning in infancy: Looking for mechanisms. *Developmental Science*, *21*(3), e12592. https://doi.org/10.1111/desc.12592

Crystal, J. D., & Foote, A. L. (2009). Metacognition in animals. *Comparative Cognition & Behavior Reviews*, *4*, 1–16. https://doi.org/10.3819/ccbr.2009.40001

Diaconescu, A. O., Mathys, C., Weber, L. A., Daunizeau, J., Kasper, L., Lomakina, E. I., Fehr, E., & Stephan, K. E. (2014). Inferring on the intentions of others by hierarchical bayesian learning. Plos Computational Biology, 10(9), 1003810. https://doi.org/10.1371/journal.pcbi.1003810

DiYanni, C., & Kelemen, D. (2008). Using a bad tool with good intention: Young children's imitation of adults' questionable choices. *Journal of Experimental Child Psychology*, *101*(4), 241–261. https://doi.org/10.1016/j.jecp.2008.05.002

DiYanni, C., Nini, D., Rheel, W., & Livelli, A. (2012). 'I Won't Trust You if I Think You're Trying to Deceive Me'': Relations Between Selective Trust, Theory of Mind, and Imitation in Early Childhood.' *Journal of Cognition and Development*, *13*(3), 354–371. https://doi.org/10.1080/15248372.2011.590462

Efklides, A. (2011) Interactions of Metacognition With Motivation and Affect in Self-Regulated Learning: The MASRL Model, *Educational Psychologist*, 46:1, 6-25, DOI: 10.1080/00461520.2011.538645

Elashi, F. B., & Mills, C. M. (2014). Do children trust based on group membership or prior accuracy? The role of novel group membership in children's trust decisions. *Journal of Experimental Child Psychology*, *128*, 88–104. https://doi.org/10.1016/j.jecp.2014.07.003

Feurer, E., Sassu, R., Cimeli, P., & Roebers, C. M. (2015). Development of meta-representations: Procedural metacognition and the relationship to Theory of Mind. Journal of Educational and Developmental Psychology, 5(1), 6–18. https://doi.org/10.5539/jedp.v5n1p6

Filevich, E., Forlim, C. G., Fehrman, C., Forster, C., Paulus, M., Shing, Y. L., & Kühn, S. (2020). I know that I know nothing: Cortical thickness and functional connectivity underlying meta-ignorance ability in pre-schoolers. Developmental Cognitive Neuroscience, 41, 100738. https://doi.org/10.1016/j.dcn.2019.100738

Fitneva, S. A., & Dunfield, K. A. (2010). Selective information seeking after a single encounter. Developmental Psychology, 46(5), 1380–1384. https://doi.org/10.1037/a0019818

Flavell, J. H. (1979). Metacognition and cognitive monitoring: A new area of cognitive–developmental inquiry. *American Psychologist*, *34*(10), 906–911. https://doi.org/10.1037/0003-066X.34.10.906

Flavell, J. H. (2003). Varieties of uncertainty monitoring. *Behavioral and Brain Sciences; New York*, *26*(3), 344.

Fusaro, M., & Harris, P. L. (2008). Children assess informant reliability using bystanders' non-verbal cues. *Developmental Science*, *11*(5), 771–777. https://doi.org/10.1111/j.1467-7687.2008.00728.x

Geurten, M., & Bastin, C. (2019). Behaviors speak louder than explicit reports: Implicit metacognition in 2.5-year-old children. *Developmental Science*, *22*(2), N.PAG-N.PAG. https://doi.org/10.1111/desc.12742

Gluck, S. C., Tahiroglu, D., & Moses, L. J. (2021). A comparison of mother and father reports of children's theory of mind: Further validation of the children's social understanding scale.

*European Journal of Developmental Psychology*, *18*(3), 459–469. https://doi.org/10.1080/17405629.2020.1813100

Goupil, L., & Kouider, S. (2016). Behavioral and Neural Indices of Metacognitive Sensitivity in Preverbal Infants. *Current Biology*, *26*(22), 3038–3045. https://doi.org/10.1016/j.cub.2016.09.004

Goupil, L., Romand-Monnier, M., and Kouider, S. (2016). Infants ask for help when they know they don't know. Proc. Natl. Acad. Sci. USA 113, 3492–3496. https://doi.org/10.1073/pnas.1515129113

Goupil, L., & Kouider, S. (2019). Developing a Reflective Mind: From Core Metacognition to Explicit Self-Reflection. Current Directions in Psychological Science, 28(4), 403–408. https://doi.org/10.1177/0963721419848672

Hadwin, A. F., & Webster, E. A. (2013). Calibration in goal setting: Examining the nature of judgments of confidence. *Learning and Instruction*, *24*, 37–47. https://doi.org/10.1016/j.learninstruc.2012.10.001

Hampton, R. R. (2009). Multiple demonstrations of metacognition in nonhumans: Converging evidence or multiple mechanisms? *Comparative Cognition & Behavior Reviews*, *4*, 17–28.

Henrich, J., & Broesch, J. (2011). On the nature of cultural transmission networks: Evidence from Fijian villages for adaptive learning biases. *Philosophical Transactions: Biological Sciences*, *366*(1567), 1139–1148.

Hermes, J., Behne, T., & Rakoczy, H. (2018). The Development of Selective Trust: Prospects for a Dual-Process Account. *Child Development Perspectives*, *12*(2), 134–138. https://doi.org/10.1111/cdep.12274

Heyes, C. (2012). Introduction: new thinking: the evolution of human cognition. *Philosophical Transactions: Biological Sciences*, *367*(1599), 2091–2096.

Heyes, C. (2016). Who Knows? Metacognitive Social Learning Strategies. *Trends in Cognitive Sciences*, *20*(3), 204–213. https://doi.org/10.1016/j.tics.2015.12.007

Heyes, C. (2019). Précis of Cognitive Gadgets: The Cultural Evolution of Thinking. *Behavioral and Brain Sciences*, *42*. https://doi.org/10.1017/S0140525X18002145

Heyes, C., Bang, D., Shea, N., Frith, C. D., & Fleming, S. M. (2020). Knowing Ourselves Together: The Cultural Origins of Metacognition. *Trends in Cognitive Sciences*, *24*(5), 349–362. https://doi.org/10.1016/j.tics.2020.02.007

James, B. T., Parrish, A. E., Guild, A. S., Creamer, C., Kelly, V., Perdue, B., Kelly, A. J., & Beran, M. J. (2021). Go if you know: Preschool children's movements reflect their metacognitive monitoring. Cognitive Development, 57, 101001. https://doi.org/10.1016/j.cogdev.2020.101001

Jaswal, V. K., & Kondrad, R. L. (2016). Why children are not always epistemically vigilant: cognitive limits and social considerations. Child Development Perspectives, 10(4), 240–244. https://doi.org/10.1111/cdep.12187

Jaswal, V. K., Pérez-Edgar, K., Kondrad, R. L., Palmquist, C. M., Cole, C. A., & Cole, C. E. (2014). Can't stop believing: Inhibitory control and resistance to misleading testimony. *Developmental Science*, *17*(6), 965–976. https://doi.org/10.1111/desc.12187

Johnston, A. M., Mills, C. M., & Landrum, A. R. (2015). How do children weigh competence and benevolence when deciding whom to trust? *Cognition*, *144*, 76–90. https://doi.org/10.1016/j.cognition.2015.07.015

Kim, S., Paulus, M., Sodian, B., & Proust, J. (2016). Young Children's Sensitivity to Their Own Ignorance in Informing Others. *PLOS ONE*, *11*(3), e0152595. https://doi.org/10.1371/journal.pone.0152595

Kim, S., Sodian, B., Paulus, M., Senju, A., Okuno, A., Ueno, M., Itakura, S., & Proust, J. (2020). Metacognition and mindreading in young children: A cross-cultural study. Consciousness and Cognition, 85, 103017. https://doi.org/10.1016/j.concog.2020.103017

Kline, R. (2011). Principles and practice of structural equation modeling (Fourth ed., Methodology in the social sciences) [Fourth edition.]. New York: Guilford Press. (2011).

Kloo, D., Rohwer, M., & Perner, J. (2017). Direct and indirect admission of ignorance by children. *Journal of Experimental Child Psychology*, *159*, 279–295. https://doi.org/10.1016/j.jecp.2017.02.014

Koenig, M. A., Clément, F., & Harris, P. L. (2004). Trust in Testimony: Children's Use of True and False Statements. *Psychological Science*, *15*(10), 694–698. https://doi.org/10.1111/j.0956-7976.2004.00742.x

Koenig, M. A., & Harris, P. L. (2005a). Preschoolers Mistrust Ignorant and Inaccurate Speakers. *Child Development*, *76*(6), 1261–1277. https://doi.org/10.1111/j.1467-8624.2005.00849.x

Koenig, M. A., & Harris, P. L. (2005b). The role of social cognition in early trust. *Trends in Cognitive Sciences*, *9*(10), 457–459. https://doi.org/10.1016/j.tics.2005.08.006

Kuzyk, O., Grossman, S., & Poulin-Dubois, D. (2020). Knowing who knows: Metacognitive and causal learning abilities guide infants' selective social learning. *Developmental Science*, *23*(3), e12904. https://doi.org/10.1111/desc.12904

Landrum, A. R., Eaves, B. S., & Shafto, P. (2015). Learning to trust and trusting to learn: A theoretical framework. *Trends in Cognitive Sciences*, *19*(3), 109–111. https://doi.org/10.1016/j.tics.2014.12.007

Leckey, S., Selmeczy, D., Kazemi, A., Johnson, E.G., Hembacher, E., Ghetti, S. (2020) Response latencies and eye gaze provide insight on how toddlers gather evidence under uncertainty. *Nature Human Behaviour,* 4, 928–936. https://doi.org/10.1038/s41562-020-0913-y

Lucas, A. J., Burdett, E. R. R., Burgess, V., Wood, L. A., McGuigan, N., Harris, P. L., & Whiten, A. (2017). The Development of Selective Copying: Children's Learning From an Expert Versus Their Mother. *Child Development*, *88*(6), 2026–2042. https://doi.org/10.1111/cdev.12711

Lucas, A. J., Lewis, C., Pala, F. C., Wong, K., & Berridge, D. (2013). Social-cognitive processes in preschoolers' selective trust: Three cultures compared. *Developmental Psychology*, *49*(3), 579–590. https://doi.org/10.1037/a0029864

Marcus, G. F., & Clahsen, H. (1992). Overregularization in language acquisition (Ser. Monographs of the society for research in child development, serial no. 228 = v. 57, no. 4 (1992). Society for Research in Child Development.

Mills, C. M. (2013). Knowing when to doubt: Developing a critical stance when learning from others. Developmental Psychology, 49, 404–418. https://doi.org/10.1037/ a0029500

Moses, L. J., & Baldwin, D. A. (2005). What can The Study of Cognitive Development Reveal about Children's Ability to Appreciate and Cope with Advertising? *Journal of Public Policy & Marketing*, *24*(2), 186–201. https://doi.org/10.1509/jppm.2005.24.2.186

Nelson, T. O. and Narens, L. 1994. “Why investigate metacognition”. In Metacognition: Knowing about knowing, Edited by: Metcalfe, J. and Shimamur, A. 1–25. Cambridge, MA: MIT Press.

Onishi, K. H., & Baillargeon, R. (2005). Do 15-Month-Old Infants Understand False Beliefs? *Science*, *308*(5719), 255–258. https://doi.org/10.1126/science.1107621

Palmquist, C. M., & Fierro, M. G. (2018). The Right Stuff: Preschoolers Generalize Reliability Across Communicative Domains When Informants Show Semantic (Not Episodic) Knowledge. *Journal of Cognition and Development*, *19*(5), 552–567. https://doi.org/10.1080/15248372.2018.1526174

Pasquini, E. S., Corriveau, K. H., Koenig, M., & Harris, P. L. (2007). Preschoolers monitor the relative accuracy of informants. *Developmental Psychology*, *43*(5), 1216–1226. https://doi.org/10.1037/0012-1649.43.5.1216

Paulus, M., Proust, J., & Sodian, B. (2013). Examining implicit metacognition in 3.5-year-old children: An eye-tracking and pupillometric study. *Frontiers in Psychology*, *4*. https://doi.org/10.3389/fpsyg.2013.00145

Poulin-Dubois, D., & Brosseau-Liard, P. (2016). The Developmental Origins of Selective Social Learning. *Current Directions in Psychological Science*, *25*(1), 60–64. https://doi.org/10.1177/0963721415613962

Rakoczy, H., Warneken, F., & Tomasello, M. (2008). The sources of normativity: Young children’s awareness of the normative structure of games. *Developmental Psychology*, *44*(3), 875–881. https://doi.org/10.1037/0012-1649.44.3.875

Rendell, L., Fogarty, L., Hoppitt, W. J. E., Morgan, T. J. H., Webster, M. M., & Laland, K. N. (2011). Cognitive culture: Theoretical and empirical insights into social learning strategies. *Trends in Cognitive Sciences*, *15*(2), 68–76. https://doi.org/10.1016/j.tics.2010.12.002

Resendes, T., Bechimol-Elkaim, B., Delisle, C., René, J-L., Poulin-Dubois, D. (2021) I know what you know: The role of metacognitive strategies in preschoolers' selective social learning. Submitted to Cognitive Development.

Reyes-Jaquez, B., & Echols, C. H. (2013). Developmental differences in the relative weighing of informants' social attributes. Developmental Psychology, 49, 602–613. https://doi.org/10.1037/a0031674

Roderer, T., & Roebers, C. (2014). Can you see me thinking (about my answers)? Using eye-tracking to illuminate developmental differences in monitoring and control skills and their relation to performance. *Metacognition & Learning*, *9*(1), 1–23. https://doi.org/10.1007/s11409-013-9109-4

Roderer, T., & Roebers, C. M. (2010). Explicit and implicit confidence judgments and developmental differences in metamemory: An eye-tracking approach. *Metacognition & Learning*, *5*(3), 229–250. https://doi.org/10.1007/s11409-010-9059-z

Roebers, C.M. (2017) Executive function and metacognition: Towards a unifying framework of cognitive self-regulation. *Developmental Review.* 45:31–51. https://doi.org/10.1016/j.dr.2017.04.001

Rogoff, B., Dahl, A., & Callanan, M. (2018). The importance of understanding children's lived experience. *Developmental Review*, *50*, 5–15. https://doi.org/10.1016/j.dr.2018.05.006

Ruffman, T. (2014). To belief or not belief: Children's theory of mind. *Developmental Review*, *34*(3), 265–293. https://doi.org/10.1016/j.dr.2014.04.001

Schneider, W. (2008). The Development of Metacognitive Knowledge in Children and Adolescents: Major Trends and Implications for Education. *Mind, Brain, and Education*, *2*(3), 114–121. https://doi.org/10.1111/j.1751-228X.2008.00041.x

Schneider, W., & Lockl, K. (2013). In J. Dunlosky & R. A. Bjork (Eds.), *Handbook of Metamemory and Memory*. essay, Taylor and Francis.

Scofield, J., & Behrend, D. A. (2008). Learning words from reliable and unreliable speakers. *Cognitive Development*, *23*(2), 278–290. https://doi.org/10.1016/j.cogdev.2008.01.003

Scott, R. M., & Baillargeon, R. (2017). Early False-Belief Understanding. *Trends in Cognitive Sciences*, *21*(4), 237–249. https://doi.org/10.1016/j.tics.2017.01.012

Smith, E. R., & DeCoster, J. (2000). *Dual-Process Models in Social and Cognitive Psychology: Conceptual Integration and Links to Underlying Memory Systems—Eliot R. Smith, Jamie DeCoster, 2000*. https://journals.sagepub.com/doi/abs/10.1207/s15327957pspr0402_01

Smith, J. D., & Washburn, D. A. (2005). Uncertainty Monitoring and Metacognition by Animals. *Current Directions in Psychological Science*, *14*(1), 19–24. https://doi.org/10.1111/j.0963-7214.2005.00327.x

Smith, J. D., Zakrzewski, A. C., & Church, B. A. (2016). Formal models in animal-metacognition research: The problem of interpreting animals' behavior. *Psychonomic Bulletin & Review*, *23*(5), 1341–1353. https://doi.org/10.3758/s13423-015-0985-2

Sobel, D. M., & Finiasz, Z. (2020). How Children Learn From Others: An Analysis of Selective Word Learning. *Child Development*, *91*(6), e1134–e1161. https://doi.org/10.1111/cdev.13415

Sobel, D. M., & Kushnir, T. (2013). Knowledge matters: How children evaluate the reliability of testimony as a process of rational inference. *Psychological Review*, *120*(4), 779–797. https://doi.org/10.1037/a0034191

Sodian B, Thoermer C, Kristen S, Perst H (2012) Metacognition in infants and young children. Foundations of Metacognition, eds Beran, M.J., Brandl, J.L., Perner, J., Proust, J. (Oxford Univ Press, Oxford, UK), pp 119–133.

Strouse, G. A., & Samson, J. E. (2021). Learning From Video: A Meta-Analysis of the Video Deficit in Children Ages 0 to 6 Years. *Child Development*, *92*, e20–e38. https://doi.org/10.1111/cdev.13429

Tabachnick, B. G., Fidell, L. S., & Ullman, J. B. (2019). *Using multivariate statistics* (Seventh edition). Pearson.

Tahiroglu, D., Moses, L. J., Carlson, S. M., Mahy, C. E. V., Olofson, E. L., & Sabbagh, M. A. (2014). The Children's Social Understanding Scale: Construction and validation of a parent-report measure for assessing individual differences in children's theories of mind. *Developmental Psychology*, *50*(11), 2485–2497. https://doi.org/10.1037/a0037914

Tenney, E. R., MacCoun, R. J., Spellman, B. A., & Hastie, R. (2007). Calibration Trumps Confidence as a Basis for Witness Credibility. *Psychological Science*, *18*(1), 46–50. https://doi.org/10.1111/j.1467-9280.2007.01847.x

Tong, Y., Wang, F., & Danovitch, J. (2020). The role of epistemic and social characteristics in children's selective trust: Three meta-analyses. *Developmental Science*, *23*(2), e12895. https://doi.org/10.1111/desc.12895

Vanderbilt, K. E., Liu, D., & Heyman, G. D. (2011). The Development of Distrust. *Child Development*, *82*(5), 1372–1380. https://doi.org/10.1111/j.1467-8624.2011.01629.x

Wellman, H. M. (2014). *Making Minds: How Theory of Mind Develops*. Oxford University Press.

Wellman, H.M., Cross, D. and Watson, J. (2001), Meta-Analysis of Theory-of-Mind Development: The Truth about False Belief. Child Development, 72: 655-684. https://doi.org/10.1111/1467-8624.00304

Wellman, H. M., & Liu, D. (2004). Scaling of Theory-of-Mind Tasks. *Child Development*, *75*(2), 523–541. https://doi.org/10.1111/j.1467-8624.2004.00691.x

Whiten, A. (2021). The psychological reach of culture in animals' lives. Current Directions in Psychological Science, 30(3), 211–217. https://doi.org/10.1177/0963721421993119

Wimmer, H., & Perner, J. (1983). Beliefs about beliefs: Representation and constraining function of wrong beliefs in young children's understanding of deception. Cognition, 13(1), 103–128. https://doi.org/10.1016/0010-0277(83)90004-5

Appendix: Confidence Task (adapted from Geurten & Bastin, 2019)