Who knows best? Mechanisms underlying infants' selective social learning

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Abstract

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The main objective of the present dissertation was to investigate the psychological mechanisms underlying selective social learning in infancy. Specifically, it was of interest to examine whether domain-specific or domain-general abilities guide infants' selective behaviour. The aim of Study 1 was to examine whether theory of mind abilities (knowledge inference and false belief) and/or statistical learning abilities relate to 18-month-olds' selective word learning. Results demonstrated that infants who had a superior performance on the knowledge inference task were less likely to learn a novel word from an informant who labeled objects inaccurately (i.e., who labeled a ball as a shoe). Infants' false belief and statistical learning abilities were unrelated to their selective social learning.

The goal of Study 2 was to examine whether infants' knowledge inference and/or associative learning abilities were linked with 14-month-olds' selective trust in an emotional congruence paradigm. Findings revealed that infants with superior knowledge inference abilities were less likely to trust an incongruent emoter, that is, an emoter who expressed an emotional reaction that did not match the situation (i.e., expressing happiness after examining an empty container). No relation was present with the associative learning task.

Lastly, the objective of Study 3 was to investigate whether infants' theory of mind abilities (knowledge inference and false belief) and/or associative learning abilities were related to 18-month-olds' performance on a selective word learning task using a within-subjects

paradigm. Consistent with the two previous studies, only infants' knowledge inference abilities were associated with their mistrust of the unreliable informant.

Taken together, the findings from the three studies demonstrate that infants use domain-specific abilities, such as their ability to infer others' knowledge states, to selectively trust and learn from others. In other words, infants with superior knowledge inference abilities may be better able to infer whether someone is ignorant/unreliable and therefore not a good source to learn from. These results provide evidence for a rich interpretation of infants' selective social learning.

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CONTRIBUTION OF AUTHOR

This dissertation consists of three manuscripts.

Study 1 (see Chapter 2)

Crivello, C., Phillips, S., & Poulin-Dubois, D. (2017). Selective social learning in infancy: Looking for mechanisms. *Developmental Science,* e12592. doi:10.1111/desc.12592

Study 2 (see Chapter 3)

Crivello, C., & Poulin-Dubois, D. (2019). Infants' ability to detect emotional incongruency: Deep or shallow? *Infancy.* Advanced online publication. doi:10.1111/infa.12277

Study 3 (see Chapter 4)

Crivello, C., Grossman, S., & Poulin-Dubois, D. (2019). Infants' ability to infer others' knowledge is linked to selective social learning. Manuscript submitted for publication.

Relative Contributions

My thesis supervisor, Dr. Diane Poulin-Dubois, and I conceptualized the design and methodology of the studies. After reviewing the literature, we chose the experimental tasks and finalized the procedure. Prior to testing, I helped the laboratory manager prepare recruitment letters that would be mailed to families. Recruitment of participants was conducted by the laboratory's recruiters, Sara Kripliani and Melanie Joly. In collaboration with Honours students (Sara Phillips, Melissa Lazo, Shawna Grossman), I created scripts for each task and prepared the task stimuli. In terms of data collection, three different experimenters were needed in each study. I was the primary experimenter for all three studies. The second and third main experimenters were: Sara Phillips (Honours student) and Camille Labrèche (research assistant) for Study 1, Melissa Lazo (Honours student) and Sara Phillips (laboratory manager) for Study 2, as well as Shawna Grossman (Honours student) and Stevie Karpman and Mallorie Brisson (research assistants) for Study 3. In addition, Catherine Delisle, Lauranne Gendron-Cloutier, Melanie Joly, Olivia Kuzyk, Giudita Marinotti, and Alexa Ruel assisted with data collection. With regards to coding, for Study 1, I coded one task for all participants, while Sara Phillips coded three tasks for all participants and Vivianne Severdija conducted the reliability coding. For Study 2, I coded three tasks for all participants, while Sara Phillips coded one task for all participants and Catherine Delisle conducted the reliability coding. For Study 3, Shawna Grossman coded all of the tasks for all participants, while Jessy Burdman-Villa conducted the reliability coding. Following the data collection and coding, undergraduate students entered the data in SPSS, and then I double-checked the data entry with a volunteer. I conducted all of the statistical analyses and interpreted the data. Furthermore, I prepared the manuscripts and completed revisions, and Dr. Poulin-Dubois provided revisions and feedback. The two Honours students on the first and third manuscripts (Sara Phillips and Shawna Grossman) also provided feedback as co-authors. Lastly, I summarized the findings of each study, which were included in a newsletter sent to all families that participated in the studies. Dr. Poulin-Dubois provided guidance and feedback throughout every step of my dissertation.

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Chapter 1

Introduction

Young children are constantly acquiring new information, most of the time by interacting with and observing others (Box, 1984). Although social learning is efficient, it can come with risks as informants may have inaccurate knowledge or may be deceptive (Dawkins & Krebs, 1978). Thus, when children engage in social learning, they need to identify who is an accurate informant and who has good intentions (Koenig & Sabbagh, 2013). The past decade of research has shown that infants and young children can identify, and often prefer to learn from, accurate informants – that is, they engage in *selective* social learning (Harris, Koenig, Corriveau, & Jaswal, 2018; Koenig & Harris, 2005; Koenig & Sabbagh, 2013; Mills, 2013; Nurmsoo, Robinson, & Butterfill, 2010; Poulin-Dubois & Brosseau-Liard, 2016). Although there is limited research on the psychological mechanisms underlying social learning, those mechanisms have already been the topic of a heated debate (Hermes, Behne, & Rakoczy, 2018; Heyes, 2017; Poulin-Dubois, 2017; Sabbagh, Koenig, & Kuhlmeier, 2017; Sobel & Kushnir, 2013). On one side of this debate are researchers who argue for a rich mechanism underlying selective social learning, where higher-order, domain-specific mechanisms, such as theory of mind, are crucial. On the other side are those who propose a lean mechanism where lower-order, domain-general mechanisms, such as statistical learning and associative learning, drive social learning particularly in the first few years of life. Therefore, the purpose of this research was to contribute critical data to this debate by examining whether domain-specific or domain-general abilities relate to selective social learning in infancy. Study 1 and 3 examined whether rich versus lean mechanisms are involved in 18-month-olds' selective word learning using different paradigms to measure infants' selectivity, whereas Study 2 investigated this research question in 14-month-olds with an emotional congruency paradigm.

Selective social learning

Selective social learning can be defined as choosing to learn from some people over others (Koenig & Sabbagh, 2013; Mills, 2013; Nurmsoo, Robinson, & Butterfill, 2010). This ability allows children to discriminate between reliable and unreliable sources of information (Harris et al., 2018; Koenig & Harris, 2005; Mills, 2013; Nurmsoo, Robinson, & Butterfill, 2010). Children may rely on a number of different cues to assess the reliability of an informant, including epistemic, communicative, and emotional cues (Mills, 2013). Epistemic cues arise when an informant gives accurate or inaccurate information, such as naming a familiar object accurately or inaccurately (Harris, 2007; Mills, 2013). Communicative cues are available when an informant demonstrates a behavioural intention toward other individuals or objects, such as helping someone or reaching a goal (Vanderbilt, Liu, & Heyman, 2011). Lastly, emotional cues are provided when an informant communicates through expressions of potential emotions, such as expressing an emotional reaction to a distressing event (Chiarella & Poulin-Dubois, 2013).

Social learning is influenced by these different cues as they help children infer the reliability and trustworthiness of others (Szcześniak, Colaço, & Rondón, 2012). The majority of the literature on selective social learning based on these cues has been conducted with preschool and school-age children, and shows that as children develop, they acquire the ability to differentiate trustworthy versus untrustworthy sources by becoming more critical of new information (for reviews, see Harris et al., 2018 and Mills, 2013). Research on selective social learning via epistemic cues has shown that 3- and 4- year-olds are more likely to learn a new word from a speaker who previously labeled familiar objects accurately (e.g., labeled a ball

“ball”) than a speaker who labeled them inaccurately (e.g., labeled a ball “shoe”) (Koenig, Clément, & Harris, 2004). Several studies have since replicated the finding that preschoolers prefer to learn a new word from an accurate speaker (e.g., Birch, Vauthier, & Bloom, 2008; Corriveau & Harris, 2009; Jaswal & Neely, 2006; Koenig & Harris, 2005). Moreover, Fitneva and Dunfield (2010) demonstrated that 7-year-olds were more likely to seek information from an informant who provided a correct answer to a question rather than incorrect after one single encounter. They also found that 4-year-olds were able to do this when provided with trait labels (i.e., demonstrated who is not very good at answering). In terms of communicative cues, research suggests that young children prefer to trust an informant who displays benevolent intent in comparison to an informant who displays malevolent intent (Mascaro & Sperber, 2009; Vanderbilt et al., 2011). For example, Mascaro and Sperber (2009) had 3-year-old children observe a puppet that was mean and another puppet that was kind. Both puppets then informed the child about the contents of a box (i.e., what object was inside) and children had to rely on their testimony, as they were not able to see the contents of the box themselves. Results revealed that children were less likely to trust the testimony of the mean puppet, suggesting that they were able to understand and evaluate both puppets’ intention, and use this information to decide whether or not to trust that puppet’s declarations. Thus, the literature demonstrates that children do not trust information from all sources, but rather become doubtful when given information from unreliable and malevolent individuals.

Although most studies have focused on selective social learning in the preschool age period, there is now a growing body of literature reporting evidence of this ability in infancy (see review by Poulin-Dubois & Brosseau-Liard, 2016). Infants have been shown to use a variety of cues in order to assess the reliability of a model, particularly those stemming from the epistemic and emotional domains. In a landmark study by Chow, Poulin-Dubois, and Lewis (2008), 14-month-old infants observed an informant who examined the content of a box that contained a toy while displaying happiness (reliable emoter) or an informant who displayed happiness towards a box that was empty (unreliable emoter). When given access to the box, results demonstrated that infants' latency to examine the content of the box increased across trials, but only in the unreliable condition, suggesting that they were able to detect the informant who was emotionally unreliable. In addition, infants were subsequently less likely to follow the gaze or to imitate novel actions of the unreliable emoter (Chow et al., 2008; Poulin-Dubois, Brooker, & Polonia, 2011). In line with selective trust based on emotional cues, research suggests that 18-month-olds are able to detect an informant who displayed a congruent versus an incongruent emotional response to an event (i.e., expressing sadness following a positive event) (Chiarella & Poulin-Dubois, 2013). Infants are subsequently less likely to trust the emotional signals of the unreliable emoter, as expressed in less willingness to help the emotionally unreliable informant when she expressed distress (Chiarella & Poulin-Dubois, 2018). In addition to emotional cues, evidence of selective social learning in infancy based on epistemic cues (i.e., verbal accuracy) has been reported in the literature (Brooker & Poulin-Dubois, 2013a; Koenig & Woodward, 2010; Krogh-Jespersen & Echols, 2012). For instance, Brooker and Poulin-Dubois (2013a) demonstrated that 18-month-old infants were less likely to learn a new word from an unreliable speaker compared to a reliable one. Moreover, research suggests that infants can use cues of competence (Zmyj, Buttelmann, Carpenter, & Daum, 2010), confidence (Birch, Akmal, & Frampton, 2010; Brosseau-Liard & Poulin-Dubois, 2014), expertise (Stenberg, 2013), familiarity (Buttelmann, Zmyj, Daum, & Carpenter, 2013), and age (Ryalls, Gul, & Ryalls, 2000; Zmyj, Daum, Prinz, Nielsen, & Aschersleben, 2012) to selectively learn from others. Taken together, there is mounting evidence that infants are precocious selective learners who rely on several different cues in order to infer the reliability of others.

The search for cognitive mechanisms

Although the evidence is mounting that both infants and children prefer to learn from reliable informants, researchers have recently debated the psychological mechanisms underlying selective social learning in young children (Heyes, 2017; Poulin-Dubois, 2017; Sabbagh, Koenig, & Kuhlmeier, 2017). The rich view claims that domain-specific, higher-order abilities guide infants' selective social learning, whereas the lean view claims that infants use domain-general, lower-order abilities to selectively learn from others, as do other species that engage in selective learning. This controversy was launched with a provocative paper suggesting that because species such as rats and pigeons also show selective social learning, higher-order cognitive abilities are not required (Heyes, 2017). Instead, infants are argued to use lower-level, domain-general abilities, such as associative learning, to guide their selective behaviour. In contrast, it has been argued that simple cognitive processes cannot account for the findings demonstrating selective social learning in infancy (Poulin-Dubois, 2017). Furthermore, Sobel and Kushnir (2013) argue that older children's own conceptual knowledge permits them to infer the reliability and competence of a model, but that infants may be relying on more basic-level abilities, such as statistical learning. Despite the debate, researchers agree that more research is needed on the psychological mechanisms underlying this ability, particularly in infancy. Therefore, the current study aimed to clarify this debate, as well as contribute research to the large gap in the literature on the mechanisms of infants' selective social learning.

Domain-specific mechanisms

Domain-specific abilities, which are sophisticated, higher-order cognitive functions, are an important aspect of cognitive development (Kail, 2004). According to a domain-specific perspective of learning, individuals develop high-level, independent, specialized skills across typical development (Kail, 2004). In line with this view, it is believed that the mind is compartmentalized or modularized (Fodor, 1983; Spelke, 1990). In other words, an individual's understanding of one concept (i.e., space) tends to differ from their understanding of another concept (i.e., language) (see review by Wellman & Gelman, 1992 on theories of cognitive development). According to Leslie (1994), the core cognitive architecture contains "heterogenous, task-specialized sub-systems".

An example of a domain-specific ability that might be important for selective social learning is theory of mind. This concept can be defined as the ability to understand others' mental states, inferring that they may have different beliefs, intentions, desires, and knowledge (Wellman, 2014). Theory of mind is a key aspect of children's socio-cognitive development, as they would not be able to interpret, predict, and understand other people's behaviour without it (Meltzoff, 1995). Much of the research on children's theory of mind has been on false belief understanding, which refers to the process of recognizing that others may have false or incorrect beliefs (Wimmer & Perner, 1983). A traditional false belief task that exemplifies how theory of mind is studied is the Sally-Anne task (Baron-Cohen, Leslie, & Frith, 1985). In this task, children are told a story in which Sally and Anne are playing together. Sally places her ball in a basket, and then leaves. While Sally is away, Anne moves the ball from the basket to the box. Once Sally returns, children are asked where Sally will look for her ball: in the basket or the box. If children exhibit theory of mind, they will predict that Sally will look for her ball in the basket based on her false belief about its location.

Although the Sally-Anne task was commonly used with preschoolers, there is a large body of research suggesting some form of false belief understanding in infancy using looking time measures and non-verbal interactive tasks (see reviews by Baillargeon, Scott, & He, 2010; Poulin-Dubois, Brooker, & Chow, 2009; and Sodian, 2011). False belief in infancy has been typically demonstrated through violation of expectation and anticipatory looking paradigms, where infants' looking responses are coded (Baillargeon, Scott, & He, 2010; Yott & Poulin-Dubois, 2016). These tasks measure infants' implicit false belief abilities, which refers to their spontaneous ability to reason without explicit awareness (Baillargeon, Scott, & Bian, 2016).

However, the depth of infants' implicit false belief understanding is also the subject of a controversial debate. The rich view proposes that infants develop theory of mind within the second year of life and fail explicit theory of mind tasks due to task demands (e.g., executive function, language), suggesting that there is continuity across implicit and explicit forms of theory of mind (Baillargeon, Scott, & He, 2010; Scott, 2017). According to this perspective, theory of mind is a modularized and innate ability that is specialized in ascribing mental states to others (Leslie, 1994; Scott & Baillargeon, 2009). In contrast, the lean view proposes that infants' looking responses on implicit false belief tasks can be due to a violation of behavioural rules (i.e., looking in the last place they saw the object; Ruffman & Perner, 2005) or low-level novelty (i.e., colours and movements of the object may be novel; Heyes, 2014). In addition, other researchers supporting a lean interpretation have suggested that there are two distinct systems (implicit and explicit) that develop in parallel (Low, Apprely, Butterfill, & Rakoczy, 2016). Lastly, additional evidence supporting a lean interpretation of false belief understanding in infancy stems from a recent "replication crisis" (see Poulin-Dubois et al., 2018). For instance, several studies have not replicated implicit false belief tasks using a wide range of paradigms, such as violation-of-expectation (e.g., Dörrenberg et al., 2018; Powell, Hobbs, Bardis, Carey, & Saxe, 2018; Yott & Poulin-Dubois, 2016), anticipatory looking (e.g., Burnside, Ruel, Azar, & Poulin-Dubois, 2018; Dörrenberg et al., 2018; Grosse Weismann, Friederici, Disla, Steinbeis, & Singer, 2018; Kulke, Reiß, Krist, & Rakoczy, 2018; Kulke, von Duhn, Schneider. & Rakoczy, 2018; Schuwerk, Priewasser, Sodian, & Perner, 2018), and interactive tasks (e.g., Crivello & Poulin-Dubois, 2018). Taken together, false belief understanding in infancy has been largely debated in the literature, and much of the research suggests that it may not be a reliable and robust concept as once previous thought.

In addition to false belief, knowledge inference is another aspect of theory of mind that seems to have its origins in infancy. While it has received less empirical attention than false belief, research has shown that preschoolers and infants can infer an individual's knowledge state (Flavell, 1999; Moll & Tomasello, 2007; Sodian, 1988). Tasks assessing knowledge inference typically require the child to understand that there is a causal association between seeing and knowing (Henning, Spinath, & Aschersleben, 2010). For instance, in a study by Tomasello and Haberl (2003), 12- and 18-month-old infants played with an experimenter with two novel toys, one at a time. The experimenter then left the room, and during her absence, an assistant played with the infant with a third, novel toy. Following this, the experimenter returned to the room, acted excitedly while looking at the three toys, and asked the infant for one of the toys. In order to succeed on the task, the infant had to understand that people are interested in new things and that new things tend to be ones that people have no prior experience with. The results demonstrated that both 12- and 18-month-olds were able to identify the object that the experimenter had not previously experienced, therefore, did not know about. Thus, infants were able to infer that the experimenter was not knowledgeable about the third novel toy.

The precursors to a theory of mind have been proposed as a potential mechanism underlying selective social learning, as children may be able to infer which informant is knowledgeable and which informant is deceptive based on their understanding of others' mental states (Poulin-Dubois & Brosseau- Liard, 2016). In other words, children who have superior theory of mind abilities or a better understanding of others' mental state of knowledge should be more selective in their learning (Brosseau-Liard, Penney, & Poulin-Dubois, 2015). These children may be better able to selectively learn from other individuals, as they can make inferences that the variability in accuracy/reliability of the informant suggests individual differences in knowledge states (Brosseau-Liard et al., 2015).

Several studies have found evidence of a relation between theory of mind abilities and selective social learning in preschool and school age children (Brosseau-Liard et al., 2015; DiYanni & Kelemen, 2008; DiYanni, Nini, Rheel, & Livelli, 2012; Fusaro & Harris, 2008; Lucas, Lewis, Pala, Wong, & Berridge, 2013; Mills & Elashi, 2014). For instance, Brosseau-Liard and colleagues (2015) demonstrated that 3- and 4-year-olds who showed a superior performance on a battery of theory of mind tasks were more selective in their learning when the informants varied on epistemic cues, such as verbal accuracy. However, theory of mind abilities did not predict performance on a second selective social learning task when the informants varied on non-epistemic cues, such as physical strength. As physical strength is not a knowledge-related attribute, the results suggest that children did not consider all attributes of the informants when deciding whether or not they should learn from them (Brosseau-Liard et al., 2015). Although there are several studies demonstrating a link between theory of mind and selective social learning, there are also conflicting findings. For example, in an earlier study, researchers demonstrated that preschoolers who had weaker theory of mind abilities, measured through a false belief task, still performed well on a selective social learning task (Pasquini, Corriveau, Koenig, & Harris, 2007). Therefore, the literature suggests that theory of mind may play a key role in children's ability to selectively learn from others, but that it does not fully predict this ability and there may be other possible mechanisms involved (Brosseau-Liard et al., 2015).

Similar research supporting a rich interpretation of children's selective social learning is research on trait inference. Trait inference can involve theory of mind abilities as one needs to understand an individual's mental state when making a trait ascription of their knowledge. Research has shown that children can make trait inferences from an informant's past behaviour that the informant is a good source of information for a particular task (Hermes, Behne, Bich, Thielert, & Rakoczy, 2017). Thus, when children are exposed to individuals who are experts in different domains, they seek knowledge from those individuals in their respective expertise (Kushnir, Vredenburgh, & Schneider, 2013; Lutz & Keil, 2002; Sobel & Corriveau, 2010). For instance, Hermes, Behne, and Rakoczy (2015) demonstrated that 4- and 5-year-olds preferred a strong model for a strength-related task and an accurate model for a knowledge-related task. In a subsequent study examining negative valence (low-competency), they found that the children avoided the inaccurate model for the knowledge-related task and avoided the weak model for the strength-related task. In both studies, this was only true for the children who correctly identified the traits of both models. Children who did not ascribe the traits correctly did not demonstrate any selectivity in choosing the models. These results suggest that selective social learning is based on rational trait-based reasoning, and not global impression formation (i.e., halo effects) or behaviour matching, which are both lean interpretations of selective social learning. It also provides support for Sobel and Kushnir's (2013) view that rational inference is involved but only when the child has the conceptual background knowledge.

Although no evidence of global impression formulation was found in the aforementioned studies, there is some research demonstrating a “halo” or “pitchfork” effect. For example, research has shown that 5-year-olds demonstrated a halo effect by predicting that an individual who previously labeled objects accurately would have a more prosocial disposition (Brosseau-Liard & Birch, 2010). In addition, a “pitchfork” effect when investigating incompetency rather than competency has been demonstrated in the literature. Specifically, Koenig and Jaswal (2011) found that children were more likely to seek information about dogs, but not artifact labels, from a dog expert over a novice informant. In contrast, children were more likely to seek information about both dogs and artifact labels from a neutral informant over a dog inexpert (i.e., making wrong claims). In other words, children use trait inference when judging the competency of others (positive valence), but they use global formation for the perceived incompetency (negative valence). This contrasts with Hermes and colleagues’ (2015) research as they found that trait inference was involved in children’s selectivity regardless of the valence. Taken together, several studies have shown a rich interpretation of preschoolers’ selective social learning by demonstrating that theory of mind and trait inference are involved. However, no study has yet to examine whether these abilities are related to infants’ selective social learning.

Domain-general mechanisms

Domain-general abilities, which are basic, low-level cognitive functions, are an essential piece of human cognition (Chiappe & MacDonald, 2005). According to a domain-general perspective of learning, individuals develop global processes (i.e., working memory, processing speed) that provide a contribution to cognitive development in numerous domains (Kail, 2004). These various domains are believed to be central aspects of the basic architecture of children’s cognitive systems (Kail, 2004). An example of a domain-general theorist of cognitive development is Piaget. He believed that general stages of cognition (i.e., sensorimotor, preoperational, concrete operational, and formal operational) apply to various domains with different areas of content (Wellman & Gellman, 1992). For instance, concrete-operational thinking is involved in the development of children's comprehension of time, numbers, morality, etc. (Wellman & Gellman, 1992). According to Wellman and Gellman (1992), Piaget's theory on cognitive development is based on "content-free logical structures".

An example of a domain-general ability that might be important for selective social learning is statistical learning. Infants are sensitive to statistical cues and use this ability to detect regularities in their environment (Aslin & Newport, 2012; Denison & Xu, 2014; Ruffman, Taumoepeau, & Perkins, 2012; Saffran, Aslin, & Newport, 1996). Evidence of statistical learning has been found in infants as young as six months old. For instance, Xu and Garcia (2008) demonstrated through a violation of expectation paradigm that 6- to 8-month-old infants looked significantly longer at a violation of random sampling. In addition, 12- to 14-month old infants were able to infer that a preferred object had a higher likelihood to be located in one of two cups (Denison & Xu, 2010). Statistical learning has been proposed to be a mechanism involved in infants' selective social learning (Sobel & Kushnir, 2013). While statistical learning involves extracting patterns of regularity, selective learning involves tracking the informants' past accuracy in order to detect a pattern of reliability to learn from these sources in future interactions. Infants can use statistical reasoning abilities to infer outcomes and this ability may play a crucial role in early social learning. Therefore, young children's ability to track informants' accuracy likely involves statistical learning mechanisms (Sobel & Kushnir, 2013). However, no research to date has investigated a link between statistical learning and selective social learning. Thus, it remains to be seen whether infants' selective social learning is guided by their ability to extract patterns of regularity through statistical cues. As such, one of the goals of the present dissertation was to examine whether there is a link between infants' selective social learning and their statistical learning abilities.

Associative learning, which is among the most basic forms of domain-general abilities, is another type of lower-order cognitive function. This basic cognitive ability can be defined as the process of learning an association between two stimuli (Abramson, 1994). Both humans and different species of animals have been shown to engage in operant conditioning, which is an aspect of associative learning (Domjan, 2006). Operant conditioning occurs when humans and/or animals learn that a response is associated with an effect it produces (e.g., behaviour is repeated when it is rewarded or reinforced) (Domjan, 2015; Rovee-Collier, Hayne, & Colombo, 2000). Skinner demonstrated that rats engage in associative learning by training them to press a lever to be rewarded with food (Domjan, 2015). Evidence of operant conditioning has also been found in infancy. For instance, research has shown that infants as young as 2 months of age can learn that kicking produces movement of a mobile above their head (Rovee-Collier et al., 2000). This response produces the movement of the mobile via a ribbon that is tied to their ankle and connected to the mobile (Rovee-Collier et al., 2000).

Heyes (2017) has argued that selective social learning in infancy can be explained by associative learning mechanisms through action-outcome relationships and learned predictiveness (Mitchell & Le Pelley, 2010). Learned predictiveness can be defined as the understanding that a particular stimulus is consistently followed by a particular outcome (Mitchell & Le Pelley, 2010). This, in turn, influences how much attention is paid to a stimulus (Le Pelley, Vadillo, & Luque, 2013; Kruschke, 2003). An attentional bias is created, as one pays more attention to a stimulus that has a higher predictability than a lower predictability (Le Pelley,Vadillo, & Luque, 2013; Kruschke, 2003).

For example, in the study by Brooker and Poulin-Dubois (2013a) where they examined infants' word learning, infants preferred to learn a new word from a reliable speaker in comparison to an unreliable one. The rich, domain-specific interpretation of this finding is that infants may have inferred that the reliable speaker was more knowledgeable, and therefore, were more likely to learn from her. From a domain-general viewpoint, however, when infants hear a word that does not predict the object they were expecting to see based on their past associations and experiences, they consider the informant odd (Heyes, 2017). Thus, they pay less attention to the subsequent vocalizations of the unreliable informant and are less likely to learn a new word from them. In other words, cues that have consistently predicted outcomes in the past will be paid attention to more in the future and will be more likely learned from compared to those that have been less predictive. This lean interpretation contrasts with the rich interpretation in requiring no higher-order, sophisticated abilities. According to this view, infants do not necessarily understand that an individual who demonstrates greater accuracy is reliable, knowledgeable, or trustworthy. For example, it has been argued that domain-specific abilities may play a role in children's selective social learning starting only at the age of 4-5 years, as domain-specific skills are developed through language and theory of mind (Heyes, 2017). To our knowledge, although the lean view of the debate strongly argues that associative learning is a mechanism of selective social learning in infancy, no study has ever examined this possible link. Therefore, another goal of the present dissertation was to examine this potential link in infancy.

Rationale of the dissertation

As the psychological mechanisms of selective social learning are currently unclear and have been the topic of a heated debate, the purpose of this dissertation was to better understand the nature of this ability in infancy. Therefore, the objective of my dissertation was to determine whether domain-specific (i.e., theory of mind) and/or domain-general (i.e., statistical learning, associative learning) skills play a role in this ability. A secondary objective was to explore a possible developmental trajectory in the mechanisms underlying selective social learning from 14-months to 18-months of age; that is, examining the continuity of these mechanisms across development.

The objective of Study 1 was to determine whether domain-general abilities, such as statistical learning, or domain-specific abilities, such as theory of mind, underlie selective social learning in 18-month-olds. Infants were exposed to an experimenter labeling familiar objects accurately or inaccurately, followed by a word learning task. Replicating previous studies, it was hypothesized that infants would be less likely to learn a new a word from an unreliable speaker compared to a reliable speaker. Moreover, in order to investigate potential mechanisms of selective social learning, infants' false belief understanding, knowledge inference, and statistical learning abilities were examined. It was predicted that, if domain-general abilities are related to the first manifestation of selective social learning, then infants who show superior performance on the statistical learning task should be less likely to learn a new word from an unreliable speaker. In contrast, if domain-specific abilities are already related to selective social learning, then infants who show superior performance on the theory of mind tasks should be less likely to learn a new word from an unreliable speaker. In addition, no relation was expected in the reliable condition, as infants have demonstrated that they can learn new words even without any information about the competence of the speaker.

The objective of Study 2 was to examine whether the findings of Study 1 could be extended to a younger age group by looking at the most basic cognitive ability among domain-general mechanisms – associative learning. By investigating associative learning mechanisms, we are closer at examining whether there is support for the lean interpretation that these basic level abilities that other species engage in are responsible for infants' selective social learning. An additional objective was to examine whether younger infants' selective social learning was linked to implicit theory of mind abilities. In order to test these research questions, 14-month-old infants were exposed to an experimenter who was emotionally congruent or incongruent. This was followed by a selective trust task, where infants were given the opportunity to follow the gaze of the experimenter behind a barrier. As infants were not able to see what the experimenter is looking at behind the barrier, they need to rely on their past experience with the experimenter in order to determine if they should trust her and follow her gaze. Accordingly, it was hypothesized that infants would be less likely to follow the gaze of an incongruent emoter compared to a congruent emoter. Furthermore, in order to investigate potential mechanisms underlying 14-month-olds' selective social learning, knowledge inference and associative learning abilities were examined. In contrast to Study 1, it was hypothesized that domain-general abilities are linked to selective social learning in 14-month-olds due to their young age. In other words, infants in the incongruent condition who show superior performance on the associative learning task should demonstrate more selectivity. In addition, we hypothesized that there would be no relation between theory of mind abilities and infants' selective social learning due their limited sophisticated socio-cognitive skills. Thus, it may be that as infants were younger, these basic-level abilities guide their selective social learning, but as children develop, their understanding of others' mental states plays a more important role to selectively learn from others.

Lastly, the objective of Study 3 was to further explore the nature of selective social learning by examining whether associative learning and/or theory of mind abilities are related to infants' selective word learning in 18-month-olds. However, in this study, two important methodological differences were observed. Firstly, infants' selective social learning was measured through a within-subjects design, which provides a more conservative test of infants' selective behaviour. This manipulation is limited in infancy, as the majority of studies investigating infants' selective social learning have used a between-subjects design. Thus, infants observed two speakers label familiar objects, one who labeled them accurately and another one who labeled them inaccurately. It was expected that infants would be more likely to learn a new word from a reliable speaker than an unreliable one. Secondly, in contrast to the first and second studies, different tasks assessing theory of mind were used in order to extend previous research and provide additional data relevant to the rich versus lean debate in the field. Based on previous studies, a relation between infants' selective word learning and their knowledge inference abilities was expected, but not their associative learning skills.

In summary, the present series of three studies were designed in order to better understand the nature and depth of infants' selective social learning by investigating whether domain-specific or domain-general abilities are related to this ability. Although much of the literature has focused on *when* infants develop selective social learning and *what* cues they use, this dissertation was designed to address, at least in part, the equally important research question of *how* infants selectively learn from others.

Chapter 2

Selective social learning in infancy: Looking for mechanisms

Selective social learning in infancy: Looking for mechanisms

Young children acquire new information mainly by interacting with and observing others (Box, 1984). This is known as social learning. Social learning is crucial for children, but it can also be risky as not all informants have accurate knowledge or good intentions (Poulin-Dubois & Brosseau-Liard, 2016). Because children frequently rely on information provided by other individuals, they need to be able to select informants who are accurate (Koenig & Sabbagh, 2013). The last decade has revealed that children engage in selective social learning, where they can differentiate unreliable and reliable sources of information, and thus select whom to trust and learn from (Koenig & Harris, 2005; Koenig & Sabbagh, 2013; Mills, 2013; Nurmsoo, Robinson, & Butterfill, 2010). In a landmark study, Koenig, Clément, and Harris (2004) presented 3- and 4-year-olds with an informant who labeled familiar objects accurately and an informant who labeled the same objects inaccurately (e.g., a ball was labeled a shoe). Results revealed that 3- and 4-year-olds preferred to learn a new word from the reliable speaker compared to the unreliable one.

While the bulk of the research on selective learning from testimony has been conducted with preschool-age children, there is now mounting evidence that it begins very early in development (see Poulin-Dubois & Brosseau-Liard, 2016, for a review). In a pioneering study, Chow, Poulin-Dubois, and Lewis (2008) presented 14-month-olds with an informant who looked inside a box containing a toy while expressing a positive emotion (reliable emoter) or an informant who demonstrated the same positive emotion towards an empty container (unreliable emoter). Results revealed that infants were able to detect the unreliable emoter, as shown by their increased latency to inspect the content of the box over trials. More importantly, they were less likely than the infants in the reliable emoter condition to subsequently follow the person's eye gaze in another context. Similarly, research has shown that infants are less likely to imitate the novel actions of an informant who displays unreliable emotional cues (Poulin-Dubois, Brooker, & Polonia, 2011). In line with this research, 18-month-olds have been found to differentiate congruent and incongruent emotional reactions to events such as losing an object and are more willing to help and be guided by the emotional expressions of a reliable informant who previously displayed congruent emotional reactions (Chiarella & Poulin-Dubois, 2013, 2018). In addition to emotional cues, infants have also been shown to rely on the conventionality (Zmyj, Buttelmann, Carpenter, & Daum, 2010) as well as the confidence (Birch, Akmal, & Frampton, 2010; Brosseau-Liard & Poulin-Dubois, 2014) conveyed by the informant. Furthermore, studies have revealed that infants, like older children, use accuracy to determine whom to learn from, which is an epistemic, or knowledge-related cue (Brooker & Poulin-Dubois, 2013a; Koenig & Woodward, 2010; Mills, 2013). For example, 18-month-old infants are more likely to learn a new word or a new action from a reliable speaker compared to an unreliable one (Brooker & Poulin-Dubois, 2013a).

Although the evidence is well established that children prefer to learn from reliable sources of information, the psychological mechanisms underlying this ability are unclear and have recently been the topic of hot debate, particularly in interpreting infants' behaviours (Heyes, 2017; Poulin-Dubois, 2017; Sobel & Kushnir, 2013). According to one view, infants possess domain-specific, higher-order, cognitive abilities that allow them to selectively learn from others, whereas an alternative "leaner" interpretation posits that infants rely on more domain-general, lower-order, cognitive functions. In a recent provocative paper, Heyes (2017) has argued that given that selective learning occurs in animals which do not possess higher cognitive functions, such as theory of mind, cognitive sophisticated abilities are unnecessary to account for infants' selective behaviours. Instead, simple domain-general mechanisms, such as associative learning, might be sufficient (Heyes, 2017). It is only in adults and older children that social learning strategies can be explained by domain-specific processes, such as metacognition, learned through experience in social interactions (Heyes, 2016).

In terms of domain-specific abilities, theory of mind has been proposed to account for how young children selectively learn from others. Theory of mind is defined as the ability to understand that others possess mental states, such as beliefs, knowledge, intentions, and desires (Wellman, 2014). A relation between these two abilities has been put forward as children can make inferences based on others' mental states when deciding who is informative and who is deceptive. Thus, children who have a greater understanding of individuals' mental state of knowledge should be better able to selectively learn from others, since they can infer that the variability in accuracy reflects individual variation in knowledge (Brosseau-Liard, Penney, & Poulin-Dubois, 2015). In fact, such a link has been documented in numerous studies that have focused on preschool and school age children (Brosseau-Liard et al., 2015; DiYanni & Kelemen, 2008; DiYanni, Nini, Rheel, & Livelli, 2012; Fusaro & Harris, 2008; Lucas, Lewis, Pala, Wong, & Berridge, 2013; Mills & Elashi, 2014). For example, in a recent study, 3- and 4-year-olds with superior theory of mind abilities performed better on a selective word learning task when the two informants differed on epistemic cues, such as verbal accuracy (Brosseau-Liard et al., 2015). Conversely, there was no such association with another selective learning task when the two informants differed on non-epistemic cues, such as physical strength. According to Brosseau-Liard and colleagues (2015), theory of mind should not be related to performance on a selective learning task involving physical strength, as it is not a knowledge-related attribute. Thus, 3- and 4-year-olds' theory of mind abilities did not lead them to selectively learn from informants by considering all of their attributes, but it was specific to informants who displayed knowledge-related cues. Although there is evidence of a relation between theory of mind and selective learning, the results are mixed. For example, in a study by Pasquini, Corriveau, Koenig, and Harris (2007), it was revealed that 3- and 4-year-olds who performed poorly on a false belief task were still able to perform well on a selective learning task. As such, the relation between theory of mind and selective learning is controversial and needs further research. In addition, this link has never been explored in infancy.

With regard to domain-general abilities, statistical learning has been proposed as a mechanism underlying selective social learning. Statistical learning is a rapid and robust ability by which infants use statistical cues to identify regularities in their environment (Aslin & Newport, 2012; Denison & Xu, 2014; Ruffman, Taumoepeau, & Perkins, 2012; Saffran, Aslin, & Newport, 1996). For instance, in a violation of expectation paradigm, 6- to 8-month old infants looked significantly longer at a violation of random sampling (Xu & Garcia, 2008). It has also been demonstrated that 12- to 14-month-old infants are able to detect that an object has a higher probability of being found in one of two cups presented to them (Denison & Xu, 2010). More importantly, research suggests that there are individual differences in statistical learning in both infancy and childhood (Arciuli & Simpson, 2011; Ellis, Robledo, & Deák, 2014; Kaufman et al., 2010; Kidd, 2012; Kidd & Arciuli, 2016; Shafto, Conway, Field, & Houston, 2012). For instance, a recent study demonstrated that individual differences in statistical learning are associated with 6- to 8-year-olds' comprehension of syntax (Kidd & Arciuli, 2016). According to Sobel and Kushnir (2013), these individual differences in statistical learning abilities may be related to infants' selective social learning (Sobel & Kushnir, 2013). Just as statistical learning involves detecting patterns of regularity, selective social learning involves detecting patterns of reliability by keeping track of the informant's prior accuracy in deciding whether to learn from them (Sobel & Kushnir, 2013). Therefore, infants may be relying on statistical cues when tracking the accuracy of the informant and inferring conclusions based on their history (Sobel & Kushnir, 2013; Tummeltshammer, Wu, Sobel, & Kirkham, 2014).

Taken together, the nature of the psychological mechanisms underlying early selective social learning is currently a controversial issue with little empirical evidence available to settle the debate. Although theory of mind and statistical learning have both been proposed as potential correlates, no study has ever pitted these abilities against one another when investigating individual differences in selective learning. Therefore, the main purpose of the present study was to provide a better understanding of the nature of selective social learning by investigating whether theory of mind and statistical learning skills play a role in this ability. Infants observed a speaker label familiar objects either accurately or inaccurately and were then provided the opportunity to learn a new word from this speaker. In line with prior research, we hypothesized that infants would be more likely to learn a new word from a reliable speaker than an unreliable one. Two theory of mind tasks and a statistical learning task were also administered to investigate whether these abilities are related to infants' performance on the selective word learning task. If domain-general abilities are associated with selective social learning, then infants who performed better on the statistical learning task should be less likely to learn a new word from an unreliable speaker. Those with larger vocabularies might also be less likely to learn from an unreliable speaker if general abilities, such as verbal IQ, account for such selectivity. In contrast, if domain-specific abilities are associated with selective social learning, then superior performance on the theory of mind tasks should be associated with less willingness to learn from an unreliable speaker. No such links would be expected with performance in the reliable condition, as infants have been shown to learn new words even without any information about the competence of the speaker.

Method

Participants

The final sample consisted of 77 18-month-old infants (M_{age} = 18.54 months, *SD* = .50; range = 17.4–20; 39 males, 38 females). Infants were excluded from the sample if they did not meet a number of task-specific criteria (see details below). Participants were recruited from birth lists provided by a governmental health agency. All infants had no auditory or visual impairments and were exposed to English or French.

Measures and Materials

MacArthur-Bates Communicative Development Inventories: Short Form (MCDI-I). The American-English and the French-Canadian adaptation of the MCDI-I were used to assess infants' total productive and receptive vocabulary (Fenson et al., 2000; Trudeau, Frank, & Poulin-Dubois, 1999). This vocabulary checklist, used for children aged 8-18 months, was completed by the child's primary caregiver. The MCDI-I consists of 89 vocabulary items and includes nouns, verbs, and adjectives that infants would have learned in this age range.

Word comprehension checklist. Parents were asked to indicate, on a 20-word checklist, which words their infant understood (Brooker & Poulin-Dubois, 2013a). The checklist consisted of typical words infants of this age would understand. This report was used for the selective social learning task in order to select words that a given child was familiar with.

Selective social learning. There were two phases in the task measuring selective social learning, where infants were presented with labels for both familiar and novel objects (Brooker & Poulin-Dubois, 2013a).

Reliability phase. Participants were randomly assigned to either a reliable (n = 33) or an unreliable (n = 44) condition. Four small plastic objects were labeled either correctly or incorrectly, depending on the condition. The four items were chosen from a set of words including *ball, banana, bird, dog, spoon, chair, and shoe*. The specific words tested depended on the child's knowledge of these words as reported on the word comprehension checklist. Children were required to know three out of the four chosen objects in order to be included in this task (Brooker & Poulin-Dubois, 2013a). In phase 1, the child was allowed 15 s to explore each object. In phase 2, the experimenter manipulated each object, one at a time, and labeled it three times either correctly (reliable speaker) or incorrectly (unreliable speaker). The objects were always given the same incorrect labels. For example, in the unreliable condition, infants watched as the experimenter pointed to a shoe and said, "That's a *bottle.* See, it's a *bottle.* Look at the *bottle",* if their parents had indicated that they understood the word *shoe* and thus could recognize that it had been mislabeled (Brooker & Poulin-Dubois, 2013a). Once the experimenter was finished labeling the object, the child was allowed to play with the toy again for 15 s.

Word learning phase. This task assessed infants' willingness to learn from the experimenter based on her accuracy during the reliability phase (adapted from Baldwin, 1993). This task included three phases: a warm-up phase, a training phase, and a test phase. In the warm-up phase, the experimenter presented the infant with a tray holding a pair of familiar objects (two objects not previously used in the reliability phase) and requested one. This phase was included for the purpose of making sure the infant understood the demands of the task (Brooker & Poulin-Dubois, 2013a). In the training phase, the experimenter modeled the function of a pair of novel toys. For instance, a wooden nut and bolt was spun, and a type of rattle was shaken. Both objects were then given to the child to explore for 15 s. The experimenter then retrieved one of the novel objects from the child and provided a novel label for it by saying, "It's a *Dax"*. The same novel object was labeled four times with the same label. In the test phase, the experimenter presented the child with one of two pairs of objects on a tray: two familiar objects or two novel objects. The same object pairs were used across all trials. The experimenter requested one of the two objects from the infant by saying, "Where is X? Give me the X". The novel object that was requested was always the one that the experimenter had provided a novel label for in the training phase. Four familiar trials were alternated with four novel trials, for a total of eight trials. The novel object chosen, the location of the objects on the tray (left or right), and the type of trial (familiar or novel) that was presented first, was counterbalanced across participants. During the test phase, the object that the infant selected and gave to the experimenter was coded. If both toys were given simultaneously, the trial was repeated. This task yielded two scores measuring the proportion of trials (out of four) where infants offered the correct object; one for novel words and one for familiar words. A Pearson product-moment correlation was computed to assess inter-rater reliability and revealed perfect agreement among raters ($r(38) = 1.00$).

False belief Theory of Mind task. An interactive false belief task was used to examine infants' theory of mind abilities by assessing their understanding that others may have different beliefs (Buttelmann, Carpenter, & Tomasello, 2009). In this task, one experimenter (E1) announced that she was going to get a toy. While E1 was away, the other experimenter (E2) showed the infant how to lock and unlock a set of 30 x 30 x 30 cm green and orange boxes with wooden pins, which were positioned at the furthest end of a table. E1 returned to the room with a toy caterpillar and told the infant that she was putting her toy in one of the boxes, while placing the toy inside as the child watched. E1 then said that she forgot her keys outside and left the room again. Following this, E2 invited the infant to play a trick on E1 by switching the location of the toy to the other box. When E1 returned, she tried to open the box in which she placed her toy, and displayed disappointment and confusion as she realized that she was not able to open it. At this point, E2 pushed the boxes closer to the infant in order to allow the infant to touch and open one of the boxes. The infant was then prompted to help E1 find the toy in the correct box. This task assessed infants' ability to understand that E1 may hold a different belief of where the hidden toy was located. The trial was coded as pass or fail, where a pass was given to the child for choosing the box where the toy was currently located, demonstrating understanding of the experimenter's false-belief. A Cohen's Kappa coefficient was computed as $\kappa = 1.00$, which is indicative of a perfect degree of consistency across independent raters.

Knowledge Theory of Mind task. A second theory of mind task was used to assess knowledge inference (Moll & Tomasello, 2007). This task measured infants' understanding that others may have knowledge that differs from their own and can make inferences based on this assumption. In a familiarization trial, two experimenters and the infant played with three familiar objects (i.e., a ball, a teddy bear, and a car) for 50 s. In a pre-test trial, E1 requested each of these toys, one at a time, in order to make sure that the infant was comfortable sharing with the experimenter. In order to pass the pre-test, infants were required to give the experimenter one of the first two objects requested. E1 then expressed*,* "I'm going over there", while the infant watched her walk to the other end of the room and sit on a chair. E2 retrieved a novel toy (i.e., a plastic gardening tool) and brought it to E1 to play with for 30 s, as the infant watched. E2 then retrieved the toy from E1 and brought it back to the table for the infant to play with for 30 s. This process was repeated for a second novel toy (i.e., a modified bird-cage mirror). After playing with the second toy, E2 placed it on the tray next to the first novel object as E1 announced that she was leaving the room. E2 then introduced a third novel object to the infant and added it to the tray (i.e., a small modified abacus). The third novel object served as the target object. When E1 returned to the room, she had a look of surprise on her face and exclaimed "Oh, look! Look there! Look at that there! Can you give it to me please?", while pointing towards the tray with her arm. This task was coded on a pass or fail basis, where a pass reflected the child giving the target object to E1. This task reflected infants' ability to understand that E1 was acting surprised toward a new toy that was not there before she had left the room and was therefore not knowledgeable about this toy. The target toy, the order in which the toys were introduced, as well as the placement order on the tray were counterbalanced. A Cohen's Kappa was computed as $\kappa = .88$, indicating excellent inter-rater agreement.

Statistical learning task. This task assessed infants' ability to make statistical inferences, while detecting patterns in others' behaviour. In this task, adapted from Kushnir, Xu, and Wellman (2010), the child was first introduced to two types of small objects (i.e., mini frogs and ducks or cows and pigs) and had two minutes to explore them with the experimenter. The infant, experimenter, and a confederate then engaged in a turn-taking game with some objects (i.e., a toy car, a cup, and a ball) in order to allow the child to become comfortable with sharing. After the game, the confederate left the room. The experimenter then showed the infant a clear box containing two of the animals they had been exposed to and labeled the two types of animals inside. The box always had a ratio of 7:31 animals, where one animal served as the minority and the other animal served as the majority. For instance, if the box contained 7 ducks and 31 frogs, the minority animal was the duck and the majority animal was the frog. In the next phase, the confederate sampled five of the same type of object from the box (i.e., 5 ducks or 5 frogs), while labeling the toy (e.g., "Wow frogs! Ribbit, ribbit!"). This served as the target object, while the remaining animals were considered the alternative objects. The confederate then left the room and the experimenter removed the box and put two bowls containing each toy in front of the infant. The confederate re-entered the room and exclaimed, “Oh goody! Just what I wanted! Can you give me one?” where the infant was then required to give a toy animal to the confederate. Each infant participated in this task twice, with the confederate sampling the majority animal on one trial and the minority animal on the other trial. For this reason, two sets of animals were used (i.e., cows and pigs in the other trial). On a minority trial (i.e., 7 ducks and 31 frogs), pulling out all ducks violated random sampling. Therefore, the child should use statistical reasoning to infer that the experimenter has a preference for this toy. On a majority trial (i.e., 31 cows and 7 pigs), pulling out all cows would not violate random sampling. This task was coded on a pass or fail basis. In order to replicate Kushnir and colleagues (2010), an infant passed when he or she gave the target toy on the minority trial. Since on the majority trial the confederate’s selection was due to random sampling, it was expected that infants would randomly select the object to offer the confederate, and therefore passed this trial regardless of their selection. The minority and majority animal, the trial order, and the placement of the bowls (left or right) were counterbalanced. A Cohen’s Kappa was computed as $\kappa = 1.00$, which is indicative of perfect inter-rater agreement.

Procedure

A warm-up phase was first conducted, during which infants familiarized themselves with the environment and the experimenters. During this time, the caregiver filled out the MCDI-I and the word comprehension checklist in order to establish the words that would be used on the selective social learning task. The testing session began with the selective social learning task, where each child was randomly assigned to either the unreliable or the reliable condition. The infant then participated in the theory of mind tasks (false-belief and knowledge) and the statistical learning task, where the order of these tasks was counterbalanced. The selective learning task was always administered first because this task served as the basis for the study and it was crucial to avoid a fatigue effect with this key task. In total, there were three experimenters. The experimenter who conducted the selective learning task did not carry out the other tasks to avoid carry-over effects from the word learning manipulation. Parents received $20 as financial compensation, and infants received a certificate of merit as well as a small gift.

Results

Participants excluded from the selective learning task were also excluded from all additional analyses in the present study. This decision was justified by the fact that performance on the selective learning task was required to test all hypotheses. Accordingly, in addition to the final sample of 77 infants, an additional 32 infants were tested but were excluded due to fussiness (n = 17), parental interference (n = 4), experimenter error (n = 2), not having enough words in their vocabulary to participate in the selective learning task (n = 6), a side preference on the word learning task (n = 1), or giving all ambiguous responses (touching and offering both toys or none) on the word learning task (n = 2).

Comparisons were made between the two conditions to ensure that both groups were equivalent on a number of factors. There were no significant differences between the two conditions with regard to age, $t(75) = -.47$, p = .64, or gender, $\chi^2(1) = .11$, $p = .74$. No significant differences were also observed in infants' receptive vocabulary across the reliable (M = 55.09, SD = 23.85) and unreliable conditions (M = 48.73, SD = 18.53), $t(75) = -1.32$, $p = .19$, Cohen's d = .31, or in infants' expressive vocabulary across the reliable (M = 19.27, SD = 18.11) and unreliable conditions (M = 17.93, SD = 16.33), $t(75) = -.34$, $p = .74$, Cohen's d = .08.

Furthermore, infants did not differ with regard to the number of familiar words they knew in the reliability phase of the selective social learning task across the reliable (M = 3.85, SD = .36) and unreliable (M = 3.86, SD = .35) conditions, $t(75) = .19$, $p = .85$, Cohen's d = -.03.

Selective Social Learning Task

Infants' behaviours and looking time in seconds were coded during the reliability phase to ensure that infants in each group were equally attentive when the experimenter was labelling the objects and to the toy that they were given to engage with during the training phase. Six participants were excluded from the analyses on looking time, as their eyes were not in clear view to be coded. Results indicated that infants' proportion of looking time to the experimenter as she was labeling the toys during phase 2 of the reliability task was equivalent across conditions (unreliable: M = .94, SD = .11; reliable: M = .96, SD = .07), $t(69) = -.68$, $p = .50$, Cohen's d = -.21. These results suggest that infants were equally attentive when the experimenter was labeling the familiar objects accurately or inaccurately. Furthermore, a condition (reliable/unreliable) by looking area (experimenter/toy/parent) mixed ANOVA was computed with infants' proportion of looking time during phase 3 of the reliability task (once the infant was given the toy) as the dependent variable. No main effect of condition, $F(1, 69) = .10$, $p = .75$, $\eta_p^2 = .001$, nor significant interaction, $F(2, 68) = 1.78$, $p = .18$, $\eta_p^2 = .05$, was found. However, a significant main effect of looking area was revealed, $F(2, 68) = 215.63$, $p < .001$, $\eta_p^2 = .67$, indicating that infants' proportion of looking time at the toy (M = .46, SD = .15) was significantly greater than their looking time at the experimenter (M = .29, SD = .13) or at their parent (M = .07, SD = .07). Thus, infants were also equally likely to engage with the toy, irrespective of whether the experimenter's label was accurate or not. During the word learning task, the proportion of time spent looking at the experimenter as she labeled the novel object was coded. Results revealed that infants in the unreliable condition (M = .69, SD = .20) and reliable condition (M = .76, SD = .18) looked equally long at the experimenter during the labeling, $t(69)$ = -1.49, p = .14, Cohen's d = -.37. In addition, there was no significant difference in the proportion of trials (out of four) that infants disengaged from their toy to attend to the experimenter's toy during the labelling phase between the reliable (M = .81, SD = .24) and unreliable (M = .84, SD = .24) conditions, $t(75)$ = .49, p = .63, Cohen's d = -.13. These findings suggest that infants across both conditions were equally attentive as the experimenter labelled the novel object.

In order to determine whether infants in the unreliable condition were less likely to learn a new word in comparison to infants in the reliable condition, a condition (reliable/unreliable) by trial type (novel/familiar) mixed ANOVA was conducted. The dependent variable was the proportion of trials where infants offered the target object. A significant main effect of trial type was found, wherein infants performed significantly better on the familiar trials (M = .66, SD = .32) than on the novel trials (M = .54, SD = .31), $F(1,75) = 6.33$, p = .01, $\eta_p^2 = .08$. In addition, a significant main effect of condition was observed, revealing that infants in the reliable condition (M = .66, SD = .34) outperformed infants in the unreliable condition across trial types (M = .54, SD = .30), $F(1,75) = 5.69$, p = .02, $\eta_p^2 = .07$. However, no significant interaction was found between condition and trial type, $F(1,75) = .86$, p = .36, $\eta_p^2 = .01$. Nevertheless, in support of our hypothesis, planned comparisons revealed that there was a significant difference in word learning on the novel trials between infants in the unreliable and reliable conditions, $F(1,75)$ = 5.89, p = .02, $\eta_p^2 = .07$. In contrast, on the familiar trials, no significant difference was found between the unreliable and reliable conditions, $F(1,75) = 1.23$, p = .27, $\eta_p^2 = .02$ (see Figure 1).

Furthermore, using one-sample t-tests, the proportion of correct offers on the novel and familiar trials were compared to chance (.50). On the familiar trials, infants in both the reliable (M = .70, SD = .29), $t(32) = 3.88$, $p < .001$, Cohen's d = .68, and unreliable conditions, (M = .62, SD = .33), $t(43) = 2.38$, $p = .02$, Cohen's d = .36, performed significantly above chance. In contrast, on the novel trials, infants in the reliable condition performed above chance (M = .62, SD = .27), $t(32) = 2.62$, $p = .01$, Cohen's d = .46, whereas infants in the unreliable condition performed at chance on the novel word trials (M = .45, SD = .33), $t(43) = -.96$, $p = .34$, Cohen's d = -.15.

Correlates of Selective Social Learning

In order to investigate whether domain-specific or domain-general abilities are related to selective social learning, a condition (reliable/unreliable) by score (pass/fail) ANOVA was conducted for each of the three tasks assessing the potential correlates of selective learning: false belief, knowledge, and statistical learning. The dependent variable for each ANOVA was the proportion of novel word trials where infants offered the target object on the word learning task. Pearson correlations were also computed between the MCDI scores and performance on the word learning task in order to determine whether infants' vocabulary size was related to their ability to selectively learn new words from others.

False Belief Task. One additional participant was excluded on the false belief task due to inattentiveness. Descriptive statistics indicated that on this task, 51% of the 76 infants touched the correct box. A binomial test revealed that infants did not perform significantly above chance (.50) ($p = .91$). A condition (reliable/unreliable) by false belief task score (pass/fail) ANOVA with infants' performance on the novel trials of the word learning task as the dependent variable revealed a non-significant interaction $F(1,72) = .84$, $p = .36$, $\eta_p^2 = .01$. Planned comparisons indicated that for infants in the unreliable condition, performance on the novel trials of the word learning task did not significantly differ as a function of whether the infant passed (*n* = 22, *M* = .40, *SD* = .28) or failed (*n* = 21, *M* = .53, *SD* = .35) the false belief task, $F(1,72) = 2.17$, $p = .15$, $\eta_p^2 = .03$, although results were in the expected direction (see Figure 2). Similar results were obtained in the reliable condition. No significant difference was found in the proportion of correct choices on the novel trials between infants who passed (*n* = 17, *M* = .62, *SD* = .25) or failed (*n* = 16, *M* = .63, *SD* = .29) the false belief task, $F(1,72) = .01$, $p = .94$, $\eta_p^2 = .00$.

Knowledge Task. Sixteen additional participants were excluded on the knowledge task due to failure of the pre-test (*n* = 8), fussiness (*n* = 5), and experimenter error (*n* = 3). Descriptive statistics indicated that on this task, 46% of the 61 infants touched the target object. Using a binomial test, it was found that infants performed at a level above chance (.33) ($p = .04$). A condition (reliable/unreliable) by knowledge task score (pass/fail) ANOVA with infants' performance on the novel trials of the word learning task as the dependent variable yielded a statistically significant interaction, $F(1,57) = 4.36$, $p = .04$, $\eta_p^2 = .07$. Planned comparisons revealed that for infants in the unreliable condition, there was a significant difference in the proportion of correct responses on the novel trials of the word learning task between infants who passed (*n* = 13, *M* = .35, *SD* = .32) and failed the knowledge task (*n* = 20, *M* = .58, *SD* = .29), $F(1,57) = 4.87$, $p = .03$, $\eta_p^2 = .08$ (see Figure 2). This suggests that infants who passed the knowledge task were significantly less likely to learn a novel word from an unreliable speaker. As expected, this was not the case in the reliable condition, where infants who passed (*n* = 15, *M* = .68, *SD* = .26) and failed (*n* = 13, *M* = .60, *SD* = .30) the knowledge task performed equally on the selective social learning task, $F(1,57) = .63$, $p = .43$, $\eta_p^2 = .01$.

Statistical Learning Task. Five additional participants were excluded on the statistical learning task due to fussiness (*n* = 4), and parental interference (*n* = 1). Descriptive statistics indicated that on this task, 49% of the 72 infants passed by touching the target object on the minority trial. As expected, the results of this task demonstrated that infants were significantly more likely to touch the target object on the minority trial and were more likely to touch the alternative or both objects on the majority trial, $\chi^2 = 6.85$, $p = .03$ (see Table 1). A condition (reliable/unreliable) by statistical learning task score (pass/fail) ANOVA with infants' performance on the novel trials of the word learning task as the dependent variable yielded a non-significant interaction, $F(1,68) = .001$, $p = .98$, $\eta_p^2 = .00$. Planned comparisons revealed that there was no statistically significant difference between infants who passed ($n = 18$, $M = .54$, $SD = .28$) or failed ($n = 23$, $M = .41$, $SD = .35$) the statistical learning task in terms of their performance on the novel trials of the word learning task in the unreliable condition, $F(1,68) = 1.73$, $p = .19$, $\eta_p^2 = .03$ (see Figure 2). Similarly, in the reliable condition, infants who passed the statistical learning task ($n = 17$, $M = .69$, $SD = .29$) were as likely to offer the correct object on the novel word trials as infants who failed the statistical learning task ($n = 14$, $M = .57$, $SD = .23$), $F(1,68) = 1.22$, $p = .27$, $\eta_p^2 = .02$.

MCDI. No statistically significant correlation was found between infants' receptive vocabulary measured through the MCDI and their performance on the word learning task in the unreliable, $r(42) = .12$, $p = .43$, or reliable condition, $r(31) = .17$, $p = .33$. The correlation was also not significant when examining the relation between infants' expressive vocabulary measured through the MCDI and their performance on the word learning task in the unreliable, $r(42) = .17$, $p = .26$, or reliable condition, $r(31) = .17$, $p = .35$.

Discussion

The goal of the present study was to examine the contribution of domain-general and domain-specific correlates to selective social learning in infancy. Specifically, it was designed to contribute to the current debate regarding a rich versus lean interpretation of selective social learning (Heyes, 2017; Poulin-Dubois, 2017 Sobel & Kushnir, 2013). One side of the debate posits that higher-order, domain-specific functions, such as theory of mind, are fundamental to young children's ability to selectively learn from others. It is argued that children who show a greater understanding of others' behaviour should be more selective in their learning (Brosseau-Liard et al., 2015; Poulin-Dubois & Brosseau-Liard, 2016). The other side of the debate posits that lower-order, domain-general abilities, such as associative or statistical learning, influence selective social learning. According to Heyes (2017), the selective learning observed in infancy does not require any cognitive sophisticated skills, as a wide range of animals display this ability as well. In addition, Sobel and Kushnir (2013) suggested that infants' selective learning might depend on their ability to detect statistical cues. The present study found preliminary support for a rich interpretation, as the only link observed is between performance on the selective social learning and a theory of mind task.

The present contribution to the debate was to investigate the relation between infants' performance on theory of mind and statistical learning tasks and their ability to learn from an unreliable or reliable informant. Specifically, 18-month-olds participated in a word learning task following exposure to a competent or an incompetent speaker. We hypothesized that infants would be less likely to learn a new word from an unreliable speaker compared to a reliable speaker. Furthermore, it was hypothesized that if domain-general functions are related to selective social learning, then infants who passed the statistical learning task should be less likely to learn a new word from an unreliable speaker in comparison to infants who failed. On the other hand, if domain-specific functions are related to selective social learning, then infants who pass the theory of mind tasks should be less likely to learn a new word from an unreliable speaker in comparison to infants who failed. We hypothesized that there would be no relation between these correlates and selective learning in the reliable condition, as infants have been shown to learn novel words from individuals who do not display any information about their competence.

The results of the selective learning task were as expected and replicated previous research with a statistically significant difference in performance on the word learning task between infants in the unreliable and reliable conditions. Specifically, infants who observed a speaker label familiar objects inaccurately exhibited a lower proportion of correct responses on the novel trials in comparison to infants who observed a speaker label familiar objects accurately. As expected, infants in both conditions performed at a level significantly above chance on the familiar word trials. Furthermore, it was found that the differences in word learning across both conditions were not due to a lack of attention to the unreliable speaker during the labeling phase of the task. Taken together, these findings suggest that 18-month-olds are able to detect when an individual is unreliable and have the ability to learn selectively from someone who provides more accurate information. These results are consistent with previous studies demonstrating selective social learning in the verbal domain with infants and toddlers (Brooker & Poulin-Dubois, 2013a; Koenig & Woodward, 2010; Krogh-Jespersen & Echols, 2012). For instance, Brooker and Poulin-Dubois (2013a) demonstrated that 18-month-olds were less likely to learn a new word from an unreliable speaker compared to a reliable speaker. Moreover, the present study adds to a growing body of literature demonstrating that young children are precocious selective learners who can use a speaker's reliability to guide their learning (see reviews by Mills, 2013; Poulin-Dubois & Brosseau-Liard, 2016).

In terms of the results regarding the psychological correlates, the findings of the present study support the hypothesis that domain-specific abilities are linked to selective learning in infancy, rather than domain-general abilities. It was found that infants who passed the knowledge task were significantly less likely to learn a novel word from an unreliable speaker compared to infants who failed the knowledge task. Importantly, in support of our hypothesis, no such relation was found for infants in the reliable condition. These results suggest that infants with superior theory of mind abilities may have been better at inferring that the unreliable speaker was ignorant or not knowledgeable. This finding is consistent with many studies demonstrating a relation between theory of mind abilities and selective learning in preschool-age and school-age children (Brosseau-Liard et al., 2015; DiYanni & Kelemen, 2008; DiYanni et al., 2012; Fusaro & Harris, 2008; Lucas et al., 2013; Mills & Elashi, 2014). However, this is the first study to demonstrate that this link is also apparent in infancy. It is important to point out that such link does not provide support for a mentalistic view of theory of mind in infancy, that is, the knowledge that infants possess about people's behaviours might be rather shallow as opposed to deep. There is a current debate regarding the nature of theory of mind in infancy, with one view proposing continuity between implicit and explicit forms of theory of mind whereas another view suggests two separate systems developing in parallel (Low, Apperly, Butterfill, & Rakoczy, 2016). Regardless of the depth of infants' computations in the knowledge inference task, the present study provides evidence that the precursors of theory of mind are related to selective learning in human infants.

The present study included two different theory of mind tasks. While both tasks measured infants' understanding of others' mental states, one task assessed infants' ability to understand that others may have different beliefs, whereas the other task assessed infants' ability to attribute knowledge states to others. The inclusion of two theory of mind tasks was important as both of these tasks are epistemic in nature and can both potentially help infants in detecting inaccuracy when choosing whom to learn from (Sabbagh & Baldwin, 2001). Furthermore, it was of particular interest to contrast performance on the false belief and knowledge tasks to their relation to selective learning abilities. Although performance on the knowledge task was significantly related to selective learning, performance on the false belief task was not, but the results were in the expected direction. This null result is consistent with findings from Pasquini and colleagues (2007), where no significant relation was found between false belief abilities and selective learning. However, the researchers argued that the absence of this relation might be explained by the fact that performance on the false belief task was at chance level. Similarly, the null findings that we observed with false belief might be due to the infants' poor performance on this task.

When looking at the difference in the pattern of results across both theory of mind tasks, the findings revealed that the effect size for the knowledge task was three times greater than the effect size of the false belief task when examining its influence on infants' word learning. Therefore, the ability to infer knowledge states, as opposed to false beliefs, is a better predictor of selective social learning. Passing the knowledge task suggests that the infant has the ability to infer knowledge, as research indicates that infants not only understand what individuals are doing and seeing, but also what individuals know (Moll & Tomasello, 2007). Infants infer what other individuals know by understanding what they have had previous experience with (i.e., not having experience with the third object; Moll & Tomasello, 2007). With regard to the word labelling phase, infants may expect a speaker to share their knowledge of the labels for these common objects, so when they observe the speaker use inaccurate labels, they detect a lack of "agreement" and are less likely to subsequently learn from this speaker. In summary, these results suggest that infants who display a greater understanding of the knowledge states of others are more selective in their word learning, as they are better able to form attributions regarding whether this individual is knowledgeable and thus the best source to learn from (Brosseau-Liard et al., 2015; Poulin-Dubois & Brosseau-Liard, 2016).

Aside from infants' understanding of knowledge states being the ability most clearly related to their selective learning abilities, another potential reason why the false belief task did not reach statistical significance may be due to the fact that the original results were not replicated. Specifically, 51% of infants in the present study passed the false belief task, whereas 72% of infants passed in the study conducted by Buttelmann and colleagues (2009). Consistent with the present findings, a recent study also reported a low performance of 36.6% on the same false belief task with 18-month-old infants (Poulin-Dubois & Yott, 2016). Additional research has also shown that even preschoolers fail this false belief task when control conditions are added to the design (Allen, 2015). However, it is important to note that slight methodological changes were made to the false belief task of the current study. Specifically, Buttelmann and colleagues (2009) administered the false belief task on the floor, whereas we administered the task on a table with infants sitting in a high chair. In fact, two recent studies have replicated Buttelmann and colleagues' (2009) pattern of results when the task was administered on the floor (Powell, Hobbs, Bardis, & Carey, 2017; Preiwasser, Rafetseder, Gargitter, & Perner, 2017). Given that the main goal of the present study was to contrast infants who passed and failed this task, the observed distribution of scores in the false belief task is ideal for our analyses since it provided us with similar sample sizes across subgroups. Still, future research should attempt to replicate the present null findings using other false belief tasks, such as those measured through an anticipatory looking or the violation of expectation paradigms.

Importantly, the present study did not find support for the hypothesis that domain-general abilities are linked to selective social learning in infancy, as no relation was found between infants' performance on the statistical learning task and their performance on the selective learning task. Specifically, infants who passed the statistical learning task demonstrated a similar performance on the word learning task to infants who failed this task. Although the link between statistical learning and selective learning has been suggested in the literature (Sobel & Kushnir, 2013), this is the first study to empirically investigate this relation. What is noteworthy is that the non-significant link between statistical learning and selective learning found in the present study cannot be accounted for by non-replication of the statistical learning task. In fact, 18-month-olds' performance on the statistical learning task in the present study is consistent with the performance of 19- to 24-month-olds' performance of this task in the original study conducted by Kushnir and colleagues (2010). The pattern of responses demonstrated that infants touched the target object significantly more on the minority trial compared to the majority trial. Since the experimenter's selection was likely not due to random sampling on the minority trial, it was expected that infants should recognize the experimenter's preference, and thus, offer the toy that the experimenter picked out. In contrast, infants touched the alternative object significantly more on the majority trial compared to the minority trial. According to Kushnir and colleagues (2010), infants may be able to recognize that the experimenter's selection on the majority trial was likely due to random sampling. As a result, infants may prefer the alternative toy, which is more novel to them (Kushnir et al., 2010). Although this task involves inferring the experimenter's preference, the pattern of results demonstrates that infants are using statistical and probabilistic cues when deciding which object to give to the experimenter. If the choice of object was based solely on the inference of a preference, then infants would be more likely to touch the target object on the majority trial as well. However, future studies should attempt to replicate these findings with other statistical learning tasks in order to provide further evidence that this ability is not associated with infants' selective social learning. Another domain-general correlate that was included in the present study was infants' vocabulary size, as a proxy for infants' verbal intelligence. The results revealed no significant association between infants' verbal skills and their selective learning behaviours. Thus, infants' tendency to learn less from the unreliable speaker was not due to the size of their vocabulary, suggesting that the effect between infants' knowledge attribution and selective social learning is robust and does not require advanced verbal skills.

In conclusion, this is the first study to investigate the correlates of selective social learning in infancy while examining theory of mind and statistical learning simultaneously. It is also the first to demonstrate that infants' ability to select competent informants is associated with the ability to infer people's knowledge state. Thus, our findings provide preliminary support for the rich interpretation of early selective social learning, in that domain-specific, socio-cognitive functions are linked with this ability in infancy. Future research should investigate the correlates of selective social learning in younger as well as older infants. This would allow researchers to explore a possible developmental trend in the correlates underlying this ability; that is, examining the continuity of these correlates across development.

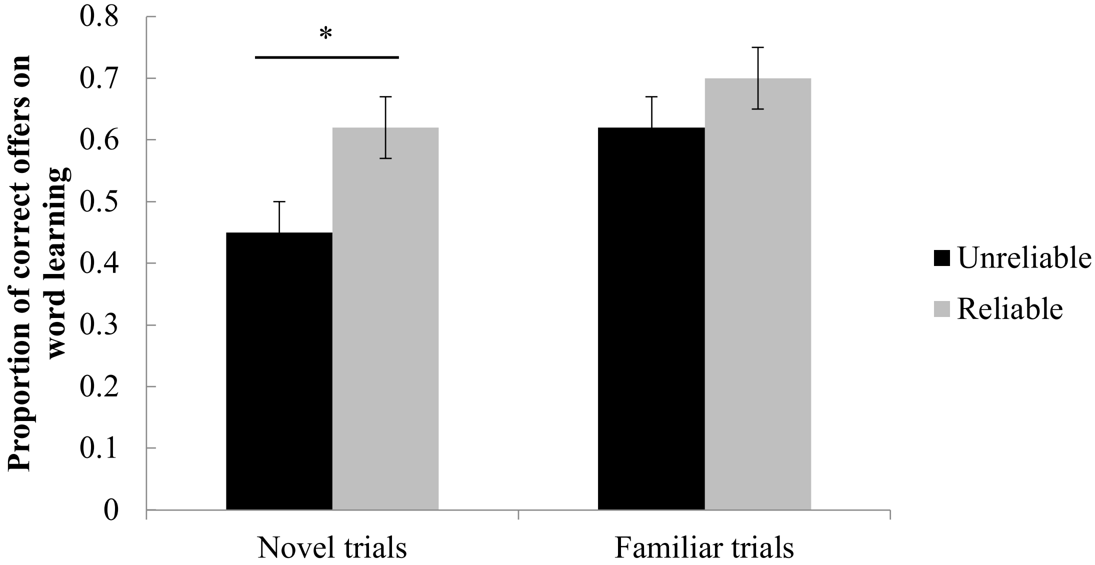

Figure 1. Proportion of correct trials on the word learning task as a function of condition.

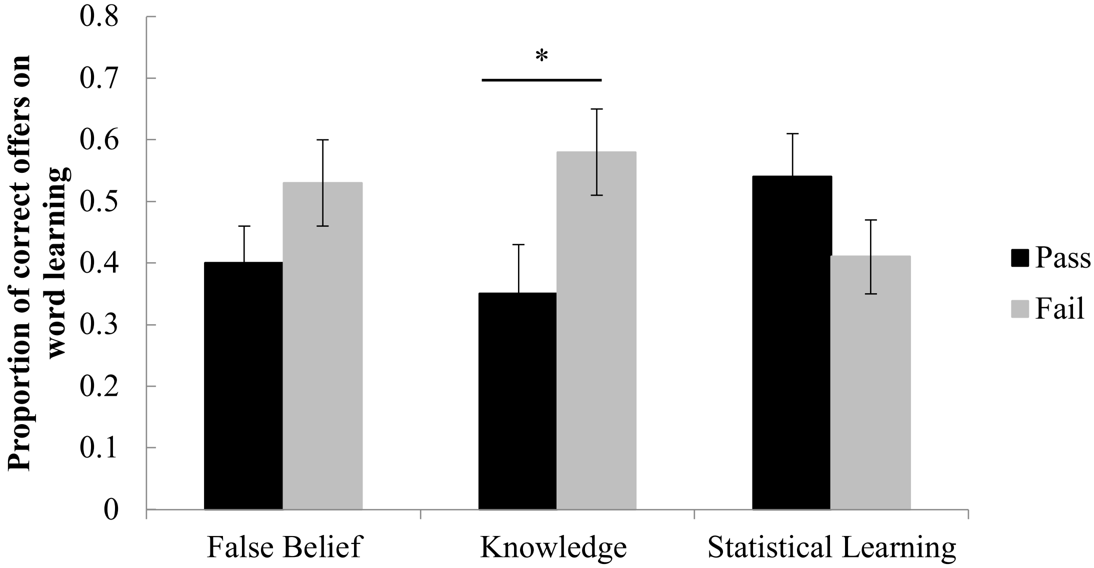

Figure 2. Mean proportion of correct responses in the unreliable condition as a function of performance on the theory of mind and statistical learning tasks.

Table 1

Infants' responses on the statistical learning task

Response	Minority trial (sampling violation) *n*	Majority trial (no sampling violation) *n*
Target toy	35	20
Alternative toy	18	28
Both (target and alternative)	19	24
Total	72	72

Note. Response was coded by infants' first touch.

Chapter 3

Infants' ability to detect emotional incongruency: Deep or shallow?

Infants' ability to detect emotional incongruency: Deep or shallow?

Like other species, humans acquire knowledge through social learning. Social learning, or socially mediated learning, can be defined as the acquisition of an individual's behaviour that has been influenced by attending to another individual (Box, 1984). Social learning allows individuals to acquire novel information and/or skills at a quicker pace and at a lower cost than asocial learning but entails the risk of acquiring false information or useless skills (van Schaik, 2010). Therefore, it is essential for humans to be able to select whom to trust and learn from (Poulin-Dubois & Brosseau-Liard, 2016; Koenig & Sabbagh, 2013).

Research over the past decade has uncovered evidence that young children are able to differentiate unreliable and reliable sources of information and trust the more accurate sources in a learning context (see Mills, 2013 and Poulin-Dubois & Brosseau-Liard, 2016 for reviews). In a ground-breaking study, Koenig, Clément, and Harris (2004) found that 3- and 4-year-olds were more likely to learn a novel word from a speaker who had previously labeled familiar objects accurately in comparison to a speaker who had previously labeled familiar objects inaccurately (e.g., a ball was labeled as a shoe). This research has since been extended to infancy, where it was found that 18-month-olds were less likely to learn a novel word from an unreliable speaker compared to a reliable one (Brooker & Poulin-Dubois, 2013a). However, the question of what individual differences predict infants' tendency to mistrust unreliable sources of information remains largely unexplored. This research question is currently the subject of a controversy in the literature. Therefore, the main goal of the present study was to contribute to this debate in order to shed light on the mechanisms associated with the emergence of selective trust in the emotional domain.

Selective trust based on emotional cues

Although most research on infants' selective trust have focused on epistemic cues or knowledge-related cues, infants have been shown to be sensitive to the "reliability" of emotional cues. For instance, in a landmark study by Chow, Poulin-Dubois, and Lewis (2008), 14-month-old infants observed an experimenter express positive affect while looking inside a container that held a toy (i.e., reliable emoter) or that was empty (i.e., unreliable emoter). It was found that infants took significantly longer to examine the contents of the container across the four trials when the emoter was previously unreliable in comparison to reliable. Furthermore, infants were less likely to imitate novel actions demonstrated by the unreliable emoter (Poulin-Dubois, Brooker, & Polonia, 2011), as well as less likely to follow her gaze behind a barrier (Chow et al., 2008) compared to the reliable emoter.

Additional research has since extended these findings demonstrating that 18-month-olds can differentiate emotional reactions that are congruent and incongruent to events and engage in more checking behaviour when an informant expresses an unjustified emotion after an event (i.e., expressing happiness after getting hurt) (Chiarella & Poulin-Dubois, 2013). In a recently published follow-up study, infants in the justified emotion group were more likely to be guided by the informant's emotions on a subsequent emotional referencing task, as well as more likely to help on an empathic helping task, compared to infants in the unjustified emotion group (Chiarella & Poulin-Dubois, 2018). Interestingly, this effect did not generalize to learning situations where the emoter was neutral (Chiarella & Poulin-Dubois, 2015). Similarly, 16- and 19-month-olds were found to demonstrate more concern and engage in more prosocial actions when their parent expressed sadness after hitting rather than missing their hand (Walle & Campos, 2014). Furthermore, 14-month-olds demonstrated increased pupil dilation when watching the video of an informant expressing emotions that were not congruent with her behaviour (i.e., petting a toy tiger while expressing anger) (Hepach & Westermann, 2013).

Other studies have shown that even younger infants can recognize incongruent emotional reactions. For instance, Skerry and Spelke (2014) found that 10-month-olds looked longer at a cartoon that demonstrated incongruent facial expressions after completing or failing to complete a goal (i.e., expressing sadness after climbing a barrier and reaching the desired location). In addition, a recent study found that 12-month-olds were sensitive to incongruent emotional reactions (Reschke, Walle, Flom, & Guenther, 2017). Taken together, these results suggest that infants are sensitive to emotional inaccuracy and prefer to trust and learn from individuals who demonstrate justified and reliable emotions.

These recent studies expand previous work on social referencing, which can be seen in infants from the age of 10 months (Feinman, Roberts, Hsieh, Sawyer, & Swanson, 1992). In standard social referencing procedures, infants are exposed to an ambiguous object or situation in order to prompt them to seek information from a person who expresses positive or negative affect toward that object or situation. Following the adults' expression, infants tend to adjust their behaviour toward the object accordingly (Feinman et al., 1992; Stenberg, 2013). For instance, it has been shown that infants tend to avoid the ambiguous object when the adult reacts with a negative emotion, whereas they tend to approach it when a positive emotion is expressed (Sorce, Emde, Campos, & Klinnert, 1985). In a landmark study demonstrating social referencing, it was found that infants were more likely to cross an ambiguous visual cliff if their mother expressed a positive emotional reaction compared to if she expressed a negative emotional reaction (Sorce et al., 1985). Thus, infants can recognize that positive affect refers to a positive experience. Selective trust capitalizes on this knowledge by introducing infants to an individual who expresses an emotion that is incongruent with the valence of her experience (i.e., positive affect and negative experience). Furthermore, consistent with selective trust, researchers have questioned whether infants prefer to seek information from certain individuals instead of others when faced with uncertainty (Harris & Lane, 2014; Stenberg, 2009; Walle, Reschke, & Knothe, 2017).

Selective trust: the mechanisms

Although the past decade of research has revealed that infants engage in selective trust, the psychological mechanisms underlying young children's selective trust has been recently debated in the literature (Hermes, Behne, & Rakoczy, 2018; Heyes, 2017; Poulin-Dubois, 2017; Sabbagh, Koenig, & Kuhlmeier, 2017; Sobel & Kushnir, 2013). According to one view of this debate, children possess socio-cognitive abilities, often reported as an implicit form of theory of mind, that allow them to selectively learn from others (Poulin-Dubois, 2017). In contrast, an alternative "leaner" interpretation of selective trust suggests that young children, like other species, rely on more domain-general cognitive abilities, such as asocial associative learning (Heyes, 2017). Finally, some researchers believe that both mechanisms may be involved in children's selective trust. For instance, infants may start with general associative learning capacities, but quickly begin to incorporate social information, including knowledge, into their reliability judgments in a rational manner (Sobel & Kushnir, 2013). In addition, a dual-process account of selective trust has been proposed, which involves both associations and rational social inferences about an informants' knowledge (Hermes, Behne & Rakoczy, 2018). Type I processes are fast, inflexible, implicit, automatic, and based on associative processes, which relates to the lean interpretation of selective social learning described above (Hermes, Behne, Bich, Thielert, & Rokoczy, 2017; Herme,s Behne, & Rakoczy, 2018). Conversely, Type II processes are slow, flexible, explicit, conscious, and are based on inferential processes, which relates to the rich interpretation of selective social learning (Hermes et al., 2017; Hermes, Behne, & Rakoczy, 2018). It has been argued that Type II processes can replace Type I processes depending on children's executive functioning and conceptual background knowledge, as well as the type of task (i.e., task demands) (Hermes, Behne, & Rakoczy, 2018).

A type of sophisticated cognitive ability proposed to be involved in young children's selective trust is theory of mind, which can be defined as the ability to understand that others may have different beliefs, desires, intentions, and knowledge than their own (Wellman, 2014). A relation between theory of mind and selective trust has been suggested as children can infer others' quantity and quality of knowledge based on their past accuracy in a given domain (Poulin-Dubois & Brosseau-Liard, 2016). An individual who repeatedly displays accuracy would be identified as knowledgeable and would therefore be expected to provide better information in the future (Poulin-Dubois & Brosseau-Liard, 2016). Some evidence for the rich view of selective trust exists in the literature, as many researchers have demonstrated a link between theory of mind and selective trust, particularly in preschoolers (Brosseau-Liard, Penney, & Poulin-Dubois, 2015; DiYanni & Kelemen, 2008; DiYanni, Nini, Rheel, & Livelli, 2012; Fusaro & Harris, 2008; Lucas, Lewis, Pala, Wong, & Berridge, 2013; Mills & Elashi, 2014). However, the results are mixed, as one study found that children who passed a false belief task were still selective in their behaviour (Pasquini, Corriveau, Koenig, & Harris, 2007).

According to the "leaner" interpretation of selective trust, associative learning, that is, learning an association between two stimuli, may be all that is needed to account for selective trust in very young children (Heyes, 2017). Only after years of social interaction will children develop explicit judgments about others' reliability through domain-specific mechanisms such as metacognition (Heyes, 2017). Associative learning has been proposed as infants' selective trust can be explained through action-outcome relationships and learned predictiveness (i.e. understanding that a stimulus is consistently followed by the same outcome) (Mitchell & Le Pelley, 2010). Learned predictiveness, in turn, influences how much attention one pays towards a stimulus (Le Pelley, Vadillo, & Luque, 2013; Kruschke, 2003). Specifically, an attentional bias is produced, as one pays more attention to stimuli with a higher predictability than those with a lower predictability. In turn, those who have a higher predictability will be learned from quicker.

For instance, previous research has found that infants prefer to learn a novel word from a reliable speaker over an unreliable one (Brooker & Poulin-Dubois, 2013a; Crivello, Phillips, & Poulin-Dubois, 2017). The interpretation of these findings from a domain-general perspective would propose that infants may have found the experimenter odd, as the label that the unreliable informant provided did not predict the object infants were expecting to see, which was established from associations that they had made in the past (Heyes, 2017). Consequently, they paid less attention to the sound that the unreliable informant was making (i.e., labeling the object), and were, in turn, less likely to learn a novel word from her. From this perspective, it is believed that infants were not inferring that the inaccurate speaker was untrustworthy, unreliable, and/or ignorant. Until recently, no study had investigated whether associative learning is related to infants' ability to selectively trust others.

In order to further clarify the nature of selective trust and contribute to this debate, Crivello and colleagues (2017) recently examined whether domain-specific or domain-general abilities were related to infants' ability to selectively learn from others. Specifically, 18-month-olds were administered a selective social learning task, two theory of mind tasks assessing infants' false belief understanding and knowledge attribution, as well as a statistical learning task assessing infants' ability to infer the experimenter's preference using statistical sampling. The results revealed that infants who passed the theory of mind task measuring knowledge attribution were less likely to learn a new word from an unreliable speaker in comparison to infants who failed this task. As expected, this effect was specific to the unreliable condition, and not to the reliable condition. Moreover, no such effect was observed for the false belief and statistical learning tasks.

Similar findings were found when investigating the mechanisms underlying infants' social referencing. In a study by Stenberg (2009), 12-month-olds were presented with an ambiguous object by either the experimenter or their mother, and both conveyed position information about the object. It was found that 12-month-olds looked more at the experimenter compared to their mother and were more likely to use the information provided by the experimenter to guide their behavior towards the object, regardless of who presented the toy. These findings suggest that infants preferred to seek information from an individual who had more expertise and who was more knowledgeable about the situation. Stenberg (2009) ruled out associative learning as a mechanism, as infants did not associate the toy with the individual who presented it. Therefore, preliminary evidence has been found that higher-order cognitive abilities, such as infants' ability to make knowledge inferences, are related to infants' selective trust and social referencing.

The present study

Given that previous research has found a link between theory of mind and selective trust in 18-month-olds, the objective of the present study was to examine the correlates of selective trust in younger infants, specifically 14-month-olds, by examining whether it may be linked to a domain-specific (i.e., theory of mind) or a domain-general (i.e., associative learning) ability.

Infants aged 14 months were tested as this is the youngest age in which infants have been shown to engage in selective trust. It was particularly important to examine associative learning as a potential correlate, as associative learning is one of the most basic forms of a domain-general ability. In addition, most theoretical accounts hypothesize that it should account for selective trust in such young infants, in parallel with domain-specific abilities or alone. As associative learning has been found in most species, such as rats and pigeons, Heyes' (2017) arguments can be directly tested.

In the present study, the same procedure as in Chow and colleagues (2008) was used to assess infants' selective trust. Specifically, infants observed an experimenter expressing joy while looking inside a container that was empty (incongruent condition) or that held a toy (congruent condition). Following this, infants were given the opportunity to follow the experimenter's gaze in front and behind a set of barriers. Infants' associative learning and theory of mind abilities were then assessed. We hypothesized that infants would be able to detect emotional incongruency, as expressed in an increased latency to examine the contents of the container across trials, but only for infants in the incongruent condition. We also hypothesized that infants in the incongruent condition would subsequently be less likely to follow the gaze of the experimenter behind the barriers. With regard to the correlates of selective trust, it was hypothesized that domain-general abilities would be related to 14-month-olds' selective trust. Specifically, it was expected that infants in the incongruent condition who show superior performance on the associative learning task would be more selective in their behaviour. This effect was not expected in the congruent condition. Furthermore, we did not expect any relation between selective trust and theory of mind in 14-month-olds due to their more limited skills in this domain.

Method

Participants

A total of 102 infants were included in the final sample (M_{age} = 14.60 months, *SD* = .52, range = 13.6 – 16.1; 45 males, 57 females). Additional infants were tested but were excluded due to reasons specific to each task (please see below). Infants were randomly assigned to a congruent (*n* = 51) or incongruent (*n* = 51) condition. They were required to have no visual or auditory impairments and to be exposed to either English and/or French in order to be included in the study. Participants were recruited from a birth list provided by a government health service agency from a large Canadian city. The present study was conducted according to guidelines laid down in the Declaration of Helsinki, with written informed consent obtained from a parent or guardian for each child before any assessment or data collection. All procedures involving human subjects in this study were approved by the University Human Research Ethics Committee at Concordia University.

Measures and Procedure

Infants and their caregivers visited the laboratory where they began with a warm-up session in which the child would play and interact with the experimenters to become accustomed to them and the new environment. First, the procedure of the study was explained to the parent or caregiver. Following this, the caregiver was asked to read and sign the consent form, as well as complete a demographics questionnaire. Once the forms were completed, the infant first participated in the reliability exposure task (Chow et al., 2008) followed by a gaze following task, a theory of mind and an associative learning task, with the last two tasks counterbalanced across participants. The reliability exposure task was always performed first as it was the most important task in the study and it was therefore crucial to avoid any fatigue effect that would prevent the detection of emotional reliability. It is important to note that the experimenter involved in the gaze following and reliability exposure tasks (E1) did not administer the other two tasks (associative learning and theory of mind task; E2 and E3) in order to avoid any carryover effects as a result of their incongruency/congruency during the selective trust task. The caregiver received a $20 compensation for the child's participation, and the child received a certificate of merit with a small gift for their participation.

Reliability exposure task. This task (adapted from Repacholi, 1998) involved two warm-up trials and four training trials. On the warm-up trials, the infant watched the experimenter (E1) look inside a yellow container while she stated, 'What's in here?'. Following this, E1 shook the container, removed the lid, and allowed the infant to see a block (i.e., blue or pink) inside by tilting the container. The experimenter then closed the lid and gave the container to the infant while saying, 'Now it's your turn'. The infant was given 30 s to explore the container and its content. This was repeated a second time, for a total of two warm-up trials. The warm-up phase was the same for infants in both conditions.

For the training trials, rather than using a yellow container as in the warm-up trials, a blue and orange container was used instead. Furthermore, as E1 looked inside the container, she exclaimed 'Wow!' while displaying happy facial expression. This demonstration lasted approximately 10 s. She then closed the lid and placed the container in front of the infant. The procedure was repeated for a total of four training trials. The difference across the congruent and incongruent condition was that for infants in the congruent condition, the container held a toy, whereas for infants in the incongruent condition, the container was empty. Infants' latency to examine the content of the container (s) in each trial was the dependent variable. Inter-rater reliability revealed excellent agreement among coders ($r(102) = .96$). Six infants were excluded from the reliability exposure task due to parental interference (n = 1), distraction (n = 1), technical error (n = 1), experimenter error (n = 1), or failure to open the lid of any of the containers (n = 2).

Gaze following task. The gaze following task was administered immediately after the reliability exposure task in order to examine whether infants' willingness to follow E1's gaze was influenced by E1's reliability (adapted from Moll & Tomasello, 2004). In this task, three barriers (i.e., blue, yellow, orange) and a red bucket were positioned around a stool where the infant was seated with a parent. The barriers were approximately 95 cm away from the stool. Each barrier/bucket consisted of a visible and non-visible trial, for a total of four visible trials and four non-visible trials. The non-visible trials consisted of a small toy (i.e., hen, horse, owl, sheep) placed behind the barriers, whereas the visible trials consisted of a sticker placed in front of the barriers. The barrier, trial (visible or non-visible), and location of E1 next to the barrier (i.e., right of left) were counterbalanced. However, the order of the trials was the same across the barriers (e.g., visible trials first for all barriers).

Prior to commencing the task, the parent was given instructions to sit on the stool and keep hold of their child until they were given a signal to let her/him go. First, E1 kneeled and faced the side of a barrier, while getting the infant's attention by stating "Hi *(name of infant)*!". On the non-visible trials, E1 leaned to look at the toy behind the barrier, while exclaiming "Ooooh", and holding her gaze for a total of 3 s. She then leaned back in order to allow the infant to approach the barrier. This was repeated a second time if the infant did not approach the back of the barrier after 4 s. As for the bucket, E1 leaned to look at the toy inside the bucket. The number of trials in which infants followed E1's gaze was coded, which consisted of infants moving to reach a distance where they could see the back of the barrier or inside the bucket. The same procedure was administered for the visible trials, except E1 looked at a sticker placed in the front of the barrier. Access to behind the barrier was blocked by the experimenter in order to prevent the infant from discovering or approaching the toy. Coding for the visible trials was based on the number of trials in which infants followed E1's gaze in front of the barrier, by approaching the sticker or pointing to it. Inter-rater reliability revealed excellent agreement among coders ($r(46) = .99$). Seven infants were excluded on the gaze following task due to fussiness ($n = 6$) and parental interference ($n = 1$).

Associative learning task. The associative learning task examined infants' ability to understand cause and effect (adapted from Bhat, Galloway, & Landa, 2010). Infants were seated in a high chair with a push button directly in front of them that was connected to a toy (Fisher Price light-up lion stacker) placed on a table approximately 95 cm away from the infant. This task consisted of a baseline, acquisition, and extinction phase. During the baseline phase (minutes 0 to 1), whenever the infant pushed the button, the toy did not activate. However, a light attached to the high chair (not visible to the infant) was activated in order to accurately code the number of times the infant pushed the button. Following this, the acquisition phase began (minutes 1 to 3), where the association between pushing the button and the toy being activated was formed. In other words, every time the infant pushed the button, the toy played music and lit up for 5 s. At the beginning of the baseline and acquisition period, the experimenter stated, "Look at that!" and pointed to the button. During the acquisition period, if the infant did not push the button within 20 seconds, the experimenter repeated the prompt. The extinction phase then began (minutes 3 to 4), where the toy did not activate when the infant pushed the button.

The number of times infants pushed the button in each phase was coded using INTERACT 14 (Mangold, 2017). In order to assess if infants learned this association, a baseline ratio was calculated, that is, the number of times the infant pushed the button during the extinction phase divided by the number of times the infant pushed the button during the baseline phase. Furthermore, an additional method to investigate associative learning was used by dividing the frequency of button pushes in the acquisition phase by four. This provided a frequency of button pushes in four 30 s intervals. Infants' rate of pushing in each interval was calculated by dividing the frequency of button pushes by the duration (30 s). Inter-rater reliability revealed strong agreement among coders (κ = .80). Forty-two infants were excluded from the associative learning task due to fussiness (n = 25), parental interference (n = 2), no response (n = 1), experimenter error (n = 1), and distraction (n = 13).

Knowledge inference task. A knowledge inference task was administered in order to assess infants' theory of mind abilities (Moll & Tomasello, 2007). In a pre-test, the infant and two experimenters (E2 and E3) played with three familiar objects (i.e., ball, teddy bear, car) one after the other for approximately 50 s. Following this, E2 requested each toy one at a time, in order to ensure that the infant understood the nature of the task. In order for infants to pass the pretest, they had to correctly touch at least one of the first two toys that the experimenter requested.

Following this, E3 introduced the infant to a novel object (i.e., abacus, bird cage toy, garden tool) and gave it to E2. E2 and the infant played with the novel object for 60 s while taking turns. During this joint engagement, E2 demonstrated to the infant how to manipulate the object, while saying "Look what you can do with this!" and "That's nice!". This procedure was repeated with a second novel object. Once finished playing with the second novel object, E3 placed it on a tray next to the first object (location was counterbalanced). E2 then announced that she was leaving the room by stating "I am going outside now. Bye bye!". Following this, E3 stated to the infant: “*(E2’s name)* is outside now. She cannot see us. We’ll keep playing!”. E3 introduced the infant to a third novel object (i.e., target object) and took turns with the infant playing with the object for 60 s. E3 then placed it on the tray with the other two objects. Once E2 returned to the room, she exclaimed with excitement and surprise “Oh look! Look at that! Look there!”, while pointing towards the tray. She then asked, “Can you give it to me, please?”, while she held out her hand in the direction of the center of the tray. If no response ensued, E2 asked this question a maximum of five times. In order for infants to pass this task, they had to first touch the target object. Inter-rater reliability revealed perfect agreement among coders (κ = 1.00). Twenty infants were excluded from the knowledge task due to failing the pretest (n = 11), fussiness (n = 2), experimenter error (n = 3), touching two objects during the test phase (n = 2), and no response (n = 2).

Results

First, comparisons were computed to ensure that infants in both conditions did not differ on demographic characteristics. The samples included in the congruent and incongruent condition did not differ in terms of age, $t(100) = -1.19$, $p = .24$, or gender $\chi2(1) = .99$, $p = .32$.

Selective Trust

Reliability exposure task. In order to determine if infants developed an expectation about the reliability of the emoter over time, a 2 (condition) X 4 (trial) mixed ANOVA was computed. The dependent variable was the latency to examine the contents of the container. Because the data were found to be not normally distributed, a log transformation was applied to the data. Thus, the inferential statistics are presented as the log-transformed data, whereas the descriptive statistics are based on the raw values.

The results of an ANOVA revealed a significant main effect of trial, $F(3, 300) = 3.54$, $p = .02$, $\eta_p^2 = .03$, and condition, $F(1, 100) = 4.69$, $p = .03$, $\eta_p^2 = .05$. Conversely, no significant interaction was found between condition and trial, $F(3, 300) = 1.82$, $p = .14$, $\eta_p^2 = .02$. According to Keppel and Wickens (2004), if comparisons were planned and a priori, then they may be tested even if the omnibus F statistic is not significant. Given that one of the research questions was to examine whether infants in each condition differed across trials, planned comparisons were executed. Infants in the incongruent condition took significantly longer to examine the contents of the container across trials, $F(3, 98) = 3.38$, $p = .02$, $\eta_p^2 = .09$. Specifically, for infants in the incongruent condition, the latency to examine the contents in the fourth trial ($M = 14.38$, $SD = 11.16$) was significantly longer than the first trial ($M = 8.67$, $SD = 8.35$; $p = .02$), and second trial ($M = 9.89$, $SD = 9.84$; $p = .05$) (p values adjusted using Bonferroni correction; see Figure 3). In contrast, infants in the congruent condition took equally long to examine the contents of the container across the four trials (1^{st} trial: $M = 6.87$, $SD = 6.92$; 2^{nd} trial: $M = 8.82$, $SD = 8.81$; 3^{rd} trial: $M = 7.14$, $SD = 7.87$; 4^{th} trial: $M = 9.20$, $SD = 9.35$), $F(3, 98) = 1.32$, $p = .27$, $\eta_p^2 = .04$. Furthermore, a significant difference between conditions emerged on the fourth trial, $F(1, 100) = 7.15$, $p = .01$, $\eta_p^2 = .07$), as well as a trend on the third trial, $F(1, 100) = 3.60$, $p = .06$, $\eta_p^2 = .04$ (see Figure 3). No significant differences across conditions were observed in the first, $F(1, 100) = 1.61$, $p = .21$, $\eta_p^2 = .02$, or second trial, $F(1, 100) = .19$, $p = .66$, $\eta_p^2 = .00$.

Gaze following task. In order to determine if the reliability of the emoter would transfer to another context, we examined if infants' gaze following would be affected by their exposure to the experimenter's reliability during the reliability exposure task. As age was found to be correlated with infants' performance on the gaze following task, $r(93) = .35$, $p = .001$, a condition (congruent/incongruent) by trial (non-visible/visible) mixed ANCOVA, controlling for age, was computed. However, it was found that 82% of infants followed the gaze of the experimenter to look inside the red bucket trial during the experimental trial. Due to this ceiling effect (less effort was required to succeed), this trial was removed from the analyses in order to conduct a more conservative test. Therefore, the dependent variable was the proportion out of three trials (i.e., blue, orange, and yellow barriers) in which infants followed the experimenter's gaze.

A significant main effect of trial was found, revealing that infants followed the gaze of the experimenter more often on the visible trials ($M = .77$, $SD = .32$) in comparison to the non-visible trials ($M = .32$, $SD = .34$), $F(1,91) = 113.48$, $p < .001$, $\eta_p^2 = .56$. In addition, a significant main effect of condition was found, indicating that infants in the congruent condition ($M = .60$, $SD = .26$) were more likely to follow the gaze of the experimenter than infants in the incongruent condition ($M = .50$, $SD = .26$), $F(1,91) = 3.84$, $p = .05$, $\eta_p^2 = .04$. No significant interaction was found, $F(1, 91) = .22$, $p = .64$, $\eta_p^2 = .002$. Nevertheless, planned comparisons revealed that infants in the incongruent condition ($M = .26$, $SD = .34$) tended not to follow the gaze of the experimenter behind the barrier compared to infants in the congruent condition ($M = .39$, $SD = .34$), $F(1, 91) = 3.19$, $p = .077$, $\eta_p^2 = .03$. As expected, infants in the incongruent condition ($M = .73$, $SD = .33$) were as likely to follow the gaze of the experimenter in front of the barrier compared to infants in the congruent condition ($M = .82$, $SD = .33$), $F(1, 91) = 1.64$, $p = .20$, $\eta_p^2 = .02$.

Correlates of Selective Trust

Knowledge inference task. One of the main goals of the present study was to investigate whether infants' selective trust, in other words, their performance on the reliability exposure task was related to their theory of mind abilities. It was found that 41% of infants passed the knowledge inference task. A binomial test revealed that infants performed at a level above chance (.33), although this effect was at the trend level, $p = .067$. In order to investigate whether infants' selective trust was related to their theory of mind, a condition (incongruent/congruent) by score (pass/fail) ANOVA was computed. The dependent variable was infants' latency to examine the contents on the last trial of the reliability exposure task (log transformed), as this was a critical trial in which a statistically significant difference emerged between the congruent and incongruent conditions. Planned comparisons were also computed as the comparisons were a priori and based on prior research and theory. For example, one of the main goals of the present study was to compare infants who passed and failed the knowledge inference task within the incongruent and congruent conditions. The ANOVA investigating the relation between infants' theory of mind abilities and their latency to examine the content on the last trial yielded no significant interaction, $F(1, 78) = 1.41$, $p = .24$, $\eta_p^2 = .02$. Nevertheless, planned comparisons revealed that for infants in the incongruent condition, those who passed the knowledge inference task ($n = 17$, $M = 19.77$, $SD = 11.17$) took significantly longer to examine the content of the container on the last trial compared to infants who failed this task ($n = 25$, $M = 11.51$, $SD = 10.83$), $F(1, 78) = 5.31$, $p = .02$, $\eta_p^2 = .06$ (see Figure 4). In contrast, there was no significant difference between infants who passed ($n = 17$, $M = 9.76$, $SD = 10.14$) and failed the knowledge inference task in the congruent condition ($n = 23$, $M = 8.66$, $SD = 9.50$), $F(1, 78) = .36$, $p = .55$, $\eta_p^2 = .01$.

In addition, we were interested in examining whether their performance on the knowledge inference task was related to their performance on the gaze following task. Therefore, an ANCOVA (controlling for age) examining the link between infants' theory of mind abilities and the proportion of trials in which infants followed the experimenter's gaze behind the barriers (non-visible trials) was computed. No significant interaction was found, $F(1, 72) = .06$, $p = .81$, $\eta_p^2 = .001$. Planned comparisons demonstrated that infants who passed the knowledge inference task ($n = 16$, $M = .25$, $SD = .33$) followed the gaze of the incongruent experimenter equally often compared to infants who failed this task ($n = 24$, $M = .28$, $SD = .34$), $F(1, 72) = .03$, $p = .86$, $\eta_p^2 = .000$. Similar results were found for the congruent condition, wherein no statistically significant difference was found between infants who passed ($n = 15$, $M = .40$, $SD = .40$) and failed the knowledge inference task ($n = 22$, $M = .42$, $SD = .37$), $F(1, 72) = .03$, $p = .87$, $\eta_p^2 = .000$.

Associative Learning Task. An additional goal of the present study was to examine whether infants' performance on the reliability exposure task was linked to their associative learning abilities. The frequency of button pushing was calculated in each phase of the associative learning task. Four outliers were found and were converted to the next highest score within three standard deviations from the mean (Kline, 2009). At the group level, it was found that the number of times infants pushed the button during the extinction phase ($M = 15.18$, $SD = 11.12$) was not significantly different than the number of times infants pushed the button during the baseline phase ($M = 16.82$, $SD = 13.60$), $t(59) = .10$, $p = .92$, $d = -.13$. As the baseline phase was found to be problematic (i.e., high rate of button pushes due to attractiveness of the button), the baseline ratio was not used in the following analyses ($M = 2.25$, $SD = 3.88$) (see Appendix A for analyses using the baseline ratio).

An alternative method was used to examine whether infants engaged in associative learning by comparing their rate of pushing the button during the acquisition period. Infants' frequency of pushes was coded by dividing the duration of the task into four intervals of 30 s each. A rate of pushing was calculated by dividing the frequency of pushes by 30 s. Four outliers were replaced with the next most extreme score that was within three standard deviations from the mean (Kline, 2009). As the data was still skewed despite the replacement of outliers, a non-parametric Friedman Test was computed to investigate changes on the rate of pushes over time. There was a statistically significant difference between the rate of pushes across intervals, $\chi^2(3) = 9.27$, $p = .03$. Post hoc tests using a Wilcoxon Signed Ranks Test (Bonferroni corrected; corrected $\alpha = .008$) revealed that the rate of pushes significantly increased from the first to the third interval ($Z = -3.55$, $p < .001$) and fourth trial ($Z = -2.69$, $p = .007$). This suggests that infants learnt across time that pushing the button activates the toy. No other significant differences across intervals were observed.

In addition, a Pearson correlation was computed to examine the link between infants' performance on the reliability exposure task and the increase in rate of button pushes, which was calculated by subtracting the rate of the first interval from the rate of the fourth interval. No significant relation was found between this difference score and infants' latency to examine the content of the container on the last trial in the incongruent condition, $r(29) = .06$, $p = .73$, or congruent condition, $r(27) = -.02$, $p = .94$. Moreover, using a partial correlation controlling for age, no link was observed between this difference score and infants' performance on the gaze following task in the incongruent, $r(26) = .13$, $p = .52$, or congruent condition, $r(24) = .20$, $p = .33$.

Discussion

The main goal of the present study was to investigate whether theory of mind abilities and/or associative learning abilities relate to 14-month-old infants' selective trust. This is a critical research question as the type of cognitive mechanisms underlying infants' selective trust is currently a topic of much controversy, whereby researchers have proposed both rich (domain-and species-specific) and lean (domain-general shared with other species) interpretation of infants' selective behaviour (Heyes, 2017; Poulin-Dubois, 2017). The findings of the present study provide preliminary support for the "rich" view on the correlates associated with selective trust, as only a relation between infants' theory of mind skills and their selective behaviour was observed. Infants' associative learning abilities, a form of asocial learning, were unrelated to their ability to detect the misleading behaviour of an emoter.

Evidence of selective trust in infancy

The current findings extend past research on selective trust in infancy by replicating the observation that infants detect an unreliable source of information about the hidden content of a box. As expected, infants in the incongruent condition took significantly longer to examine the content of the container across trials compared to infants in the congruent condition on the reliability exposure task. Consequently, a significant difference emerged on the last trial across conditions, such that infants in the incongruent condition were taking longer to examine its contents. These results suggest that infants in the incongruent condition had built up an expectation that the person's attentional and affective cues were misleading and that there was nothing to look at inside the containers and became disinterested in its contents. Thus, infants were able to detect the informant who expressed incongruent emotions and were subsequently less likely to trust her gaze in a different context.

These findings replicate the pattern of results demonstrated by previous studies using the same procedure (Chow et al., 2008; Poulin-Dubois & Chow, 2009; Poulin-Dubois et al., 2011) and add to a growing body of literature demonstrating that infants use emotional cues to help determine whom to trust and learn from. Specifically, several studies have shown that infants can recognize when an individual's emotional reaction is incongruent with a prior event (Chiarella &

Poulin-Dubois, 2013; Hepach & Westermann, 2013; Reschke et al., 2017; Skerry & Spelke, 2014; Walle & Campos, 2014) and prefer to trust those who display congruent emotional reactions (Chiarella & Poulin-Dubois, 2018). The results are also consistent with the past decade of research revealing that children and infants engage in selective trust, where they prefer to trust and learn from reliable sources of information (Mills, 2013; Poulin-Dubois & Brosseau-Liard, 2016).

In addition to measuring infants' selective trust using the reliability exposure task, we were interested in examining whether infants' prior exposure to the informant's emotional reliability would generalize to a subsequent gaze following task. It was hypothesized that infants would be less likely to follow the gaze of the incongruent emoter behind the barrier in comparison to the congruent emoter. The results of the gaze following task supported our hypothesis, as infants were more likely to trust the congruent emoter and follow her gaze behind barriers when she showed interest in an invisible object. However, it is important to note that this effect was small, as demonstrated by a difference at the trend level. Nevertheless, as expected, no significant difference across conditions was found on the visible trials, as infants in both conditions equally followed the gaze of the experimenter in front of the barrier. The distinction between the visible trials and non-visible trials is important, as the reliability manipulation should only affect infants' performance on the non-visible trials. As infants could not see what the informant was looking at behind the barrier, following the informant's gaze involved trusting her looking and vocal cues. Alternatively, infants were not required to trust the informant on the visible trials, as they were able to see the target object (i.e. sticker) that the informant was looking at in front of the barrier. These results replicate prior research reported with the same procedure (Chow et al., 2008).

Identifying the mechanisms

Given that the main goal of the study was to investigate the cognitive mechanisms related to infants' selective trust, we examined whether infants' performance on the reliability exposure task was related to their performance on a knowledge inference task and associative learning task. Interestingly, a relation was found between infants' theory of mind abilities and their performance on the reliability exposure task. For infants in the incongruent condition, those who passed the knowledge inference task took significantly longer to examine the contents of the container on the last trial compared to infants who failed this task. Importantly, no such effect was observed in the congruent condition. These results suggest that infants with superior theory of mind abilities may have been better at detecting a person who shows unreliable emotional referencing. However, it is important to note that the knowledge inference task consisted of only one trial that children either passed or failed. Future research should examine the link between infants' selective social learning and their knowledge inference abilities using a task that has more variability in order to provide more definitive support for this relation.

The present findings are consistent with several studies revealing that theory of mind is linked to selective trust in preschool and school-age children (Brosseau-Liard et al., 2015; DiYanni & Kelemen, 2008; DiYanni et al., 2012; Fusaro & Harris, 2008; Lucas et al., 2013; Mills & Elashi, 2014). Furthermore, these results provide additional support and extend the findings of Crivello and colleagues' (2017) study, as the researchers demonstrated that 18-month-olds who passed the knowledge inference task were more selective in their word learning than infants who failed this task. The researchers argued that infants who had a better understanding of the knowledge state of others were better able to infer that the unreliable speaker was not knowledgeable. However, such a link does not support the view that infants have a rich theory of mind, as there is also a controversial debate in the literature regarding the depth of infants' theory of mind abilities with many recent studies providing support for a lean interpretation (Heyes, 2014; Ruffman, 2014; Poulin-Dubois & Yott, 2017). Nonetheless, the present findings provide additional support for the interpretation that infants' selective trust is related to domain-specific abilities, such as the precursors of theory of mind or socio-cognitive abilities.

In contrast to the findings showing a link between infants' performance on the knowledge inference task and the reliability exposure task, no such link was observed on the gaze following task. One possible explanation for these findings is that the difference across conditions on the reliability exposure task was much larger than the difference observed on the gaze following task. Thus, the weak effect on the gaze following task may explain the lack of association with infants' theory of mind abilities. An additional explanation may be due to the fact that the variability in the outcome measure of the gaze following task (range: 0-3) is much less than the variability in the reliability exposure task (range: 0-30).

Furthermore, in contrast to the argument that infants' selective trust is driven by simple associative learning, we observed no relation between infants' performance on a task measuring such skills and selective trust tasks. Infants' associative learning was assessed by investigating the change in the rate that infants pushed the button across the acquisition period. As expected, infants' pushing rate significantly increased across this phase, demonstrating that they learned the association between pushing the button and activating the toy. This is consistent with research showing that infants as young as 3 months of age have been shown to understand cause-effect relationships (Rovee-Collier, Hayne, & Colombo, 2001). In addition, 6-month-old infants at low and high risk for Autism Spectrum Disorder learned the association between a wrist movement and the activation of a toy (Bhat et al., 2010).

It is important to note that infants' baseline ratio was not used in the analyses of the present study due to the high frequency of button pushes in the baseline phase. This is in contrast to other studies that have used a baseline ratio to assess infants' associative learning (e.g., Bhat et al., 2010). One explanation for this difference could be the way in which infants' baseline of responses was measured. For instance, in the study by Bhat and colleagues (2010), 6-month-olds were tested by attaching their hand to a joystick through a string. The toy activation occurred when infants bent the joystick during the acquisition phase. For the baseline phase, the researchers assessed a baseline of how many times infants moved their hand. For the current adaptation of the associative learning task, infants were required to push a button in order to activate the toy. The number of times infants pushed the button in the baseline phase was also calculated. A novelty effect may explain the high number of responses in the baseline phase as they were attracted to the push button and wanted to explore it. Even though the toy is not being activated when infants push the button in the baseline phase, pushing the button is a reward for them. In contrast, there is no reward in the baseline phase in previous research. Due to the unexpected rewarding baseline phase, the average baseline ratio was so low that only a small percentage of infants passed the task. As a result, the baseline measure was dropped from the analyses and the acquisition phase was used to assess infants' associative learning.

Infants' pattern of responding in the acquisition phase demonstrates that although they engaged in associative learning, this ability was not related to their selective trust. The present findings are consistent with the results reported in a recent study showing no relation between 18-month-olds' selective word learning and their statistical learning abilities (Crivello et al., 2017). In summary, the lack of association between infants' associative learning abilities and their selective trust does not support Heyes' (2017) arguments that infants, like different species of animals, are using domain-general abilities to guide their selective behaviour. These results provide further support for a rich interpretation of selective trust, rather than a leaner interpretation.

The present findings have important implications for understanding the nature of infants' selective trust, emotional development, and social cognition more broadly. Trusting others can be risky as not all individuals are reliable sources of information (Poulin-Dubois & Brosseau-Liard, 2016). This risk is particularly prevalent in infancy, as infants learn an abundance of novel information from other individuals. In addition, infants engage in social referencing, where they frequently refer to an adult's emotional reaction when faced with uncertainty (Sorce et al., 1985). Consequently, understanding how infants select others is crucial, as inadequate selective trust abilities can bring about negative consequences in a child's future social development (Mills, 2013).

Importantly, examining "how" infants selectively trust others directly contributes to the controversial debate in the literature regarding the mechanisms of infants' selective trust. Some researchers have suggested that children's selective trust is guided by rational inference and theory of mind (e.g., Brosseau-Liard et al., 2015; Sobel & Kushnir, 2013). According to a rich view, it is assumed that even infants' selective trust is guided by their theory of mind skills. Thus, infants who have superior theory of mind abilities should be better able to selectively trust others (Crivello et al., 2017; Poulin-Dubois & Brosseau-Liard, 2016). In contrast, others have argued that because animals, such as rats, demonstrate selective learning, such selectivity is not a unique aspect of human social learning and does not necessitate sophisticated cognitive skills

(Heyes, 2017). As a result, this lean view of selective trust would predict that infants' associative learning abilities guide their selective behaviour (Heyes, 2017).

Other domain-specific and domain-general mechanisms have been proposed to underlie infants' selective trust, such as metacognition and causal learning (Heyes, 2016). Metacognition is a domain-specific ability, that refers to the skill of reflecting on one's own cognitive processes, such as memory or knowledge (Gliga & Southgate, 2016). This has been proposed to influence children's selective trust, as one modifies their learning strategies based on their own knowledge state (Goupil, Romand-Monnier, & Kouider, 2016). Metacognition and theory of mind have been compared in the literature, as both concepts involve "knowledge about the mental world" (Ebert, 2015). Moreover, previous research has found that theory of mind predicts metamemory later in development above and beyond language, and thus, can be seen as a precursor to metacognition (Ebert, 2015; Lockl & Schneider, 2007). In addition to metacognition, causal learning has been proposed to be involved in infants' selective trust. Similar to associative learning, infants may be less likely to learn from an unreliable speaker because the association between the label provided and the object identified does not match (Heyes, 2016). Additional research should also examine these other domain-specific and domain-general correlates to further understand the depth of infants' selective trust.

In addition to the domain-specific and domain-general mechanisms mentioned above, other individual differences have been identified in the literature. For instance, children of parents who have higher, versus lower, authoritarianism are less likely to trust an inaccurate informant (Reifen Tagar, Federico, Lyons, Ludeke, & Koenig, 2014). As parents with an authoritarian style exhibit strict rules, the child is more likely to dismiss information that is inaccurate/non-conventional (Reifen Tagar et al., 2014). Similarly, preschoolers' reliance on their mother's claims differs based on the attachment profile during infancy (Corriveau et al., 2009). It was found that children with a secure attachment had a flexible strategy and accepted claims from their mother or stranger when appropriate, whereas children with an insecure attachment had an inflexible strategy (Corriveau et al., 2009). Following this study, Brooker and Poulin-Dubois (2013b) demonstrated that toddlers' selective trust is influenced by the model's emotional availability and responsiveness, as 24-month-olds were less likely to learn a novel word from a caregiver who was less sensitive and responsive. Furthermore, Canfield, Saudino, and Ganea (2015) demonstrated that young children rated high in affect/extraversion performed better on a selective trust task, suggesting that temperament may be influencing children's competency in social interactions. Lastly, research has shown that children between 2.5 and 3.5 years of age who were frequently deferential to the experimenter's misleading information had more difficulty on an inhibitory control task compared to children who were more skeptical (Jaswal et al., 2014). The researchers suggest that children with poorer inhibitory control may have more difficulty inhibiting a bias to trust others' testimony. Future research should investigate these individual differences and others in infancy, as there may be additional mechanisms involved.

Limitations

One of the limitations in the design of the present study is that there was no toy in the container in the incongruent condition. Therefore, an alternative explanation of the results of the reliability exposure task may be that infants took longer to examine the contents of the container because they kept finding an empty container, not because the experimenter was incongruent in her emotional expression. As a result, future research should include a 2 (toy/no toy) X 3 (happy, neutral, sad) design that controls for this potential confound. For instance, it would be of particular interest to compare infants who observe an experimenter express sadness while looking inside a container that holds a toy (incongruent) or that is empty (congruent). However, this “crybaby” condition is unlikely to generate an effect as previous research has failed to show such detection in infants of that age (Chiarella & Poulin-Dubois, 2013). In addition, an experimenter expressing no emotion after finding a toy might not be considered an incongruent emoter as even older infants do not consider a neutral emoter who lost an object as incongruent (Chiarella & Poulin-Dubois, 2015).

Despite this limitation, the findings of the present study regarding the correlates of selective trust provide support for the hypothesis that the reliability exposure task does measure infants’ selective emotional referencing. In the present study, infants who had better social-cognitive skills showed a stronger decrease of interest in searching inside the container when the emoter was emotionally misleading. This is a striking replication of the pattern of results reported by Crivello and colleagues (2017) who demonstrated that 18-month-old infants’ performance on the same theory of mind task assessing knowledge attribution was related to their selective trust in a very different task, a word learning task. Thus, if infants’ behavior in the reliability exposure task does not reflect a form of selective trust but is due to a confound of no “reward”, it remains to be explained why losing interest in looking inside the container due to an absence of reward would be specifically related to theory of mind abilities.

Conclusion

To conclude, this is the first study to examine the correlates of selective trust using an emotional reliability manipulation. The findings of the present study support the rich interpretation of selective trust in infancy, such that domain-specific abilities were related to infants’ ability to detect when someone is producing emotional cues that mismatch her experience. Further evidence for this conclusion is that domain-general abilities were unrelated to infants' selective trust. Future research should include different age groups within the same study in order to address developmental changes in the mechanisms driving infants' selective trust. In addition, future attempts to extend these findings should use different theory of mind tasks to assess whether the present pattern of findings can be replicated. This would provide further support for the rich view that sophisticated cognitive abilities are involved in infants' selectivity.

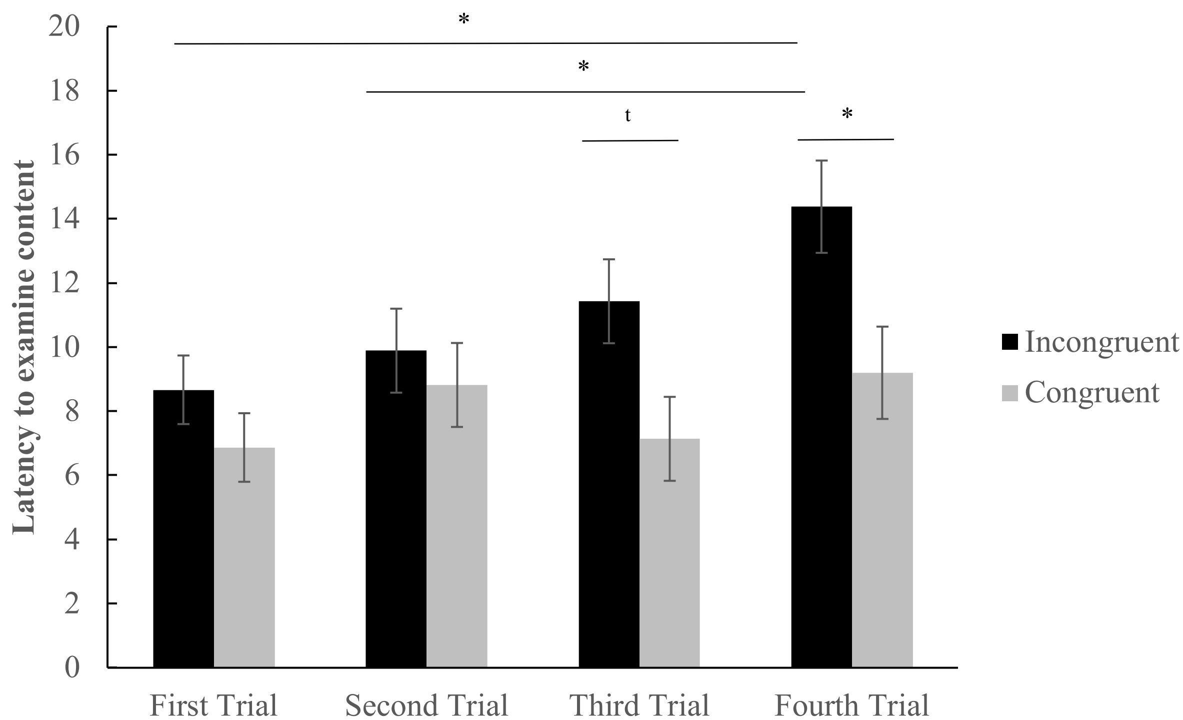

Figure 3. Mean latency to examine content by condition and trial type during the reliability exposure task.

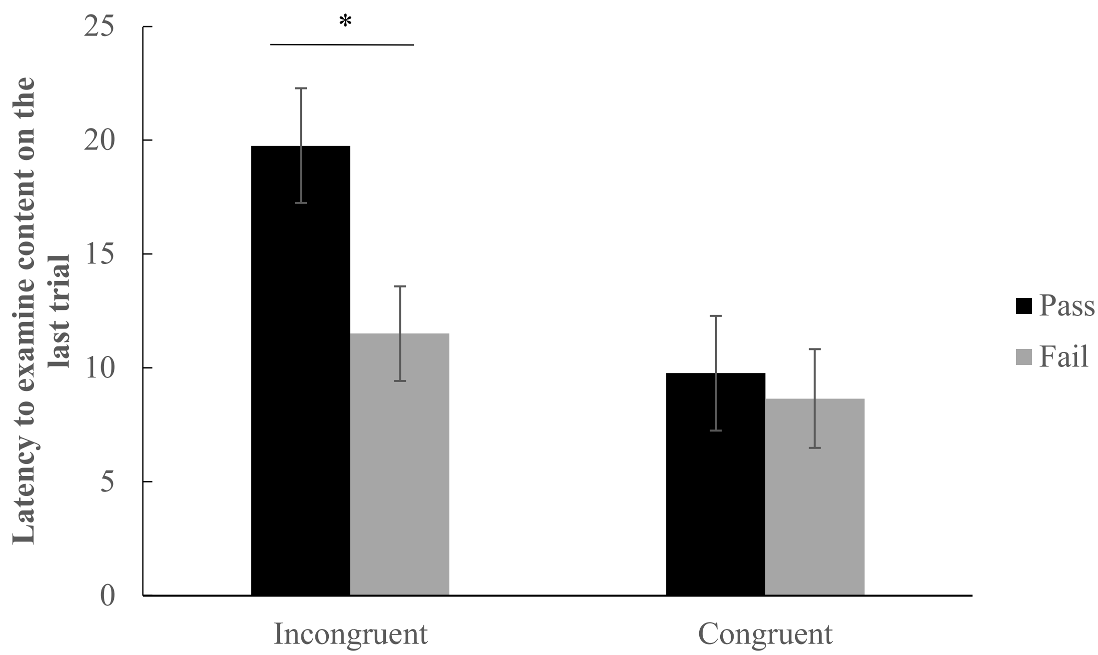

Figure 4. Mean latency to examine content on the last trial as a function of condition and performance on the knowledge inference task.

Chapter 4

Infants' ability to infer others' knowledge is linked to selective social learning

Infants' ability to infer others' knowledge is linked to selective social learning

Young children most often acquire knowledge from the testimony of those around them (Harris, Koenig, Corriveau, & Jaswal, 2018). However, children do not learn indiscriminately from others, but instead preferably learn from reliable sources of information (Koenig & Sabbagh, 2013; Poulin-Dubois & Brosseau-Liard, 2016). This crucial ability has been termed selective social learning, which can be defined as differentiating among reliable and unreliable individuals and choosing to learn from one source over the other (Koenig & Sabbagh, 2013; Mills, 2013; Nurmsoo, Robinson, & Butterfull, 2010). There has been an abundance of research over the past decade demonstrating that children engage in selective social learning (see review by Mills, 2013). More recently, research on selective social learning has revealed that this precocious ability begins within the first year of life (Tummeltshammer, Wu, Sobel, & Kirkham, 2014). In fact, infants appear to rely on a number of social characteristics in order to assess the reliability of a model (see review by Poulin-Dubois & Brosseau-Liard, 2016). For example, infants take into account an individual's age (e.g., Ryalls, Gul, & Ryalls, 2000; Zmyj, Daum, Prinz, Nielsen, & Aschersleben, 2012), confidence (e.g., Birch, Akmal, & Frampton, 2010; Brosseau-Liard & Poulin-Dubois, 2014), competency (e.g., Zmyj, Buttelmann, Carpenter, & Daum, 2010), expertise (e.g., Stenberg, 2013), and emotional credibility (e.g., Chiarella & Poulin-Dubois, 2013, 2018; Chow, Poulin-Dubois, & Lewis, 2008; Walle & Campos, 2014) when choosing from whom to learn.

One of the most researched cues that infants and children rely on is verbal accuracy. In a seminal study, Koenig, Clément, and Harris (2004) demonstrated that 3- and 4-year-olds preferred to learn a new word from an informant who had previously labeled familiar objects accurately (e.g., a ball was labeled as a ball) compared to an informant who labeled them inaccurately (e.g., a ball was labeled as a shoe). This finding has also been observed in infancy and toddlerhood (Brooker & Poulin-Dubois, 2013a; Crivello, Phillips, & Poulin-Dubois, 2017; Koenig & Woodward, 2010; Krogh-Jespersen & Echols, 2012; Luchkina, Sobel, & Morgan, 2018). For instance, Brooker and Poulin-Dubois (2013a) found that infants as young as 18 months were more likely to learn a new word from a reliable speaker rather than an unreliable speaker.

Furthermore, in addition to documenting when selective learning develops and what cues are guiding this selectivity, researchers have started to examine the cognitive processes underlying this ability. More specifically, researchers have a thorough understanding of *what* and *when* infants selectively learn from others, yet *how* infants engage in selective social learning is a topic that is heavily debated in the literature. Specifically, there are discrepant views regarding the psychological mechanisms underlying infants' selective social learning (Heyes, 2017; Poulin-Dubois, 2017). According to the rich interpretation, domain-specific, sophisticated cognitive abilities (e.g., theory of mind) guide infants' selectivity. In contrast, the lean interpretation suggests that infants use domain-general, basic level abilities (e.g., associative learning) to selectively learn from others.

The lean view of infants' selective social learning has proposed that other species of animals also selectively learn from others, suggesting that simple species-general mechanisms might be involved (see review by Rendell et al., 2011). For instance, research has shown that small fish are sensitive to many cues when learning from their tutors, such as age (Dugatkin & Godin, 1993), size (Duffy, Pike, & Laland, 2009), boldness (Godin & Dugatkin, 1996), and familiarity (Swaney, Kendal, Capon, Brown, & Laland, 2001). As selective social learning has been found in cognitively unsophisticated animals, it has been argued that infants' selectivity is based on domain-general cognitive processes, such as associative learning. According to Heyes (2017), infants' selective social learning is based on action-outcome relationships and learned predictiveness, which refers to a stimulus consistently being followed by the same outcome (Mitchell & Le Pelley, 2010). An individual will pay more attention to a stimulus with a higher predictability (i.e., followed by the same outcome) than one with a lower predictability. This greater attention to the stimulus allows for quicker and superior learning. For example, infants' selective word learning can be explained by the fact that when infants hear a label provided by the unreliable speaker, it does not match the object they were expecting based on past associations that they have made (Heyes, 2017). As the stimulus has low predictability, infants paid less attention to the unreliable speaker labeling the novel object and were therefore less likely to learn a new word from her compared to the reliable speaker where more attention was allocated. Despite this argument, there is a debate in the literature on the attentional theories of associative learning (Le Pelley, Vadillo, & Luque, 2013). For example, Mackintosh's (1975) theory posits that more attention is given to cues with higher predictability of the outcome, whereas Pearce & Hall's (1980) theory suggests that more attention is given to stimuli followed by surprising outcomes (consisted with research using a violation of expectation paradigm). Thus, Heyes' arguments are in line with Mackintosh's theory that infants pay more attention to informants when there is greater learned predictiveness.

In contrast to this lean interpretation, the rich view suggests that infants' selective social learning is based on rational inference or theory of mind abilities. Researchers have suggested that children may infer that an individual has particular traits based on their past accuracy (e.g., the individual is more knowledgeable as they provided accurate information) (Hermes, Behne, & Rakoczy, 2015; Hermes, Behne, Bich, Thielert, & Rakoczy, 2017; Sobel & Kushnir, 2013). This sophisticated reasoning has been demonstrated in studies showing that children are sensitive towards domains of competence (Kushnir, Vredenburgh, & Schneider, 2013; Lutz & Keil 2002; VanderBorght & Jaswal, 2009). For instance, preschoolers are more likely to trust adults compared to children when it involves a subject that adults know more about (e.g., food), but are more likely to trust children compared to adults when it involves a subject that children know more about (e.g., toys) (VanderBorght & Jaswal, 2009). According to Liu, Gelman, and Wellman (2007), the child needs to infer a trait based on the individual's past behaviour, as well as predict the individual's future behaviour based on this trait. In relation to selective social learning, children who demonstrate superior theory of mind abilities or trait inference should be better able to selectively learn from others as they can make inferences about the knowledge states of others (Brosseau-Liard, Penney, & Poulin-Dubois, 2015). Evidence of a link between children's theory of mind abilities and their selective social learning has been demonstrated in a large body of research (e.g., Brosseau-Liard et al., 2015; DiYanni & Kelemen, 2008; DiYanni, Nini, Rheel, & Livelli, 2012; Fusaro & Harris, 2008; Lucas, Lewis, Pala, Wong, & Berridge, 2013; Mills & Elashi, 2014; but see Pasquini et al., 2007).

In addition to the lean and rich interpretation being examined separately, some researchers argue that both lower-order and higher-order cognitive abilities may be involved in selective social learning (Hermes, Behne, & Rakoczy, 2018; Sobel & Kushnir, 2013). Sobel and Kushnir (2013) developed a theoretical model which proposes that infants may be using more basic-level abilities, such as statistical learning, and then progress to using more sophisticated abilities when growing older but only once they have the conceptual background knowledge. Such sophisticated abilities include being able to infer the competence of the informant. In other words, simple associative learning rules may be predominant in early stages of development and then knowledge inference becomes dominant later on. Similarly, Hermes, Behne, and Rakoczy (2018) have proposed a dual-process account of selective social learning. They argue that several factors can influence whether children will use trait inference or more basic cognitive abilities, such as their level of executive functioning skills and conceptual background knowledge, as well as the demands of the task. For example, children can infer the informant's knowledge if they have the conceptual background knowledge and sufficient executive functioning skills to complete the task.

Despite there being an increasing number of studies discussing the mechanisms of selective social learning, much of the research has focused on preschool-age children. However, recent studies that examined the mechanisms underlying infants' selective social learning have found evidence favoring a rich interpretation. For example, Crivello and colleagues (2017) examined whether domain-specific (e.g., theory of mind) or domain-general (e.g., statistical learning) abilities were related to 18-month-olds' selective word learning. The findings revealed that infants who passed a theory of mind task assessing knowledge inference were significantly less likely to learn a new word from an unreliable speaker compared to infants who failed this particular task. In addition, no link was found between infants' selective social learning and their statistical learning abilities (inference of preference from a violation of sampling) or false belief understanding. These results suggest that infants may have inferred that the unreliable speaker was not knowledgeable, and were therefore, less likely to learn from her. A follow-up study by Crivello and Poulin-Dubois (2019) examined whether theory of mind or associative learning abilities were related to 14-month-olds' selective trust after exposure to emotional incongruency (e.g., expressing happiness after a negative event). Extending the findings of their first study, the researchers found that infants with superior knowledge inference abilities were better able to detect the emotional incongruency of the experimenter. No relation was found between this ability and their associative learning skills, as measured by the ability to learn the association between pushing a button and a toy lighting up and playing music. Moreover, in a recent study, Luchkina and colleagues (2018) found that infants were more likely to generalize words from a speaker who correctly labeled an object than one who did so incorrectly. In a second experiment, infants observed two informants ask questions containing the correct or incorrect labels instead of statements (e.g., "is this a cup? as the informant holds a ball). If infants are using associative learning abilities, in other words are making associations among labels, objects, and speakers, then they should believe that the informant who used the correct label in their question is a more reliable source than the informant who used the incorrect label. On the other hand, if infants are inferring the epistemic state of the informants, then they should believe that both informants are equally reliable or unreliable. In fact, the researchers found that infants did not consider either informant reliable when they asked questions containing the correct or incorrect labels instead of statements. This finding suggests that 18-month-olds evaluated the speaker based on epistemic competence and not through associative learning processes (i.e., label-object-speaker associations). Taken together, these results provide preliminary support for a rich interpretation of infants' selective social learning, such that individual differences in domain-specific abilities are related to individual differences in infants' selective behaviour.

Although previous research supports a rich interpretation of infants' selectivity, the psychological mechanisms underlying this ability remain to be determined. Thus, the main objective of the present study was to investigate whether theory of mind and/or associative learning predict selective social learning in 18-month-old infants. There are many differences between the current study and the study by Crivello et al. (2017). Firstly, a within-subjects design was used, in which infants were exposed to an informant who labeled familiar objects accurately and another informant who labeled familiar objects inaccurately. A forced-choice word learning paradigm was then administered, whereby infants had the opportunity to learn a novel word from each of the informants who provided conflicting information. Based on previous research, it was expected that infants would choose to learn a new word from the reliable speaker rather than from the unreliable one. Although this type of design contrasts with previous research in infancy, it is a more conservative test to measure selective social learning, as infants are presented with two informants and they are then required to choose from whom to learn which can eliminate potential differences between conditions (Hermes, Rakoczy, & Behne, 2018). Furthermore, a new set of theory of mind tasks were used in the present study to investigate potential mechanisms. Crivello and colleagues (2017) found that infants' performance on a knowledge inference task (Moll & Tomasello, 2007) was linked to infants' selective social learning, but not to their performance on a false belief task (Buttelmann, Carpenter, & Tomasello, 2009). However, the null results with false belief may have been due to infants' poor performance on the original false belief task. Therefore, a different false belief task was administered in the present study to further examine its possible relation with selective social learning. In particular, we sought to measure false belief abilities with a different task in an effort to confirm that no link is present. Moreover, a different task assessing infants' knowledge inference was used in order to investigate whether previous findings could be extended and replicated. This would provide additional evidence for the rich interpretation of infants' selective social learning. Lastly, instead of using a statistical learning task as in Crivello et al. (2017), an associative learning task was administered. Investigating associative learning as a mechanism was essential, as it is the lowest level of domain-general functioning observed in several species (e.g., rats, pigeons). Heyes (2012) has argued that the core mechanism underlying infants' social learning is the same associative learning mechanism responsible for asocial learning. Thus, in order to test Heyes' arguments, a nonsocial associative learning task was needed in the current study. Furthermore, no study has yet assessed the link between infants' associative learning abilities and their selective word learning. In line with Crivello and colleagues' (2017) study, it was hypothesized that infants with superior theory of mind abilities would be less likely to learn a new word from the unreliable informant. No relation between infants' word learning and associative learning abilities was expected.

Method

Participants

A total of 79 infants were tested for the present study. Out of these participants, 23 were excluded for various reasons, such as fussiness (*n* = 9), throwing toys (*n* = 5), consistently touching both objects simultaneously on test trials (*n* = 2), lack of responses on all test trials (*n* = 1), lack of attention (*n* = 1), experimenter error (*n* = 1), technical issues (*n* = 1), and not having enough words to participate in the word learning task (*n* = 3). After these exclusions, 56 infants (30 males and 26 females) composed the final sample (*Mage* = 18.30 months, *SD* = .87; range = 17 – 20.5). Reflecting the demographics of the population of Montréal, Québec, infants' primary language was either English or French. All infants were tested in their mother tongue, which was determined by asking the primary caregiver what language the child was most exposed to. These infants were recruited from birth lists provided by the Agence de la Santé et des Services Sociaux de Montréal after approval by the Commission d'Accès à L'Information du Québec. Infants had no auditory or visual impairments.

Measures and Procedure

MacArthur-Bates Communicative Development Inventories: Short Form (MCDI-II). The American-English or the French-Canadian adaptation of the MCDI-II was used to assess productive vocabulary (Fenson et al., 2000; Trudeau, Frank, & Poulin-Dubois, 1999). This vocabulary checklist, typically used with children between 16-30 months, consisted of 100 items (i.e., nouns, verbs and adjectives) and was completed by the child's primary caregiver.

Word comprehension checklist. Parents were asked to complete a 20-item checklist in order to indicate which words their infants understood (Brooker & Poulin-Dubois, 2013a). The checklist consisted of words that were typically understood by 18-month-olds. Responses from the checklist were used to select familiar items for the reliability exposure phase of the selective social learning task.

Selective social learning. There were two phases in the task measuring selective social learning, where infants were presented with labels for both familiar and novel objects (Brooker & Poulin-Dubois, 2013a). Each phase was repeated twice in order to reinforce which experimenter was reliable and which was unreliable. Therefore, two trials of the reliability exposure phase were followed by three test trials in the word learning phase. This procedure was repeated twice for a total of four reliability exposure trials and six test trials.

Reliability exposure phase. A total of four small plastic objects were labeled both correctly (by the reliable informant) and incorrectly (by the unreliable informant). The familiar items were chosen from a set of words known to be understood by infants of that age according to the norms of the French and English versions of the MCDI (e.g., *ball, banana, bird, dog, spoon, chair, and shoe)*. The specific words that were tested depend on reports of the 20-item word comprehension checklist, as completed by the parents. To be included in the task, children were required to know three out of the four chosen items (Brooker & Poulin-Dubois, 2013a).

Three experimenters administered this task: one who labeled familiar objects accurately (Experimenter 1 – E1), one who labeled familiar objects inaccurately (Experimenter 2 – E2), and a third "neutral" experimenter who did not label the toys during that phase (Experimenter 3 – E3). In phase 1, E3 introduced the toy and allowed the child 15 s to explore it. In phase 2, E3 turned her back to the child, while E1 turned around to face the child, manipulated the object and labeled it correctly three times (reliable speaker). At this point, E1 turned her back to the child, while E2 turned to face the child, manipulated the object, and labeled it incorrectly three times (unreliable speaker). The objects were always given the same incorrect labels. For example, when labeling a familiar object inaccurately, infants watched as the unreliable experimenter pointed to a shoe and said, "Look it's a bottle. See, a bottle. Wow, it's a bottle". If the parents had previously indicated that the child understood the word shoe, the infant should be able to recognize that it had been mislabeled (Brooker & Poulin-Dubois, 2013a). In phase 3, which is after both experimenters finished labeling the objects, E3 allowed the child to play with the object for an additional 15 s. The order in which the reliable and unreliable speakers labeled the objects, as well as which experimenter was reliable or unreliable, was counterbalanced among participants.

Word learning phase. This task evaluated infants' willingness to learn from the two experimenters who labeled the toys, given their past record of accuracy during the reliability exposure phase (adapted from Baldwin, 1993). It included three phases: a warm-up phase, a training phase, and a test phase. In the warm up phase, E3 presented the infant with two familiar objects (which had not previously been seen in the reliability exposure phase) and requested one of them. In the training phase, E3 demonstrated the function of two novel objects and, subsequently, gave both objects to the infant to explore for 15 s. E3 then retrieved one of the objects and turned around. Until this point in the word learning phase, both E1 and E2 were seated on opposite sides of E3, with their backs towards the infant. Once the object was retrieved, E1 turned around to face the child and labeled the toy that she retrieved four times by repeatedly saying, “It’s a Dax”. As E1 turned her back to the child, E2 then turned to face the child and provided a different label to the novel object by repeating four times, “It’s a Fep”. E3 then allowed the infant to explore both novel objects for 30 s. Only E3 administered the test phase, while both E1 and E2 turned their backs to the infant. In this phase, E3 presented both novel objects on a tray and requested one of the two objects from the infant by saying, “Where is the Dax/Fep? Give me the Dax/Fep”. If both toys were given simultaneously, the trial was repeated. A total of 6 test trials were administered in separate blocks: 3 asking for the label provided by the reliable informant in one block (e.g., Dax) and 3 asking for the label provided by the unreliable informant in another block (e.g., Fep). The object that the infant first touched was coded. Thus, this task yielded two separate scores – that is, a proportion of correct touches to the target object labeled by the reliable speaker out of trials completed (reliable block) and a proportion of correct touches to the target object labeled by the unreliable speaker out of trials completed (unreliable block). A Pearson correlation was computed to assess inter-rater reliability by two independent coders and revealed near-perfect agreement among raters, $r(24) = .97$, $p < .01$. The novel object chosen, the location of the objects on the tray (left or right), and the order of the block of reliable and unreliable test trials, were counterbalanced across participants.

Theory of Mind battery. Two theory of mind tasks were administered to evaluate infants’ understanding of others’ false belief and knowledge inference.

False belief task. An interactive task was administered to assess infants’ concept of false belief (Southgate, Chevallier, & Csibra, 2010). During a warm up phase, an experimenter was seated on the floor with the infant and two familiar objects (i.e., a duck and a teddy bear). The infants were given 10 s to explore the objects. The experimenter then placed one object in each of two boxes and asked the child to find one of the objects by saying, “Can you find the duck?”. Once the first object was found, the experimenter then asked the child, “Can you find the teddy bear?”. Once the child located the two objects subsequently from two different boxes, the test trial began (Southgate et al., 2010). In the test trial, the experimenter placed two novel objects (e.g., a red lemon squeezer and a blue watering can spout) in front of the child. The child had 10 s to play with the objects. The experimenter then placed one object in each box, closed the lids of the boxes, and excused herself from the room. While the experimenter was outside, a second experimenter entered the room. This second experimenter crept forward in a deceptive manner while making a “sh” vocalization. The second experimenter switched the location of the objects and then left the room. The first experimenter then returned to the room, pointed at one of the boxes, and said, “Do you remember what I put in here? There’s a sefo in here. There’s a sefo in this box. Shall we play with the sefo?”. The experimenter then opened the lids of both of the boxes, so that only the child was able to see inside the boxes, and asked, “Can you get the sefo?”. The object that the infant either pointed towards or approached was coded (Southgate et al., 2010). In order to pass the task, infants had to point to or approach the box that contained the target object (i.e., the box that the experimenter did not refer to when asking the test question). A Cohen’s Kappa coefficient of $\kappa = 1.00$ was obtained, which is indicative of perfect agreement between two independent raters. Fourteen participants were excluded from the false belief task due to fussiness ($n = 5$), distraction ($n = 4$), parental interference ($n = 2$), and no response ($n = 3$) for a final sample of 42 infants.

Knowledge inference task. A second theory of mind task was used to assess infants' understanding that others may have knowledge that differs from their own (Liszkowski, Carpenter, & Tomasello, 2008). The infant was seated on the floor in front of a table with two short ramps and two long ramps attached to it. In the first phase, the demonstration phase, the experimenter placed an object pair (such as a pair of child safety scissors and a small glue stick) on a foam block. The experimenter showed each object to the infant and modeled the function of each object by using it on a substrate (e.g., using the scissors to cut a piece of paper). In the displacement phase, the experimenter lifted one of the objects (object A) and placed it near the edge of one of the ramps. She then turned her back to object A, while attending to the second object (object B), as she placed it near the edge of the ramp on the opposite side of the table. The experimenter then let object B fall out of her hand and watched as it slid down the ramp. While attending to object B, the experimenter secretly pulled a hidden trigger that allowed object A to fall down the ramp on the other side of the table. In the search phase, the experimenter oriented back to the center of the table, looked at the foam block and then back at the participant. The experimenter expressed surprise, raised her hands with her palms up and said, "Hmm? Where did it go? Where is it?". During this time, the infant had 30 s to point to the object that the experimenter did not attend to while it was falling down the ramp (object A). If the child pointed towards the non-target object (object B), the experimenter said, "Yes there", and continued to engage in a searching behaviour until the child identified the target object (object A). At the end of this phase, once the child located the target object, the experimenter used that object on a third substrate and expressed satisfaction. A total of four test trials were administered, each using different object pairs and substrates. The order of the object presented, the target object within each pair, and the object that fell first were counterbalanced among all participants. During the search phase, the object that the infant pointed at or approached was coded for each trial. The proportion of trials out of total trials included in which infants first pointed or approached the target or distractor was calculated. The proportion scores were also converted to a pass/score. A pass was coded if the infant was more likely to approach the target object, whereas a fail was coded if the infant was more likely to approach the distractor or approach the target and distractor equally. A Cohen's Kappa coefficient of $\kappa = .91$ was obtained, which is indicative of excellent agreement between two independent raters. Six participants were excluded from the knowledge task due to fussiness ($n = 4$), parental interference ($n = 1$), and technical error ($n = 1$) for a final sample of 50 infants.

Associative learning. This task was used to evaluate infants' ability to learn cause-effect relationships (adapted from Bhat, Galloway, & Landa, 2010). The infants were seated at a table, in an infant chair, with a large push button in front of them. The button was connected to a colorful stacking toy located 56 cm from the infant's reach. Each time the infant pushed the button throughout the task, it activated a light attached to the side of the chair, just outside of the infant's visual field. The purpose of this light was to help coders record the number of times the infant pressed the button. The task involved three distinct phases: baseline, acquisition, and extinction. During the baseline phase, the child then had 30 s to press the button, during which the toy was not activated. During the acquisition phase, lasting 60 s, the child was free to push the button as many times as he/she wished and each time the button was pressed, the toy lit up and produced music. The experimenter expressed "Look at that" at the beginning of the baseline and acquisition phase. In the final extinction phase, the toy was turned off and, therefore, did not illuminate and produce music when the child pressed the button. The child had 30 s to press the button. The duration of each phase was shorter than in previous research (Crivello & Poulin-

Dubois, 2019) in order to reduce the number of exclusions due to a fatigue effect. The number of pushes at each phase was coded using the software Mangold Interact 14 (Mangold, 2017). A baseline ratio was calculated by dividing the total number of times infants pushed the button in the extinction phases by the total number of times infants pushed the button in the baseline phase. In addition, the frequency of button pushes in the acquisition phase was divided into four intervals of 15 s. This frequency was then divided by 15 s to determine if infants' rate of button pushing increased across the acquisition phase, which would demonstrate associative learning. A Cohen's Kappa coefficient was computed as $\kappa = .86$, reflecting excellent inter-rater reliability. Nine participants were excluded from the associative learning task due to fussiness ($n = 4$), distraction ($n = 3$), experimenter error ($n = 1$), and technical issues ($n = 1$) for a final sample of 47 infants.

Design

Testing sessions began with a warm-up phase, during which infants familiarized themselves with their environment and the experimenters. During this time, the caregiver completed the MCDI-II and the word comprehension checklist. The testing session always began with the selective social learning task, as this task was the basis of the study and it was necessary to avoid fatigue effects. The two theory of mind tasks (false belief and knowledge inference) and the associative learning task were administered next. The order of administration of these tasks was counterbalanced among participants. In total, there were three experimenters. The experimenters who displayed accuracy or inaccuracy during the selective learning task did not carry out the other tasks as primary experimenters to avoid carry-over effects from the word learning manipulation. Therefore, the neutral experimenter (E3) in the selective social learning task carried out the other tasks. As a compensation for participation, caregivers received $20, and infants received a certificate of merit, as well as a small gift.

Results

Word learning task

A series of analyses were conducted to examine if infants' performance on the word learning task was influenced by their verbal skills. Firstly, infants' expressive vocabulary measured through the MCDI (M = 15.95, SD = 12.72) was not related to infants' proportion of correct responses in the reliable block (i.e., when the reliable label was used), $r(53) = .10$, $p = .46$, or unreliable block (i.e., when the unreliable label was used), $r(53) = .09$, $p = .50$, on the word learning task. One participant was excluded from theses analyses due to missing data. There was also no link between the number of familiar words on the vocabulary checklist (M = 3.95, SD = .23) and infants' proportion of correct responses in the reliable, $r(54) = .08$, $p = .58$, or unreliable block, $r(54) = .04$, $p = .75$.

Additional analyses were conducted to ensure that infants' performance on the word learning task was not confounded by their level of attention. Thus, in order to ensure that infants were equally attentive to the reliable and unreliable informants labeling the novel object, the number of trials (out of eight) that infants attended to the speaker and disengaged from their own toy was coded. Infants were equally attentive to the reliable (M = 7.54, SD = 1.14) and unreliable informant (M = 7.48, SD = .91) when they were labeling the novel object, $t(55) = .44$, $p = .66$, $d = .06$. Furthermore, infants' proportion of looking time at the informants when labeling (out of total looking time of 8 s) was examined. There was no significant difference in the proportion of looking time at the reliable (M = 97.01, SD = 6.25) and unreliable informant (M = 97.00, SD = 5.90) when labeling the familiar objects, $t(55) = .01$, $p = 1.00$, $d = .00$. Infants also spent an equal amount of time looking at the reliable (*M* = 91.22, *SD* = 16.75) and unreliable informant (*M* = 90.91, *SD* = 10.67) when labeling the novel object, $t(55) = .14$, $p = .89$, $d = .02$.

In addition, two sets of ANOVAs were conducted to ensure that the proportion of correct responses on the word learning task was not influenced by a preference for an experimenter. Specifically, the dependent variable was the proportion of correct responses on the word learning task and the independent variable was the experimenter who labelled the objects either reliably or unreliably. Results revealed that there was no experimenter preference in the reliable speaker trials, $F(2, 53) = .89$, $p = .42$, or in the block of unreliable speaker trials, $F(3, 52) = 1.43$, $p = .25$. Moreover, as the order in which the speaker labeled the novel object was counterbalanced, it was imperative to ensure that there was no recency effect. Thus, infants' performance on the word learning task was contrasted between infants who heard the novel object being labeled last by the reliable and unreliable speaker. Infants' proportion of correct responses on the word learning task in the reliable block was not influenced by whether the reliable (*M* = .46, *SD* = .30) or the unreliable (*M* = .39, *SD* = .33) speaker labeled the novel object last, $t(54) = .89$, $p = .38$, $d = .23$. Similarly, whether or not infants heard the reliable (*M* = .31, *SD* = .26) or unreliable (*M* = .35, *SD* = .30) speaker label the novel object last did not influence the proportion of correct responses in the unreliable block, $t(54) = -.46$, $p = .65$, $d = -.15$. These results suggest that no recency effect was present on the word learning task.

The proportion of correct first touches on the test trials was calculated and compared to chance (.50). Infants' performance on the word learning task was significantly below chance when the unreliable (*M* = .33, *SD* = .28; $t(55) = -4.68$, $p <.001$, $d = -.61$) label was tested. However, infants' performance was not significantly different than chance when the reliable label was tested (*M* = .43, *SD* = .32; $t(55) = -1.73$, $p = .09$, $d = -.23$). In order to investigate whether infants were more likely to learn a novel word from the reliable speaker, a paired samples t-test was conducted. Results indicated that infants' proportion of correct first touches was significantly greater in the reliable block than in the unreliable block, $t(55) = 2.05$, $p = .045$, $d = .34$. Although the task was challenging and children do not appear to have been able to learn the novel word in the reliable condition, these results suggest that infants preferred to learn a new word from the reliable informant compared to the unreliable one.

False belief task

When examining the success rate, it was found that 55% of 42 infants passed the false belief task. A binomial test indicated that infants' performance on this task was not significantly different from chance (.50; $p = .36$). It is important to note that infants' performance on the false belief task did not differ as a function of the administration order, $\chi^2(1) = .20$, $p = .90$. In order to investigate whether infants' false belief abilities would impact their success on the word learning task, a 2 (reliable block/unreliable block) X 2 (pass/fail) ANOVA was computed. No significant interaction was found, $F(1, 40) = .14$, $p = .71$. Planned comparisons revealed that infants who passed the false belief task ($n = 23$, $M = .31$, $SD = .27$) had a similar proportion of correct responses in the unreliable block on the word learning task compared to infants who failed the false belief task ($n = 19$, $M = .35$, $SD = .32$), $t(40) = .44$, $p = .66$, $d = -.14$ (see Figure 5). Similarly, there was no significant difference in the reliable block between infants who passed ($n = 23$, $M = .41$, $SD = .28$) and failed ($n = 19$, $M = .49$, $SD = .39$) the false belief task, $t(40) = .82$, $p = .42$, $d = -.25$.

In addition to examining the proportion of correct responses in the reliable and unreliable block, infants' difference score on the word learning task was examined as a function of their performance on the false belief task. The difference score was calculated by subtracting the proportion of correct responses in the reliable block by the proportion of correct responses in the unreliable block. An independent samples t-test was computed with infants' score on the false belief task as the independent variable and the difference score on the word learning task as the dependent variable (range: -1 to 1). Results revealed no significant difference in the word learning difference score between infants who passed (n = 23 M = .09; SD = .38) and failed (n = 19; M = .14; SD = .42) the false belief task, $t(40) = .38$, $p = .71$, $d = -.13$.

Knowledge task

There was no significant difference between the proportion of trials in which infants first pointed/approached the target object (i.e., the object that the experimenter had not seen fall; M = .45, SD = .34) compared to the distractor (M = .35, SD = .35), $t(49) = 1.13$, $p = .26$, $d = .29$. However, there was a significant difference when examining the frequency of infants who approached more often the target than the distractor. Specifically, 42% of infants approached the target more often compared to 24% who more often approached the distractor, $p = .03$. The other 34% of infants (17 infants) approached the target and distractor equally (11/17) or approached neither (6/17). As Liskowski and colleagues (2008) found that the temporal sequence of the target object falling was a confound, a 2 (target, distractor) X 2 (first to fall, second to fall) ANOVA was conducted to examine whether the temporal sequence influenced which object infants approached. The results revealed no significant interaction, $F(1, 91) = .05$, $p = .82$, $\eta_p^2 = .00$, suggesting that, unlike 12-month-olds, 18-month-old infants' performance on the knowledge task was not influenced by whether the target object fell first or second. Therefore, in contrast to the original study, the temporal sequence of the target object falling was not a confound. Moreover, infants' performance on the knowledge task was not influenced by the order of administration, $\chi^2(1) = 3.51$, $p = .17$.

In order to examine whether infants' superior knowledge inference abilities would be related to better performance on the word learning task, a 2 (reliable block/unreliable block) X 2 (pass/fail) ANOVA was computed. Infants who approached neither the target nor distractor (6/50) were excluded from this analysis. The results from this ANOVA revealed no significant interaction, $F(1, 42) = 2.37$, $p = .13$, $\eta_p^2 = .05$. However, planned comparisons indicated that infants who passed the knowledge task (i.e., approached the target object more; $n = 21$, $M = .22$, $SD = .22$) had a significantly lower proportion of correct responses in the unreliable block compared to infants who failed the knowledge task (i.e., approached the distractor more or approached the target and distractor equally; $n = 23$, $M = .41$, $SD = .28$), $t(42) = 2.50$, $p = .02$, $d = -.77$ (see Figure 5). In contrast, no difference emerged in word learning from the reliable speaker between infants who passed ($n = 21$, $M = .43$, $SD = .30$) and failed ($n = 23$, $M = .45$, $SD = .33$) the knowledge task, $t(42) = .22$, $p = .83$, $d = -.06$. In addition to the ANOVA, an independent samples t-test with the difference score on the word learning task as the dependent variable revealed no significant difference between infants who passed ($n = 21$, $M = .21$, $SD = .30$) and failed ($n = 23$, $M = .04$, $SD = .42$) the knowledge task, $t(42) = -1.54$, $p = .13$, $d = .47$.

Associative learning task

Using a Fisher's Exact Test, the order of administration was found to have no impact on infants' score on the associative learning task ($p = .14$). Two outliers (one in each of the baseline and extinction phase) were converted to the next most extreme score within three standard deviations from the mean (Kline, 2009). Contrary to what was expected, the number of times infants pushed the button in the baseline phase ($M = 9.78$, $SD = 6.72$) was higher than in the extinction phase ($M = 7.19$, $SD = 5.94$), $t(46) = 2.21$, $p = .03$, $d = .41$. As a result, a different method was used to investigate infants' associative learning, specifically by examining whether infants' rate of pushing the button increased across the acquisition phase. A paired-samples t-test was used to compare the rate of pushing in the first interval and the fourth interval. Results revealed that infants' rate of pushing significantly increased from the first interval (M = .20, SD = .16) to the fourth interval (M = .29, SD = .28), $t(46) = -2.01$, $p = .05$, $d = -.39$. These results indicate that infants engaged in associative learning, as they learnt that pushing the button causes the toy to light up and play music. Moreover, the increase in rate of pushing was calculated by subtracting the rate of pushing in the first interval from the rate of pushing in the fourth interval. A Pearson correlation demonstrated no statistically significant relation between the difference score across intervals and the proportion of correct responses in the unreliable block, $r(45) = .21$, $p = .17$, and reliable block, $r(45) = -.07$, $p = .63$. Also, no link was found with the difference score on the word learning task, $r(45) = -.21$, $p = .15$.

Discussion

The goals of the present study were two-fold: 1) to investigate whether infants prefer to learn a new word from a reliable speaker using a within-subjects design, and 2) to examine whether domain-specific abilities (i.e., theory of mind) or domain-general abilities (i.e., associative learning) relate to infants' selective word learning. The findings from the word learning task replicated previous evidence of selective social learning in infancy using a more conservative approach – that is, a within-subjects design where two informants offered conflicting labels for the same object. Thus, infants preferred to learn a new word from a reliable speaker over an unreliable speaker. Furthermore, the results of the present study revealed that infants with superior knowledge inference abilities were more adept at identifying the unreliable informant and were less likely to learn from her in a word learning context, which support a rich interpretation of selective social learning in infancy.

The results of the selective social learning task extend past research demonstrating that infants prefer to learn new words from informants who had previously labeled familiar objects accurately compared to inaccurate speakers (Brooker & Poulin-Dubois, 2013a; Crivello et al., 2017; Koenig & Woodward, 2010; Krogh-Jespersen & Echols, 2012; Luchkina et al., 2018). However, unlike studies with preschoolers, almost all studies on infants' selective social learning have tested this ability using a between-subjects design in order to minimize tasks demands (i.e., requires fewer executive functioning skills). Despite a between-subjects design being the most common design to measure infants' selective social learning, a within-subjects design was considered a more conservative approach, as infants are expected to *choose* one of two informants to learn from. To date, only one study has examined infants' selective word learning using a within-subjects design (Schmid et al., 2018). The researchers found that 2-year-olds did not prefer to learn from the reliable speaker compared to the unreliable speaker. The results of the present study are in contrast to those of Schmid and colleagues (2018), as we found that infants were significantly more likely to learn a new word from the reliable speaker. The contrasting results may be due to the different methodology used to assess infants' selective word learning. For instance, Schmid and colleagues (2018) tested infants' word learning using an endorsement and a disambiguation task using an eye-tracker paradigm, as well as one single test trial of an interactive task. In contrast, in the present design, infants' word learning was assessed using six test trials of an interactive task, which were divided into two blocks to test their preference to learn from the reliable and unreliable speaker separately. The two blocks allowed minimization of task demands, as infants were re-exposed to the reliability of the speakers in the second block before being tested on a new word. Although the two blocks allowed infants to experience less task demands, the within-subjects word learning task was still challenging for 18-

month-olds, as infants' proportion of correct responses in the reliable block was not significantly different from chance. In other words, despite the modifications to the within-subject design, it could be that task demands were still too high (i.e., a lot of information to process, remembering what each experimenter said, etc.). According to Hermes, Rakoczy, and Behne (2018), a within-subject task with two informants involves higher task demands and requires more working memory and inhibitory control abilities compared to a between-subjects task with only one informant. Despite the fact that a within-subjects design may be more challenging for infants due to increased task demands, there is research demonstrating that the number of informants presented to the child influences their selective trust (Vanderbilt, Heyman, & Liu, 2014). Specifically, Vanderbilt and colleagues (2014) found that preschoolers were more likely to trust an inaccurate informant when presented alone than when presented alongside an accurate informant, revealing that children display more selectivity when exposed to two informants who offer conflicting information.

In addition to examining infants' selective social learning using a conservative approach, it was of main interest to examine the mechanisms underlying infants' selectivity in order to shed some light on the controversial debate in the literature. According to the rich view of infants' selective social learning, infants use domain-specific abilities, such as precursors of theory of mind, to selectively learn from others (Poulin-Dubois, 2017). On the other hand, the lean view suggests that infants rely on domain-general abilities, such as associative learning (Heyes, 2017). Since different species of animals that do not possess sophisticated cognitive abilities also engage in selective behaviour (Rendell et al., 2011), it was proposed that infants rely on very basic cognitive processes to guide their selectivity.

The results of the present study provide no evidence for a lean interpretation of infants' selective social learning. Specifically, infants' performance on the word learning task was not influenced by their associative learning skills. Consistent with previous research showing that infants engage in associative learning (Bhat et al., 2010; Rovee-Collier et al., 2001), 18-month-olds in the present study were able to learn the association between pushing the button and the toy activating, as demonstrated by an increase in their rate of pushing across the acquisition phase. However, in the present study, a large button was used to measure infants' associative learning in contrast to other studies where the infant's body part (e.g., wrist, ankle) was tied with a string and attached to the apparatus. This change in methodology may be the reason why infants' baseline ratio was problematic in the present study and could not be used as a measure of associative learning. Specifically, the attractive button may have been too attractive in itself and a distractor that enabled infants to display a higher than expected frequency of button pushes in the baseline phase. In other words, pushing the button in the baseline phase was a reward for the infants, whereas previous research examining infants' associative learning did not include a baseline phase involving a reward. Thus, the number of pushes in the baseline phase may have been significantly greater than the number of pushes in the extinction phase due to the unexpected attractiveness of the button. Despite this limitation, the lack of relation between infants' selective word learning and their associative learning abilities suggests that infants may not be simply using past object-label associations when deciding who is the best source of information. The findings also replicate previous studies that ruled out domain-general abilities as a mechanism of infants' selective social learning (Crivello et al., 2017; Crivello & Poulin-Dubois, 2019; Luchkina et al., 2018).

As predicted, the findings of the present study demonstrated that domain-specific abilities, particularly knowledge inference, were related to infants' selective social learning. Specifically, infants who passed a knowledge inference task were less likely to learn a new word from an unreliable speaker compared to infants who failed. No such link was observed with infants' performance in the reliable block on the word learning task. These results suggest that infants who have superior knowledge inference abilities may have been better at inferring that the unreliable speaker was not knowledgeable or ignorant, and were therefore, less likely to learn from her. This extends previous findings in the literature that have shown that selective social learning in preschool and school-age children is related to their theory of mind abilities (Brosseau-Liard et al., 2015; DiYanni & Kelemen, 2008; DiYanni et al., 2012; Fusaro & Harris, 2008; Lucas et al., 2013; Mills & Elashi, 2014). More importantly, the present results are consistent with recent findings demonstrating that the precursors of theory of mind are linked to infants' selective social learning (Crivello et al., 2017; Crivello & Poulin-Dubois, 2019; Luchkina et al., 2018). For instance, a recent study demonstrated that 18-month-olds make judgments about the epistemic knowledge of the speakers during a word learning task, and do not base their learning on simple associative learning mechanisms (Luchkina et al., 2018). In addition, the present results replicate and extend the findings from two recent studies demonstrating that infants with superior knowledge inference abilities are more selective in their behaviour (Crivello et al., 2017; Crivello & Poulin-Dubois, 2019). Specifically, Crivello and colleagues (2017) demonstrated that 18-month-olds who passed a knowledge inference task were less likely to learn a new word from an unreliable speaker, but that this was not the case with a reliable speaker. In a follow-up study, Crivello and Poulin-Dubois (2019) recently found that 14-month-olds who passed the same knowledge inference task as in their previous study were better able to detect an experimenter who expressed an incongruent emotional reaction to a situation, but not an experimenter who expressed congruent emotions. In the present study, the same conclusion was drawn using a different knowledge inference task, which provides further support for the rich interpretation of infants' selective social learning. Furthermore, the effect was specific to the unreliable block, replicating the same pattern of findings as previous research. Importantly, all three studies ruled out domain-general mechanisms, as no relation was found between infants' selective social learning and a range of learning tasks, measuring associative learning as well as statistical learning abilities.

Although infants' knowledge inference abilities were related to their selective social learning, infants' false belief abilities were not. Infants who passed or failed the false belief task performed similarly on the word learning task. This is also consistent with findings from Crivello and colleagues (2017) who found that only performance on the knowledge inference task, and not the false belief task, influenced infants' tendency to learn a new word from the unreliable speaker. Thus, there is evidence from two different false belief tasks that not all theory of mind abilities may be guiding infants' selective social learning. Specifically, the ability to attribute others' knowledge states may be a more important predictor than the ability to understand that others may have different beliefs. It is important to note the pass rate of the false belief task in the current study (55%) did not replicate infants' performance on this task in the original study (75%; Southgate et al., 2010). However, other studies have also not replicated this particular false belief task, in which the pass rate was not significantly different from chance (Dörrenberg, Rakoczy, & Liszkowski, 2018; Grosse Wiesmann, Friederici, Singer, & Steinbeis, 2016; Király, Oláh, Kovács, & Csibra, 2016). In fact, there is a controversial debate regarding the depth of infants' theory of mind, particularly false belief abilities, as well as a number of failed attempts to replicate false belief tasks in infancy, measured with spontaneous or elicited responses. Several recent studies have failed to replicate standard implicit false belief tasks using anticipatory looking paradigms (e.g., Burnside, Ruel, Azar, & Poulin-Dubois, 2018; Dörrenberg et al., 2018; Grosse Weismann, Friederici, Disla, Steinbeis, & Singer, 2018; Kulke, Reib, Krist, & Rakoczy, 2018; Schuwerk, Priewasser, Sodian, & Perner, 2018), violation-of-expectation paradigms (e.g., Dörrenberg et al., 2018; Powell, Hobbs, Bardis, Carey, & Saxe, 2018; Yott & Poulin-Dubois, 2016), and interactive tasks (e.g., Crivello & Poulin-Dubois, 2018). These non-replications cast doubt on the reliability and robustness of false beliefs abilities in infancy. In addition to non-replications, some researchers argue that a violation of behavioural rules (Ruffman, 2014; Ruffman & Perner, 2005) or low-level novelty (Heyes, 2014) may explain infants' performance on implicit false belief tasks. Regardless of the depth of the interpretation of infants' behavior in false belief tasks, it appears not to be relevant to infants' selective social learning. Thus, the lack of association between infants' performance on the false belief task and their performance on the word learning task may be due to several reasons – i) infants' false belief skills are not a good predictor of their ability to selectively learn from others, ii) researchers have yet to establish a way to adequately measure this implicit ability in infancy, or iii) the depth of infants' false belief abilities is rather shallow.

It is important to note that although the current study focuses on theory of mind and associative learning as potential mechanisms, several studies have found that other mechanisms might be at play. For example, executive functioning may be involved, as research has demonstrated that young children with poor inhibitory control were less skeptical of an informant's misleading information, suggesting that inhibiting their bias to trust testimony was more challenging (Jaswal et al., 2014). Other studies have focused on whether parenting style and attachment predict children's selective social learning. For example, children who have parents with high authoritarianism are less willing to trust an unreliable informant in comparison to children who have parents with lower authoritarianism (Reifen Tagar, Federico, Lyons, Ludeke, & Koenig, 2014). Moreover, Corriveau and colleagues (2009) demonstrated that children who had a secure attachment accepted claims made by a stranger or their mother depending on the perceptual information that was available. In contrast, children with an insecure attachment either relied on their mother's claims too often if they were resistant or did not rely on their mother's claims enough if they were avoidant. Likewise, toddlers are less willing to learn a new word from a caregiver who demonstrated less sensitivity and responsiveness (Brooker & Poulin-Dubois, 2013b). Finally, temperament (i.e., affect/extraversion) has been shown to predict young children's selective social learning (Canfield, Saudino, & Ganea, 2015).

In summary, the ability to learn from reliable sources of information is a critical skill for infants to develop. This is the first study to show that infants as young as 18-months choose to learn a new word from the reliable informant when two informants are presented to them who provide conflicting information. Furthermore, this research provides important implications for understanding how infants selectively learn from others. Specifically, the findings of the present study add to a growing body of literature demonstrating that infants' ability to infer others' knowledge state is related to their selective social learning. In other words, infants' ability to infer ignorance may be guiding their unwillingness to learn from unreliable informants. This study directly contributes to the controversial debate providing evidence that selective social learning is a mature and precocious ability in infancy. Future research should examine other domain-specific and domain-general mechanisms, such as metacognition and causal learning, in order to obtain a more comprehensive understanding of the nature of infants' selective social learning.

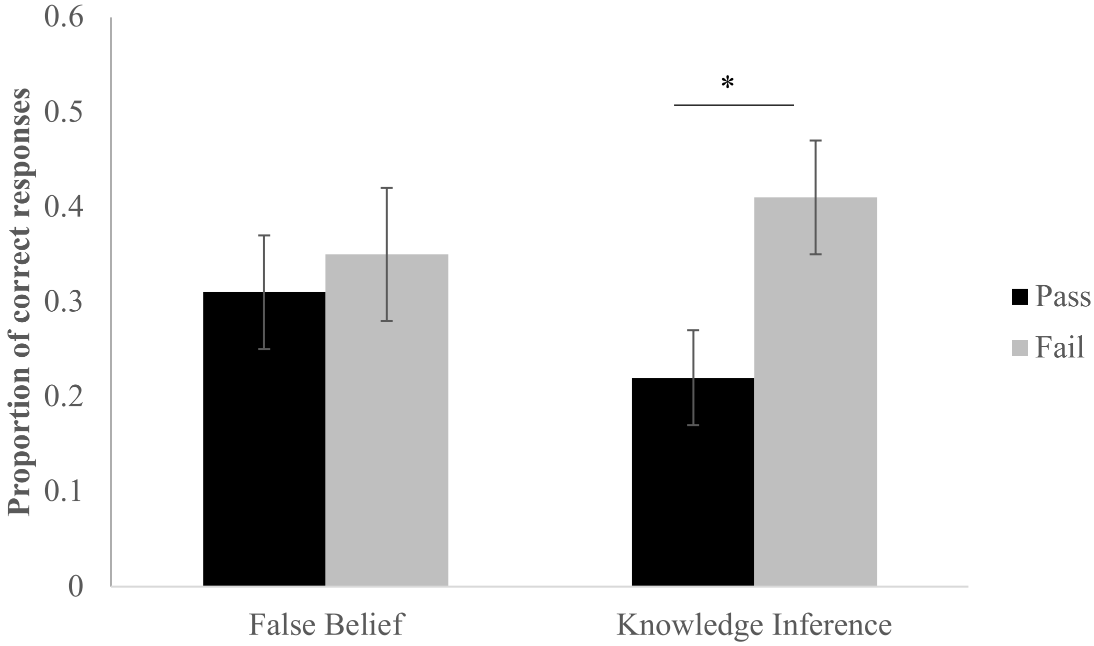

Figure 5. Proportion of correct responses in the unreliable block on the word learning task as a function of infants' score on the theory of mind tasks.

General Discussion

Throughout their development, children often engage in social learning as there are many advantages of learning from others' expertise and knowledge (Einav & Robinson, 2014; Stephens, Suarez, & Koenig, 2015). However, although people typically offer information that is true, in some cases, they can provide misleading and/or inaccurate information (Einav & Robinson, 2014; Poulin-Dubois & Brosseau-Liard, 2016). Therefore, in order to take full advantage of social learning, children need to be able to evaluate the reliability or accuracy of informants and select reliable sources of information – that is, engage in selective social learning (Einav & Robinson, 2014; Koenig & Sabbagh, 2013). Selective social learning has been a popular topic of study in the past decade in developmental science. Several studies demonstrate that both children and infants prefer to learn from reliable sources of information (see reviews by Harris et al., 2018; Mills, 2013 and Poulin-Dubois & Brosseau-Liard, 2016). Although most of the research has focused on "who" infants selectively learn from and "when" this ability begins, "how" infants engage in such selectivity is an area of research that needs to further be explored. It particularly needs more attention given the hot debate on the putative mechanisms underlying infants' selective social learning (Heyes, 2017; Poulin-Dubois, 2017; Sabbagh et al., 2017; Sobel & Kushnir, 2013). A rich view posits that infants' selective social learning is guided by domain-specific, sophisticated abilities, whereas the lean view posits that it is based on domain-general, low-level cognitive abilities. While some research on the mechanisms of selective social learning is available to account for selective trust in preschoolers, this has yet to be explored in infancy. Providing empirical evidence to contribute to this debate would help us better understand the depth of infants' selective social learning.

Research Goals and Overview of Findings

The main goal of the present dissertation was to investigate the psychological mechanisms underlying infants' selective social learning. Specifically, it was of interest to explore whether domain-specific abilities, such as theory of mind, and/or domain-general abilities, such as statistical learning and associative learning, were involved in this ability. Study 1 (Crivello, Phillips, & Poulin-Dubois, 2017) examined this research question by investigating whether infants' selective social learning was related to their false belief, knowledge inference, or statistical learning skills. First, 18-month-olds were exposed to a reliable speaker or an unreliable speaker, followed by a word-learning task. Based on previous research (Brooker & Poulin-Dubois, 2013a; Koenig & Woodward, 2010; Krogh-Jespersen & Echols, 2012), it was expected that infants in the reliable condition would be more likely to learn a novel word in comparison to those in the unreliable condition. Infants also completed two theory of mind tasks (false belief and knowledge inference) and a statistical learning task in order to examine potential mechanisms. Although exploratory, hypotheses regarding the mechanisms were as follows: If infants' selective social learning is guided by domain-specific abilities, then those who demonstrate superior performance on the theory of mind tasks should be more selective word learners (i.e., learn less from the unreliable speaker). This would support a rich interpretation of infants' selective social learning. On the other hand, if infants use more domain-general abilities to selectively learn from others, then infants who have better statistical learning abilities should be less likely to learn from the unreliable speaker. This would support the lean interpretation of infants' selective social learning. It is important to note that if such an effect exists, we expected that it would only be present in the unreliable condition given that infants have been shown to learn new words without any information about the speaker's competence.

Findings of Study 1 were consistent with our first hypothesis and demonstrated evidence of selective social learning in 18-month-olds. Specifically, we found that infants were more likely to learn a new word from a reliable speaker. In terms of the results regarding the mechanisms, it was found that infants who passed a knowledge inference task were less likely to learn a new word from the unreliable speaker. Importantly, and as predicted, the effect was specific to the unreliable condition. However, infants' selective word learning was not related to infants' theory of mind abilities in general, as this finding was not replicated when examining infants' false belief abilities. No such effect was observed in the case of statistical learning. Thus, the findings of Study 1 provided partial support for a rich interpretation of infants' selective social learning.

Similar to our first study, Study 2 (Crivello & Poulin-Dubois, 2019) also examined whether domain-specific and/or domain-general abilities were related to infants' selective social learning. Three important differences in the methodology were observed. First, it was of interest to examine the mechanisms of infants' selective social learning using a different manipulation of reliability cues. Thus, instead of manipulating epistemic cues as in Study 1, we manipulated emotional congruency. Second, a different domain-general ability was examined, which was associative learning. In Study 1, infants' statistical learning was assessed through a task that required them to infer the experimenter's preference based on probabilistic cues. Although a valid measure of statistical learning, this task required infants to make inferences, which is a socio-cognitive aspect of development. In order to directly test the argument that infants, like other species such as rats and pigeons, are using very basic cognitive abilities to selectively learn from others, a very rudimentary skill shared across species was examined – associative learning. Lastly, an important difference with the first study was the age group. Specifically, 14-month-olds were tested rather than 18-month-olds in order to examine the mechanisms underlying younger infants' selective social learning, allowing us to explore whether these mechanisms are continuous across development. Thus, the main rationale for changing the age in Study 2 was to examine a possible developmental trend, as well as to examine whether younger infants may be using more basic-level abilities to guide their selectivity.

In order to examine this research question, infants observed an individual who expressed happiness while looking inside a container that was empty (incongruent emoter) or that contained a toy (congruent emoter). It was hypothesized that infants would be able to detect the individual's emotional incongruency, as demonstrated by an increase in the latency to examine the contents of the container across trials. In addition, infants' interactions with the individual in a different context was expected to be influenced by their prior experience with her. Thus, a gaze following task was administered following the emotional congruency exposure. We hypothesized that infants would be less likely to follow the gaze of the incongruent emoter. Finally, in order to examine the mechanisms underlying infants' selective trust, a knowledge inference task (modified from Study 1) and an associative learning task were administered. Given the age of the infants, we expected different findings from Study 1 regarding the mechanisms. Specifically, it was expected that infants in the incongruent condition who had superior associative learning abilities would be more selective in their behaviour. No link was expected with infants' theory of mind abilities due to their more limited skills in this domain at 14-months of age. Thus, in contrast to our first study, we expected 14-month-olds to rely on domain-general abilities rather than domain-specific abilities due to their young age. In other words, we suspected that younger infants might be using basic-level abilities to selective learn from others, but as children mature, their sophisticated socio-cognitive abilities such as the understanding of others' mental states might be more involved in their selective social learning.

The findings of Study 2 provided evidence of selective trust using an emotional congruency paradigm with 14-month-olds. Infants in the incongruent condition took significantly longer to examine the contents of the container across trials compared to infants in the congruent condition, suggesting that infants were able to detect the emotional incongruency of the experimenter. Furthermore, infants' prior exposure to the congruency of the experimenter's emotions influenced their gaze following in a subsequent context. Specifically, infants were less likely to follow the gaze of the incongruent emoter when the target object was not visible to them. These results demonstrate that infants were less likely to trust the gaze and emotional expression of the experimenter after observing her express emotions that were incongruent with the situation. Regarding the mechanisms, results were inconsistent with our prediction. In fact, similar results to Study 1 were observed, such that infants in the incongruent condition who passed the knowledge inference task demonstrated more selectivity (i.e., took longer to examine the contents of the container on the last trial). In addition, no effect was observed with domain-general abilities (i.e., associative learning). Therefore, findings from our second study provided additional support for the rich interpretation of infants' selective social learning.

Lastly, Study 3 (Crivello, Grossman, & Poulin-Dubois, 2019) continued to investigate the mechanisms of infants' selective social learning. However, in this study, a more conservative approach was used to examine infants' selective social learning – that is, a within-subjects design. In contrast to research with preschool-age children, the majority of studies examining infants' selective social learning have used a between-subject paradigm with the aim of minimizing task demands, such as utilizing fewer executive functioning abilities. Such a design would be considered a more conservative and optimal approach to investigate the nature of infants' selective social learning, as infants are required to *choose* one of two informants to learn a new word from. Thus, 18-month-old infants were presented with two informants: one who labeled familiar objects accurately and one who labeled inaccurately. A word learning task was then administered, in which infants were given the opportunity to learn a new word from the reliable and unreliable speakers. We hypothesized that infants would be more likely to learn a novel word from the reliable speaker. Knowledge inference, false belief, and associative learning tasks were also administered. In the first two studies of the current dissertation, a relation was found between infants' selective social learning and their knowledge inference abilities, as measured through Moll and Tomasello's (2007) task. It was of interest to assess infants' knowledge inference using a different task to determine whether these findings could be replicated and extended. We predicted that such a relation would exist. Specifically, we expected that infants with superior knowledge inference abilities would demonstrate more selectivity in their word learning, consistent with Study 1 and Study 2. Finding this effect with a different knowledge inference task would provide additional support for the rich interpretation. Although infants' selective social learning was linked to their performance on the knowledge inference task in Study 1, no such effect was observed with the false belief task. However, infants' poor performance on this false belief task (Buttelmann et al., 2009) may be a possible explanation for the null results. Thus, it was important to include a different false belief task in order to verify that no link exists between false belief and infants' selective social learning. Lastly, an associative learning task was administered, as it had yet to be explored with 18-month-olds' selective word learning. In general, we hypothesized that infants who performed better on the theory of mind tasks would be less likely to learn a new word from the unreliable speaker. We did not expect infants' performance on the associative learning task to be related to their word learning.

The results of Study 3 were consistent with our hypotheses. Firstly, we found evidence of selective social learning in infancy using a within-subjects design, as infants were more likely to choose the reliable speaker to learn a new word from. Next, regarding the mechanisms, we observed findings consistent with the first two studies of the dissertation. Infants who passed the knowledge inference task were less likely to learn a new word from the unreliable speaker compared to infants who failed. No effects were observed with the false belief or associative learning tasks. The findings of Study 3 provide additional evidence for the rich interpretation of infants' selective social learning.

Main Contributions

The findings of the present study contribute to the literature on selective social learning in several ways. Firstly, the results of the selective social learning tasks in each study replicate and extend previous research demonstrating that infants prefer to trust and learn from reliable sources of information (see review by Poulin-Dubois & Brosseau-Liard, 2016). Evidence of selective social learning was found in the present dissertation in both 14- and 18-month-olds by manipulating reliability cues in both the epistemic and emotional domains.

Within the epistemic domain, Studies 1 and 3 both demonstrated that infants preferred to learn a new word from a reliable speaker compared to an unreliable one. This replicates previous research showing that infants' word learning is influenced by whether the informant labeled familiar objects accurately or inaccurately (Brooker & Poulin-Dubois, 2013a; Koenig & Woodward, 2010; Krogh-Jespersen & Echols, 2012; Luchkina et al., 2018). Furthermore, Koenig and Echols (2003) demonstrated that even 16-month-old infants looked significantly longer at an unreliable speaker than at a reliable one, with several infants even attempting to correct the unreliable speaker (e.g., producing the correct label, shifting their eye gaze from object-to-human while vocalizing and pointing, shaking head "no", waving their hands, pointing to correct object such as their own shoe). According to Stephens and colleagues (2015), infants can detect messages that are in conflict with their existing knowledge, such as conflicts of meaning (e.g., labeling a ball a shoe). This conflict of meaning provokes infants to evaluate the competency of the speaker and reject their statement (Stephens et al., 2015). In order to reject such inaccurate testimony, children are required to use epistemic defense mechanisms, such as "coherence-checking" in order to compare the testimonial statement to their prior beliefs (Stephens et al., 2015).

A unique aspect of the current dissertation was the inclusion of a within-subject design to measure infants' selective social learning. The majority of the studies investigating this ability in infancy have used a between-subjects design in order to minimize task demands (i.e., minimal executive functioning abilities required). This is an important gap in the literature that requires more research as a within-subjects design is the most conservative and optimal approach to assess infants' selective behaviour. To date, only one study has used such a design, and their findings contrast with the present results (Schmid et al., 2018). Study 3 demonstrated evidence of selective word learning using a within-subject design, whereas in Schmid and colleagues' study, the results did not. However, methodological differences may explain the contrasting results, as Schmid and colleagues used an eye-tracking paradigm (i.e., an endorsement and disambiguation task). Despite the finding in our study that infants were more likely to select the reliable speaker to learn a new word from, we observed that the forced-choice paradigm was rather difficult for 18-month-olds. This may be due to the higher task demands involved in a within-subject design.

For instance, having infants select one of two informants to learn from requires superior inhibitory control and working memory abilities (Hermes, Rakoczy, & Behne, 2018). Infants are required to process an abundance of information, including remembering what each experimenter labeled as well as who was accurate and inaccurate. In addition, infants observed three experimenters during this task, which may have been distracting.

Within the emotional domain, Study 2 revealed that 14-month-olds were less likely to trust an individual who demonstrated an incongruent emotional reaction to a situation. These findings are in line with research demonstrating that infants as young as 10 months of age are able to detect incongruent emotional expressions (Chiarella & Poulin-Dubois, 2013; Hepach & Westmann, 2013; Reschke et al., 2017; Skerry & Spelke, 2014). In the second year of life, it has been shown that infants' exposure to emotional incongruency influences their subsequent behaviour with the emoter in a different context (Chiarella & Poulin-Dubois, 2018; Chow et al., 2008; Walle & Campos, 2014). For instance, recent studies demonstrated that infants are more likely to act prosocially and to empathically help a congruent emoter rather than an incongruent emoter (Chiarella & Poulin-Dubois, 2018; Walle & Campos, 2014). Taken together, the current findings reveal that infants are able to adjust their learning based on an individual's epistemic and emotional reliability.

The second main contribution of the dissertation is that the findings offer insight into the controversial debate in the literature regarding the depth of infants' selective social learning (Heyes, 2017; Poulin-Dubois, 2017; Sabbagh et al., 2017; Sobel & Kushnir, 2013). On one side of the debate, researchers theorize that infants' selective social learning is guided by domain-specific abilities, such as theory of mind (e.g., Poulin-Dubois, 2017). Theory of mind has been suggested as a cognitive mechanism underlying infants' selective social learning as children can use their understanding of others' mental states when selecting who is knowledgeable and who is deceptive (Poulin-Dubois & Brosseau-Liard, 2016). Thus, children with superior theory of mind abilities should demonstrate more selectivity (Brosseau-Liard et al., 2015). In contrast, the alternative view suggests that infants are using domain-general abilities, such as statistical learning or associative learning (e.g., Heyes, 2017). According to the lean view, other species such as rats and pigeons also engage in selective social learning, suggesting that sophisticated cognitive abilities are not responsible for the development of this ability (Heyes, 2017). Furthermore, some researchers believe that both mechanisms may be at play (Hermes, Behne, & Rakoczy, 2018; Sobel & Kushnir, 2013). For instance, Sobel and Kushnir proposed a developmental progression, in which infants may be using statistical learning abilities and then switch to higher-order abilities that allow them to infer the informant's competence once they have the conceptual knowledge. Additionally, Hermes, Behne, and Rakoczy (2018) have argued for a dual-process account of selective social learning, which suggests that children make inferences about an informant's knowledge but may use more basic cognitive abilities dependent on task demands as well as the child's executive functioning skills and conceptual background knowledge.

Taken together, the findings of all three studies that are included in the present dissertation provide support for the rich interpretation of infants' selective social learning, by demonstrating that infants' selectivity is related to domain-specific abilities, such as the precursors of theory of mind. Specifically, all three studies demonstrated that infants who passed a knowledge inference task were less likely to trust and learn from an unreliable informant using two different tasks. Thus, regardless of whether selective social learning was measured by manipulating epistemic or emotional cues, or by using a between- or a within-subject design, the results were consistent and clear: infants who had superior knowledge inference abilities were more selective in their behaviour. These striking results suggest that infants' ability to infer others' knowledge states may have helped them infer that the unreliable informant was ignorant and not knowledgeable, and therefore not a good source to trust or learn from. The findings are consistent with several studies that have shown a relation between children's theory of mind abilities and their selective social learning (Brosseau-Liard et al., 2015; DiYanni & Kelemen, 2008; DiYanni et al., 2012; Fusaro & Harris, 2008; Lucas et al., 2013; Mills & Elashi, 2014). The present dissertation (Study 1) was the first to demonstrate that this link is also present in infancy.

Furthermore, the findings demonstrating an effect with knowledge inference add to a growing body of literature on how trait reasoning is involved in children's selective social learning, rather than global impression formation (e.g., halo effect), which is a leaner mechanism. Children have been shown to infer traits based on a model's past behaviour that would make them a good source of information in the future for particular tasks (Hermes et al., 2017). For example, Lutz and Keil (2002) demonstrated that 3- and 4-year-olds sought knowledge from a doctor and a car mechanic within their area of expertise. Moreover, Kushnir, Vredenburgh, and Schneider (2013) discovered that 3- and 4-year-olds asked for help from the toy fixer when fixing a toy and from the competent labeler when wanting to know the name of a toy. Other results have shown that 3- to 5-year-old children preferred to ask questions about food to adults compared to children (as adults know more about food) and ask questions about toys to children (as children know more about toys) (VanderBorght & Jaswal, 2009). More recently, Hermes and colleagues (2015) found that 4- and 5-year-olds preferred the knowledgeable individual (and avoided the inaccurate one) for knowledge-related tasks and the strong individual (and avoided the weak one) for strength-related tasks. This was only true for children who had conceptual knowledge of these traits. Overall, these studies demonstrate that children infer competencies/traits and then select the informant that is best suited for a task (Hermes, Behne, & Rakoczy, 2018). Similar to the present dissertation, based on infants' observation of the informants labeling objects, infants inferred that the unreliable informant was ignorant/not knowledgeable and therefore chose not to learn a new word from her. Likewise, infants may have inferred that the incongruent emoter was ignorant of what was inside the container (did not experience seeing = knowing as one would expect) and chose to subsequently not trust her affective and visual cues.

It is important to note that the link with performance on the knowledge inference task was specific to the unreliable condition/block in all three studies, which supported our hypotheses. One potential reason for this consistent finding is that infants are constantly exposed to individuals labeling objects accurately as well as individuals expressing emotions congruent with situations. For example, infants learn new words from these individuals in their everyday lives without the need to infer the competence of the speaker. Another potential reason may be that children have a bias to trust others; however, this bias can be overridden once children have the conceptual knowledge and executive functioning abilities to distrust an unreliable model (Hermes, Behne, & Rakoczy, 2018). Having a default to trust testimony can be adaptive, as it saves children time from having to verify everything they are told since most of what people are told is likely to be accurate (Harris et al., 2018). Individuals do occasionally say something inaccurate due to error, ignorance, or deception; yet this occurrence is rare (Jaswal & Pérez-Edgar, 2014). Having a bias to believe permits one to benefit from others' expertise and knowledge (Jaswal & Pérez-Edgar, 2014). However, according to Stephens and colleagues

(2015), children may generally accept testimony unless the speaker gives them a reason not to (e.g., mislabeling an object), in which then they can revise these testimony-based beliefs. Taken together, it may be that no effect was found in the reliable condition/block in the present dissertation as infants have a bias to trust testimony and therefore do not need much cognitive effort to trust the testimony of the reliable model. In contrast, more cognitive processing is necessary, such as inferring the informant's knowledge state, in order to mistrust the unreliable model.

Of note, only knowledge inference was related to infants' selective social learning and not other theory of mind skills, such as false belief. This was observed in Studies 1 and 3 using different knowledge inference and false belief tasks. In Study 1, infants who passed and failed Buttelmann and colleagues' (2009) false belief task performed similarly on the selective social learning task. However, this may have been due to infants' chance performance on the false belief task (55% pass rate), which is in contrast to the original results (72% pass rate). Thus, it was of importance to re-test the link between infants' false belief and selective social learning using a different false belief task in order to rule out this socio-cognitive ability as a potential mechanism. Study 3 confirmed the null results with false belief observed in Study 1 using a different task. Unfortunately, performance on this task was also not significantly different from chance (55% pass rate) and did not replicate the original study by Southgate and colleagues (2010) (75% pass rate).

The poor performance observed on the false belief tasks may be one reason why false belief was not related to infants' selective social learning in the present dissertation. It is worth pointing out that several studies have also failed to replicate Southgate and colleagues' (2010) study (Dörrenberg et al., 2018; Grosse Wiesmann et al., 2016; Király et al., 2016) and have failed or reported weak replications in the case of Buttelmann and colleagues' study (Poulin-Dubois & Yott, 2016; Priewasser et., 2018). This is part of a much larger issue; that is, a replication crisis (Poulin-Dubois et al., 2018). Many recent studies have failed to replicate all implicit false belief tasks used in infancy, including anticipatory looking and violation of expectation paradigms, as well as interactive helping paradigms (e.g., Burnside et al., 2018; Crivello & Poulin-Dubois, 2018; Dörrenberg et al., 2018; Grosse Weismann et al., 2018; Kulke et al., 2018; Powell et al., 2018; Schuwerk et al., 2018; Yott & Poulin-Dubois, 2016). Thus, researchers have yet to establish a reliable measure of infants' false belief understanding. Fortunately, a large multisite project (ManyBabies 2) is underway with the goal of promoting reproducibility and best practices in infancy research and more specifically theory of mind.

Another reason for the null results may be that false belief is a rather shallow concept in infancy. In fact, implicit false belief understanding has been heavily debated in the literature (Poulin-Dubois & Yott, 2017). According to the rich view, it is believed that infants' false belief abilities are comparable to those of preschoolers and adults, except they are masked by task demands (Carruthers, 2013; Baillargeon et al., 2016). In contrast, researchers adopting a lean view argue that performance on implicit false beliefs tasks are based on low-level novelty (Heyes, 2014) or a violation of behavioural rules (Ruffman, 2014; Ruffman & Perner, 2005), suggesting that infants do not have a mentalistic false belief understanding. The aforementioned non-replications support the lean interpretation as they cast doubt on the robustness and reliability of infants' false belief abilities. In other words, the lack of effect with false belief may be due to the lack of depth of this ability in infancy. According to Tomasello (2018), infants and apes pass implicit false belief tasks using socio-cognitive skills that are also used in other tasks not measuring false belief. For example, they can predict an agent's behaviour based on what the agent sees and therefore knows (i.e., seeing = knowing). That is, implicit false belief tasks are measuring infants' ability to infer knowledge based on what an agent sees, rather than their ability to infer that an agent has a false belief. However, if this were true, then we would expect infants' performance on the false belief tasks in the present dissertation to be related to their selective social learning as is the case with the knowledge inference tasks that measure seeing equals knowing. Our findings do not seem to support this view as no link was present with the false belief tasks.

Lastly, an additional reason for the null findings with false belief may be that infants' false belief abilities are not the best predictor of their selective social learning. Instead, infants' ability to infer others' knowledge states, rather than their ability to infer others' false beliefs, is a much stronger predictor. Results from Studies 1 and 3 support this hypothesis. Specifically, when examining infants' selective word learning as a function of their performance on the theory of mind tasks, the knowledge inference task had an effect size that was three and five times greater than the false belief task in Study 1 and Study 3, respectively.

Finally, results from all three studies in the present dissertation ruled out domain-general mechanisms (i.e., statistical learning and associative learning) as playing a role in selective social learning, providing no support for a lean interpretation of infants' selective social learning. The present dissertation was the first to examine the relation between these domain-general abilities and infants' selective behaviour. Since then, a recent study also ruled out an associative learning mechanism for 18-month-olds' selective word learning (Luchkina et al., 2018). Specifically, when the speakers asked questions instead of statements using the accurate and inaccurate labels of the objects, infants inferred that neither informant was reliable. This study indicates that infants did not use associative learning mechanisms, but instead used epistemic competence to evaluate the speaker. Taken together, infants in the present studies were not using statistical regularities or object-label associations to select whom to learn a new word from, nor were they using situation-emotion associations to decide whom they should trust. The lack of relation with performance on the statistical learning task and associative learning task does not support Heyes' (2017) arguments that infants are using very basic cognitive abilities that are shared with other species in order to selectively learn from others. This provides further support for the rich interpretation of infants' selective social learning. In other words, infants' selective social learning may already be a form of cultural learning.

Overall, the findings of the present dissertation have important implications for young children's social-cognitive development. Young children, including infants, constantly rely on information from others, however this information may be false or deceptive (Poulin-Dubois & Brosseau-Liard, 2016; Stengelin, Grueneisen, & Tomasello, 2018). Consequently, young children need to be vigilant when trusting others and identify those who can and are willing to provide accurate information (Sperber et al., 2010). Poor selective social learning abilities may bring about negative consequences in children's social development (Mills, 2013). For example, children who have very high trust beliefs (i.e., are naïve in believing that others will always keep their promises) and children who have very low trust beliefs (i.e., are cynical in believing that others will not keep their promises) in their peers and best friends have been shown to have more internalized maladjustment (e.g., depression, anxiety, loneliness) and social exclusion, as well as less self-perceived acceptance and social preference (Rotenberg, Boulton, & Fox, 2005). According to Mills (2013), believing in inaccurate information may also cause educational consequences (e.g., errors on a test by believing that Wikipedia is a reliable source of information), interpersonal consequences (e.g., having an argument with a peer due to believing a rumour to be true), and health-related consequences (e.g., making decisions about one's health based on information provided by a questionable website). Thus, examining the individual differences underlying this ability is essential. This research provides strong evidence that infants with superior socio-cognitive abilities, such as knowledge inference, are more critical and selective from whom they learn. Therefore, it may be that young children are more likely to take a critical stance by improving their ability to infer the epistemic states of others.

Limitations and Future Directions

There are a number of limitations to the present dissertation. One such limitation was the specific associative learning task used in Studies 2 and 3. A common measure to assess associative learning is to calculate a baseline ratio (e.g., Bhat et al., 2010), which was not possible in this set of studies due to the problematic baseline. Previous research has mainly tested associative learning in younger infants (3-6-month-olds), whereby the infant's body part (e.g., wrist, ankle) is attached to the apparatus with a string (Bhat et al., 2010; Rovee-Collier et al., 2001). In the acquisition phase, every time infants move that body part, the apparatus is activated. The baseline phase consists of a baseline measure of how many times infants move that same body part without the reward of the apparatus. As we tested older infants (14- and 18-month-olds), a large red button that infants were required to push in order to activate the toy was used, as we believed this device would be more age appropriate. Although the acquisition and extinction phase worked very well with the button, the baseline phase turned out to be problematic as infants seemed attracted to the large red button and were motivated to push the button regardless if the toy was activated or not. This may have resulted in a higher than expected frequency of pushes in the baseline phase, rendering the baseline ratio unusable to measure associative learning. In sum, pushing the button was intrinsically rewarding for the infants, which contrasted with previous studies measuring associative learning. Future research should modify the button (e.g., smaller size) or use a different task to measure associative learning and its relation to selective social learning. For instance, an associative learning task that does not have any reward in the baseline phase should be used. Nevertheless, we were able to demonstrate that infants did in fact engage in associative learning, as demonstrated through their increase in the rate of pushes across the acquisition phase. This demonstrates that they were able to learn the association between pushing the button and toy activation. Furthermore, the lack of relation between infants' associative learning and their selective social learning replicates previous research that ruled out associative learning (e.g., Luchkina et al., 2018).

Another limitation of the present dissertation was that infants' performance on the false belief tasks did not replicate previous research as their performance was not statistically significantly different from chance. This is in contrast to the original studies that developed these tasks, as they found that infants performed above chance level (Buttelmann et al., 2009; Southgate et al., 2010). It is important to note that there were slight methodological changes from Buttelmann and colleagues' procedure, such as the administration of the task at a table instead of on the floor, which may have impacted our results. These null findings are also consistent with an abundance of research demonstrating that a non-replication crisis exists in this research area (Poulin-Dubois et al., in press). This includes previous non-replications of current false belief tasks used in this dissertation (Yott & Poulin-Dubois, 2016; Dörrenberg et al., 2018; Grosse Wiesmann et al., 2016; Király et al., 2016). Despite the lack of replication of the original false belief tasks, the distribution of scores was optimal as one would need balanced sample sizes to compare infants who passed and failed this task. Since we used two interactive false belief tasks that were not replicated, future research should assess infants' false belief and its relation to their selective social learning using other paradigms, such as anticipatory looking or violation of expectation.

An additional limitation, as mentioned in Study 2, was that there may have been a confound of not having a toy in the container in the Reliability Exposure Task. A leaner interpretation of the selective trust results is that infants took longer to begin examining the contents of the container because they quickly learned that it was empty. However, this explanation does not seem plausible as the gradual increase of the latency to examine the contents of the container was linked to infants' knowledge inference skills. These findings are consistent with results from Studies 1 and 3, which demonstrated that 18-month-olds with superior knowledge inference abilities were more selective on a word learning task. Why would theory of mind abilities be related to infants' lack of interest in examining the contents of an empty container? This issue remains to be explored. In an attempt to control for the confound of an absence of reward, a future study could manipulate both negative and positive emotional displays in a 2 (toy/no toy) X 3 (happy, neutral, sad) design. For instance, one could investigate infants' latency to examine the contents of the container after observing an experimenter express sadness when looking inside a container that is empty (congruent emoter) or that contains a toy (incongruent emoter). Infants who observed the incongruent emoter (sadness/toy in container) should take significantly longer to examine the contents of the container compared to infants who observed the congruent emoter (sadness/no toy). This would rule out the explanation that the behaviors in this task are confounded with the presence or absence of a reward in the container.

Another potential limitation was the forced-choice word learning paradigm used in Study 3. Using a within-subject design to test infants' selective social learning has many benefits, such as being a more conservative and optimal approach to assess this ability as well as filling a large gap in the literature. However, it was observed that the task was rather challenging for 18-month-olds. Although infants significantly preferred to learn a new word from the reliable speaker, the proportion of correct responses in the reliable block was not significantly above chance. We aimed to minimize task demands by introducing two blocks of trials in order to test their word learning from the reliable and unreliable informant separately and to re-expose them to the reliability of the speakers. Despite this re-exposure to the speaker's accuracy, it seems that there were still too many task demands. For instance, being presented with two informants and having infants select whom to choose from requires superior executive function abilities, such as working memory and inhibitory control. Future research should modify the within-subjects design to further minimize the task demands. A trial of the word learning task could be administered after each speaker labels two familiar objects. This would be repeated four times, for a total of eight exposure trials and four test trials Additionally, it could be of interest to include executive functioning measures to investigate whether infants with superior performance on these tasks would also have superior performance on the word learning task. For instance, a battery of executive functioning tasks (e.g., Carlson, 2005) could be included in future studies, however this would add to the length of the procedure, which could generate a fatigue effect. Not only would these findings help explain infants' poor performance on the word learning task, but they could also shed light on other potential mechanisms of infants' selective social learning, such as executive functioning abilities.

Lastly, an additional limitation of the present dissertation is the lack of general intelligence measure when examining the mechanisms underlying selective social learning. Despite this limitation in the first study, we used infants' vocabulary size as a component of their verbal intelligence and found no relation with their selective social learning. In addition, we did not find a relation between selective social learning and all correlate tasks, as it was specific to the knowledge inference task, suggesting specificity. Future studies should include a general intelligence measure, such as the Bayley Scales of Infant and Toddler Development – Third Edition, when examining the mechanisms of infants' selective social learning in order to control for their intellectual ability.

Furthermore, other theory of mind abilities may be at play and should therefore be investigated. Aside from examining false belief and knowledge inference abilities as potential mechanisms underlying selective social learning in infancy, future research should examine whether infants' ability to infer others' intentions is involved. According to Dunfield and Kuhlmeier (2010), infants are able to recognize specificity of intentions (Buresh & Woodward, 2006), differentiate intentional vs. accidental behaviour (Carpenter, Akhtar, & Tomasello, 1998; Olineck & Poulin-Dubois, 2009), as well as distinguish someone who is unwilling vs. unable (Behne, Carpenter, Call, & Tomasello, 2005). In fact, Dunfield and Kuhlmeier (2010) found that 21-month-olds preferred to help an individual who intended to give them a desired object compared to an individual who did not, demonstrating that the individual's positive intention influenced their prosocial behaviour towards that individual in subsequent interactions. With regard to selective social learning, researchers argue that children use both competence and intentions when inferring the reliability of an informant (Shafto, Eaves, Navarro, & Perfors, 2012; Vanderbilt, Liu, & Heyman, 2011). This is an important cue as individuals can intentionally provide inaccurate and misleading information (Stengelin, Grueneisen, & Tomasello, 2018). A recent study demonstrated that 12- to 15-month-old infants can understand deceptive intentions and are less likely to trust a deceptive but knowledgeable individual than one who is helpful and knowledgeable (Varró-Horváth, Dorn, & Lábadi, 2017). Given the importance of understanding communicative intent, a next step in examining the mechanisms underlying infants' selective social learning could be to investigate its relation with infants' intention understanding (e.g., Meltzoff, 1995).

Future research should also continue to explore individual differences involved in selective social learning. Heyes (2016) argues that meta-cognition may guide older children and adults' selective social learning due to their experience with social interaction, and that such abilities are absent in infancy. Metacognition may be a mechanism involved in selective social learning, as one may need to assess his or her own knowledge state in order to learn from others (Heyes, 2016; Sobel & Kushnir, 2013). Recent research in our laboratory has started to investigate meta-cognitive and causal learning abilities as potential mechanisms in infancy and found that both mechanisms might be at play (Kuzyk, Grossman, & Poulin-Dubois, 2018). Specifically, 18-month-olds who demonstrated less confidence in their own knowledge as well as superior causal learning skills were more likely to learn a new word from an unreliable informant. This has yet to be explored with older children. Other mechanisms of interest could be examining whether infants' attachment style and temperament underlie infants' selective social learning. Previous research has shown that 4- and 5-year-olds with a secure attachment used a flexible strategy on the selective social learning task, whereby they relied on claims from both their mother as well as from a stranger when appropriate (Corriveau et al., 2009). A different picture emerged for children with an insecure attachment. Avoidant children relied the least on their mother's claims, while resistant children overly relied on their mother's claims. Children with a disorganized attachment demonstrated a pattern of responding that was the least systematic. It could be of interest to examine whether infants would show such patterns. In addition, research has demonstrated that infants between 28 and 38 months of age with higher levels of affect/extraversion had a superior performance on a selective social learning task, indicating that aspects of temperament may be a predictor of children's selectivity (Canfield et al., 2015). This may be the case as individual differences in affect/extraversion may enhance young children's social interactions, which can then strengthen their selective social learning abilities. Alternatively, young children who have higher levels of affect/extraversion may perform better on a selective social learning task as they are more attentive and willing to engage with the experimenter. Future research should explore the relation between temperament and selective social learning in infancy.

Finally, a longitudinal design examining selective social learning in infancy and subsequently during the preschool period can shed light on the depth of infants' selective behaviour. Specifically, infants of the present study could be tested when they are 4-years of age to examine the stability of the mechanisms across development. It would be of interest to examine if infants' performance on the selective social learning task in infancy would predict preschoolers' performance on the selective social learning task, which would suggest stability of this ability across development. Such stability would provide further support for the rich interpretation of infants' selective social learning.

Conclusion

In conclusion, the current dissertation investigated the psychological mechanisms of infants' selective social learning in the epistemic and emotional domain. Evidence of selective social learning was found, as 14-month-olds were more like to trust the emotional displays of a congruent emoter and 18-month-olds were more likely to learn a new word from a reliable speaker. More importantly, all three studies demonstrated that infants with superior knowledge inference abilities were less likely to learn from and trust the unreliable model. Furthermore, domain-general abilities such as statistical learning and associative learning were consistently found to be unrelated to infants' selective social learning. These findings provide important contributions to the field of selective social learning, particularly to the controversial debate on the mechanisms underlying this ability. The results provide support for the rich interpretation of infants' selective social learning, as infants seem to be using socio-cognitive mechanisms to guide their learning. In other words, the depth of infants' selective social learning is not shallow, but rather deep.

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Appendix A: Associative Learning Analyses using the Baseline Ratio – Study 2

Associative Learning Analyses using the Baseline Ratio – Study 2

The ANOVA investigating the relation between infants' associative learning abilities and their latency to examine the content on the last trial yielded no significant interaction, $F(1, 56) = 1.01$, $p = .32$, $\eta_p^2 = .02$. Planned comparisons revealed that for infants in the incongruent condition, those who passed the associative learning task ($n = 8$, $M = 14.10$, $SD = 13.25$) took equally long to examine the content of the container on the last trial compared to infants who failed this task ($n = 23$, $M = 15.46$, $SD = 11.58$), $F(1, 56) = .20$, $p = .65$, $\eta_p^2 = .004$. There was also no significant difference between infants who passed ($n = 6$, $M = 14.22$, $SD = 11.59$) and those who failed the associative learning task in the congruent condition ($n = 23$, $M = 9.52$, $SD = 9.25$), $F(1, 56) = .90$, $p = .35$, $\eta_p^2 = .02$.

Moreover, it was of particular interest to investigate whether infants' performance on the gaze following task was related to their associative learning abilities. The ANCOVA (controlling for age) examining the link between infants' associative learning abilities and the proportion of trials in which infants followed the experimenter's gaze behind the barriers (non-visible trials) yielded no significant interaction, $F(1, 51) = .07$, $p = .80$, $\eta_p^2 = .001$. Planned comparisons revealed no statistically significant difference in following the gaze of the incongruent experimenter between infants who passed ($n = 8$, $M = .38$, $SD = .33$) and failed ($n = 21$, $M = .27$, $SD = .34$), $F(1, 51) = .43$, $p = .52$, $\eta_p^2 = .01$. Similar findings were observed in the congruent condition, such that infants who passed ($n = 5$, $M = .33$, $SD = .41$) and failed the associative task ($n = 22$, $M = .33$, $SD = .37$) followed the gaze of the congruent experimenter equally often, $F(1, 51) = .04$, $p = .84$, $\eta_p^2 = .001$.

In terms of the baseline ratio, the data were found not to be normally distributed. As a result, a log transformation was applied to the data. A Pearson correlation was computed to examine whether the baseline ratio (*M* = 2.25, *SD* = 3.88) was related to infants' performance on the reliability exposure task. No statistically significant correlation was found between infants' baseline ratio and their latency to examine the content of the container on the last trial in the incongruent condition, $r(29) = .16$, $p = .38$, or congruent condition, $r(27) = .10$, $p = .60$. Moreover, a partial correlation controlling for age revealed that infants' baseline ratio and the proportion of trials that they followed the gaze of the experimenter were not significantly correlated in the incongruent condition, $r(26) = .16$, $p = .41$, or in the congruent condition, $r(24) = .12$, $p = .56$.

Appendix B: Recruitment materials

Recruitment letter – Study 1

Recruitment letter – Study 2

Recruitment letter – Study 3

Dear parent(s),

The Cognitive and Language Development Laboratory, which is part of the Center for Research and Human Development at Concordia University, is presently conducting a study on **how children learn selectively from others.** If you have participated in a study in the past, we would like to thank you for your enthusiasm and commitment to research. Our research has been funded by federal and provincial agencies for the past twenty-five years and our team is internationally recognized for its excellent work on early child development. Our articles are frequently published in prestigious journals, such as "Infancy" and "Developmental Science". You also might have heard about our studies on national radio or on the *Discovery Channel*.

For the present study, your child will have the opportunity to participate in a few short games. In the first game, your child will observe an experimenter label familiar objects either incorrectly or correctly. Next, your child will have the opportunity to learn new words from this individual. Of interest is whether his/her prior learning experience with the experimenter will influence his/her ability to learn from her. Other tasks will involve helping an experimenter search for a toy, sharing a novel toy with an experimenter, and predicting an experimenter's preference for an object based on previous selection in a jarful of objects. **During all tasks, your child will be sitting in a child seat and you will be seated directly behind.** We will videotape the entire session and all tapes will be treated in the strictest of confidentiality.

Overall, your participation will involve approximately **one 60-minute visit** to our laboratory at the Loyola Campus of Concordia University, located at 7141 Sherbrooke Street West, in Notre-Dame-de-Grace. Appointments can be scheduled at a time which is convenient for you and your child, including weekends. Free parking is available on the campus and we offer babysitting for siblings who come to the appointment. Upon completion of the study, a Certificate of Merit for Contribution to Science will be given to your child, and you will be offered a financial compensation of 20$ for participating. A summary of the results of our study will be mailed to you once it is completed.

For the purposes of this study, we are looking for infants who are **17-19 months of age**, who hear English or French at home or at daycare, and who do not have any visual or hearing difficulties. If you are interested in having your child participate in this study, or would like any further information, please contact Cristina Crivello at (514) 848-2424 ext. 2279, or Dr. Diane Poulin-Dubois at (514) 848-2424 ext. 2219. For more information on our studies, please visit our website at http://crdh.concordia.ca/dpdlab/. We will try to contact you by telephone within a few days of receiving this letter.

We are looking forward to speaking with you in the near future.

Sincerely yours,

Diane Poulin-Dubois, Ph.D.	Olivia Kuzyk, B.A.	Cristina Crivello, M.A.
Professor	Laboratory Coordinator	Ph.D. Student
Department of Psychology	Department of Psychology	Department of Psychology

Dear parent(s),

The Cognitive and Language Development Laboratory, which is part of the Center for Research and Human Development at Concordia University, is presently conducting a study on **how children learn selectively from others.** The Commission d'Accès à l'Information du Québec has kindly given us permission to consult birth lists provided by the Agence de la santé et des services sociaux de Montréal. Your name appears on the birth list of March 2016, which indicates that you have a child of an age appropriate for our study. Our research has been funded by federal and provincial agencies for the past twenty-five years and our team is internationally recognized for its excellent work on early child development. Our articles are frequently published in prestigious journals, such as "Infancy" and "Developmental Science". You also might have heard about our studies on national radio or on the *Discovery Channel*. If you have participated in a study in the past, we would like to thank you for your enthusiasm and commitment to research.

For the present study, your child will have the opportunity to participate in a few short games. In the first game, your child will observe an experimenter display happiness while looking inside a container that either holds a toy or is empty. Next, your child will participate in a game of finding figurines hidden behind different barriers. Other tasks will involve sharing a novel toy with an experimenter and understanding cause and effect. During all tasks, your child will be sitting in a child seat and you will be seated directly behind. We will videotape the entire session and all tapes will be treated in the strictest of confidentiality.

Overall, your participation will involve approximately **one 60-minute visit** to our laboratory at the Loyola Campus of Concordia University, located at 7141 Sherbrooke Street West, in Notre-Dame-de-Grace. Appointments can be scheduled at a time which is convenient for you and your child, including weekends. Free parking is available on the campus and we offer babysitting for siblings who come to the appointment. Upon completion of the study, a Certificate of Merit for Contribution to Science will be given to your child, and you will be offered a financial compensation of 20$ for participating. A summary of the results of our study will be mailed to you once it is completed.

For the purposes of this study, we are looking for infants who are **13-15 months of age**, who hear English or French at home or at daycare, and who do not have any visual or hearing difficulties. If you are interested in having your child participate in this study, or would like any further information, please contact Cristina Crivello at (514) 848-2424 ext. 2279, or Dr. Diane Poulin-Dubois at (514) 848-2424 ext. 2219. For more information on our studies, please visit our website at http://crdh.concordia.ca/dpdlab/. We will try to contact you by telephone within a few days of receiving this letter.

We are looking forward to speaking with you in the near future.

Sincerely yours,

Diane Poulin-Dubois, Ph.D.	Sara Phillips, B.A.	Cristina Crivello, M.A.
Professor	Laboratory Coordinator	Ph.D. Student
Department of Psychology	Department of Psychology	Department of Psychology

Dear parent(s),

The Cognitive and Language Development Laboratory, which is part of the Center for Research and Human Development at Concordia University, is presently conducting a study on **how children learn selectively from others.** The Commission d'Accès à l'Information du Québec has kindly given us permission to consult birth lists provided by the Agence de la santé et des services sociaux de Montréal. Your name appears on the birth list of July 2016, which indicates that you have a child of an age appropriate for our study. Our research has been funded by federal and provincial agencies for the past twenty-five years and our team is internationally recognized for its excellent work on early child development. Our articles are frequently published in prestigious journals, such as "Infancy" and "Developmental Science". You also might have heard about our studies on national radio or on the *Discovery Channel*. If you have participated in a study in the past, we would like to thank you for your enthusiasm and commitment to research.

For the present study, your child will have the opportunity to participate in a few short games. In the first game, your child will observe an experimenter label familiar objects incorrectly and another experimenter label familiar objects correctly. Next, your child will have the opportunity to learn new words from these individuals. Of interest is whether his/her prior learning experience with the experimenters will influence his/her ability to learn from them. Other tasks will involve helping an experimenter search for her toys and understanding cause and effect. During all tasks, your child will be sitting in a child seat and you will be seated directly behind. We will videotape the entire session and all tapes will be treated in the strictest of confidentiality.

Overall, your participation will involve approximately **one 60-minute visit** to our laboratory at the Loyola Campus of Concordia University, located at 7141 Sherbrooke Street West, in Notre-Dame-de-Grace. Appointments can be scheduled at a time which is convenient for you and your child, including weekends. Free parking is available on the campus and we offer babysitting for siblings who come to the appointment. Upon completion of the study, a Certificate of Merit for Contribution to Science will be given to your child, and you will be offered a financial compensation of 20$ for participating. A summary of the results of our study will be mailed to you once it is completed.

For the purposes of this study, we are looking for infants who are **17-19 months of age**, who hear English or French at home or at daycare, and who do not have any visual or hearing difficulties. If you are interested in having your child participate in this study, or would like any further information, please contact Cristina Crivello at (514) 848-2424 ext. 2279, or Dr. Diane Poulin-Dubois at (514) 848-2424 ext. 2219. For more information on our studies, please visit our website at http://crdh.concordia.ca/dpdlab/. We will try to contact you by telephone within a few days of receiving this letter.

We are looking forward to speaking with you in the near future.

Sincerely yours,

________________________	________________________	________________________
Diane Poulin-Dubois, Ph.D.	Catherine Delisle, B.A.	Cristina Crivello, M.A.
Professor	Laboratory Coordinator	Ph.D. Student
Department of Psychology	Department of Psychology	Department of Psychology

Appendix C: Consent forms

Consent form – Study 1

Consent form – Study 2

Consent form – Study 3

Parental Consent Form

This is to state that I agree to allow my child to participate in a research project being conducted by Dr. Diane Poulin-Dubois, in collaboration with graduate student Cristina Crivello of Concordia University.

A. PURPOSE

I have been informed that the purpose of the research is to examine how children learn selectively from others.

B. PROCEDURES

For the present study, you will be invited to complete a short questionnaire about your child's vocabulary. You will also be invited to complete a short questionnaire about your own child-rearing values. Then, your child will participate in a series of short games with three female researchers. In the first game, your child will observe an experimenter label familiar objects either incorrectly or correctly. Next, your child will have the opportunity to learn new words from this individual. Of interest is whether his/her prior learning experience with the experimenter will influence his/her ability to learn from her. Other tasks will involve helping an experimenter search for her toy, sharing a novel toy with an experimenter, and making predictions based on statistical probabilities.

We will videotape your child's responses and all tapes will be treated in the strictest of confidentiality. That means that the researcher will not reveal your child's identity in any written or oral reports about the study. You and your child will be assigned a coded number, and that code will be used on all materials collected in this study. All materials and data will be stored in secure facilities in the Department of Psychology at Concordia University. Only members of the research team will have access to these facilities. Questionnaires and electronic datafiles will be identified by coded identification numbers, unique to each family. Information collected on paper (questionnaires) or videotapes (observed behaviours) will be entered into computer databases. Raw data will be kept for a minimum of 5 years. When it is time for disposal, papers will be shredded, hard-drives will be purged, and videotapes and computer disks will be magnetically erased.

As well, because we are only interested in comparing children's understanding as a function of age, no individual scores will be provided following participation. The whole session should last approximately 60 minutes. During all tasks, your child will be sitting in a child seat and you will be seated directly behind.

C. RISKS AND BENEFITS

Your child will be given a certificate of merit at the end of the session as a thank-you for his/her participation. Also, you will be offered 20$ for your participation.

There is one condition which may result in the researchers being required to break the confidentiality of your child's participation. There are no procedures in this investigation that inquire about child maltreatment directly. However, by the laws of Québec and Canada, if the researchers discover information that indicates the possibility of child maltreatment, or that your child is at risk for imminent harm, they are required to disclose this information to the appropriate agencies. If this concern emerges, the lead researcher, Dr. Diane Poulin-Dubois, will discuss the reasons for this concern with you and will advise you of what steps will have to be taken.

D. CONDITIONS OF PARTICIPATION

- I understand that I am free to withdraw my consent and discontinue my participation at any time without negative consequences, and that the experimenter will gladly answer any questions that might arise during the course of the research.
- I understand that my participation in this study is confidential (i.e. the researchers will know but will not disclose my identity).
- I understand that the data from this study may be published, though no individual scores will be reported.

I would be interested in participating in other studies with my child in the future (yes/no): ______

I HAVE CAREFULLY STUDIED THE ABOVE AND UNDERSTAND THIS AGREEMENT. I FREELY CONSENT AND VOUNTARILY AGREE TO HAVE MY CHILD PARTICIPATE IN THIS STUDY.

MY CHILD'S NAME (please print) ___________________________________

MY NAME (please print) ____

SIGNATURE __________________________ DATE ___________________

WITNESSED BY _______________________ DATE ___________________

If at any time you have questions about your rights as a research participant, you are free to contact the Research Ethics and Compliance Officer of Concordia University, at (514) 848-2424 ext 7481 or by email at ethics@alcor.concordia.ca.

____

Diane Poulin-Dubois, Ph.D.
Professor
Department of Psychology
514-848-2424 ext. 2219
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____

Cristina Crivello, M.A.
Ph.D. Student
Department of Psychology
514-848-2424 ext. 2279
dpdlab@crdh.concordia.ca

Parental Consent Form

This is to state that I agree to allow my child to participate in a research project being conducted by Dr. Diane Poulin-Dubois, in collaboration with graduate student Cristina Crivello of Concordia University.

A. PURPOSE

I have been informed that the purpose of the research is to examine how children learn selectively from others.

B. PROCEDURES

For the present study, you will be invited to complete a short questionnaire about your child's vocabulary. Then, your child will participate in a series of short games with three female researchers. In the first game, your child will observe an experimenter display happiness while looking inside a container that either holds a toy or is empty. Next, your child will participate in a game of finding figurines hidden behind different barriers. Other tasks will involve sharing a novel toy with an experimenter and understanding cause and effect. During all tasks, your child will be sitting in a child seat and you will be seated directly behind.

We will videotape your child's responses and all tapes will be treated in the strictest of confidentiality. That means that the researcher will not reveal your child's identity in any written or oral reports about the study. You and your child will be assigned a coded number, and that code will be used on all materials collected in this study. All materials and data will be stored in secure facilities in the Department of Psychology at Concordia University. Only members of the research team will have access to these facilities. Questionnaires and electronic datafiles will be identified by coded identification numbers, unique to each family. Information collected on paper (questionnaires) or videotapes (observed behaviours) will be entered into computer databases. Raw data will be kept for a minimum of 5 years. When it is time for disposal, papers will be shredded, hard-drives will be purged, and videotapes and computer disks will be magnetically erased.

As well, because we are only interested in comparing children's understanding as a function of age, no individual scores will be provided following participation. The whole session should last approximately 60 minutes. During all tasks, your child will be sitting in a child seat and you will be seated directly behind.

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D. CONDITIONS OF PARTICIPATION

- I understand that I am free to withdraw my consent and discontinue my participation at any time without negative consequences, and that the experimenter will gladly answer any questions that might arise during the course of the research.
- I understand that my participation in this study is confidential (i.e. the researchers will know but will not disclose my identity).
- I understand that the data from this study may be published, though no individual scores will be reported.

I would be interested in participating in other studies within the Centre for Research in Human Development (CRDH) with my child in the future (yes/no): ______

I HAVE CAREFULLY STUDIED THE ABOVE AND UNDERSTAND THIS AGREEMENT. I FREELY CONSENT AND VOUNTARILY AGREE TO HAVE MY CHILD PARTICIPATE IN THIS STUDY.

MY CHILD'S NAME (please print) ___________________________________

MY NAME (please print) ____

SIGNATURE __________________________ DATE ___________________

WITNESSED BY _______________________ DATE ___________________

If at any time you have questions about your rights as a research participant, you are free to contact the Research Ethics and Compliance Officer of Concordia University, at (514) 848-2424 ext 7481 or by email at ethics@alcor.concordia.ca.

____
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Parental Consent Form

This is to state that I agree to allow my child to participate in a research project being conducted by Dr. Diane Poulin-Dubois, in collaboration with graduate student Cristina Crivello of Concordia University.

A. PURPOSE

I have been informed that the purpose of the research is to examine how children decide which person is the best source of information.

B. PROCEDURES

For the present study, you will be invited to complete a short questionnaire about your child's vocabulary. Then, your child will participate in a series of short games with three female researchers. In the first game, your child will observe an experimenter label familiar objects correctly and another experimenter label familiar objects incorrectly. Next, your child will have the opportunity to learn new words from these individuals. Of interest is whether his/her prior learning experience with the experimenter will influence his/her ability to learn from her. Other tasks will involve helping an experimenter search for toys and understanding cause and effect.

We will videotape your child's responses and all tapes will be treated in the strictest of confidentiality. That means that the researcher will not reveal your child's identity in any written or oral reports about the study. You and your child will be assigned a coded number, and that code will be used on all materials collected in this study. All materials and data will be stored in secure facilities in the Department of Psychology at Concordia University. Only members of the research team will have access to these facilities. Questionnaires and electronic datafiles will be identified by coded identification numbers, unique to each family. Information collected on paper (questionnaires) or videotapes (observed behaviours) will be entered into computer databases. Raw data will be kept for a minimum of 5 years. When it is time for disposal, papers will be shredded, hard-drives will be purged, and videotapes and computer disks will be magnetically erased.

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D. CONDITIONS OF PARTICIPATION

- I understand that I am free to withdraw my consent and discontinue my participation at any time without negative consequences, and that the experimenter will gladly answer any questions that might arise during the course of the research.
- I understand that my participation in this study is confidential (i.e. the researchers will know but will not disclose my identity).
- I understand that the data from this study may be published, though no individual scores will be reported.

I would be interested in participating in other studies within the Centre for Research in Human Development (CRDH) with my child in the future (yes/no): ______

I HAVE CAREFULLY STUDIED THE ABOVE AND UNDERSTAND THIS AGREEMENT. I FREELY CONSENT AND VOUNTARILY AGREE TO HAVE MY CHILD PARTICIPATE IN THIS STUDY.

MY CHILD'S NAME (please print) ____________________________________

MY NAME (please print) ____

SIGNATURE ___________________________ DATE ___________________

WITNESSED BY ________________________ DATE ___________________

If at any time you have questions about your rights as a research participant, you are free to contact the Research Ethics and Compliance Officer of Concordia University, at (514) 848-2424 ext 7481 or by email at ethics@alcor.concordia.ca.

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Appendix D: Demographics questionnaire

The Cognitive and Language Development Laboratory
Concordia University
Participant Information

Child's Name: ______________________________ ________________________________
First Last

Child's Date of Birth: ____________________ Child's Gender: ☐ M ☐ F
MM / DD / YY

Basic Family Information

Parent A's Full Name: ______________________ ________________________ ☐ **M** ☐ **F**
First **Last**

Parent B's Full Name: ______________________ ________________________ ☐ **M** ☐ **F**
First **Last**

Address (including **postal code**):

____

____

Phone numbers	**Where?** (e.g. home, Mom work, Dad cell)
1.	
2.	
3.	
4.	
5.	

E-mail: ____

Does your child have any siblings?

Name of Sibling	**Date of Birth** MM / DD / YY	**Gender**	**Can we contact you for future studies for this child?**
		M F	☐ **Yes** ☐ **No**
		M F	☐ **Yes** ☐ **No**
		M F	☐ **Yes** ☐ **No**

<u>Languages Spoken in the Home, School, or Childcare Setting</u>

Note. Total of all languages should add up to 100%.

What percent of the time does your child hear **English**? _________ **%**

What percent of the time does your child hear **French?** _________ **%**

What percent of the time does your child hear **another language**? _________ **%**
Please specify this language**:** ________________________

Has the child lived/vacationed in any country **where s/he would hear a language other than English or French**? ☐ **Yes** ☐ **No**
If yes, please detail (when, where, and for how long?) _________________________________

<u>Health History</u>

What was your child's birth weight? __ __ **lbs** __ __ **oz** OR __ __ __ __ **grams**

How many weeks was your pregnancy? ____________**weeks**

Were there any **complications** during the pregnancy? ☐ **Yes** ☐ **No**
If yes please detail ____

Has your child had any major **medical problems**?
If yes please detail____

Does your child have any **hearing or vision problems**?
If yes please detail____

Does your child **<u>currently</u>** have an ear infection? ☐ **Yes** ☐ **No**

Has your child had any ear infections **<u>in the past</u>**? ☐ **Yes** ☐ **No**
If yes at which ages____

Does your child have a **cold** today? ☐ **Yes** ☐ **No**

If yes, does he/she have pressure/pain in ears (if known)? ☐ **Yes** ☐ **No**

Is there any other relevant information we should know (health or language-related)?

____

Has another university contacted you to participate in one of their studies? ☐ **Yes** ☐ **No**
If yes, which university? _________________________________

Family and Child Background Information (optional)

Parent A's Marital Status:

- ☐ Married
- ☐ Separated
- ☐ Remarried
- ☐ Single
- ☐ Divorced
- ☐ Common Law
- ☐ Widow
- ☐ Other

Parent B's Marital Status

- ☐ Married
- ☐ Separated
- ☐ Remarried
- ☐ Single
- ☐ Divorced
- ☐ Common Law
- ☐ Widow
- ☐ Other

Parent A's Current Level of Education
Check any/all that apply:

- ☐ Primary School
- ☐ Some High School
- ☐ High School
- ☐ Some College/University
- ☐ College Certificate/Diploma
- ☐ Trade School Diploma
- ☐ Bachelor's Degree
- ☐ Master's Degree
- ☐ Doctoral Degree
- ☐ Professional Degree
- ☐ Not Applicable/Unknown
- ☐ Other (please specify): _____________

Parent B's Current Level of Education
Check any/all that apply:

- ☐ Primary School
- ☐ Some High School
- ☐ High School
- ☐ Some College/University
- ☐ College Certificate/Diploma
- ☐ Trade School Diploma
- ☐ Bachelor's Degree
- ☐ Master's Degree
- ☐ Doctoral Degree
- ☐ Professional Degree
- ☐ Not Applicable/Unknown
- ☐ Other (please specify): _____________

Parent A's Occupational Status (optional)
Check any/all that apply:

- ☐ Employed Full-Time
- ☐ Employed Part-Time
- ☐ Stay-at-Home-Parent
- ☐ Student
- ☐ Unemployed
- ☐ Not Applicable/Unknown
- ☐ On Temporary Leave (e.g., maternity, paternity, sick, etc.; **please also check status when *not* on leave**)
- ☐ Other (please specify): ____________________________
- ☐ Occupation: _________________

Parent B's Occupational Status (optional)
Check any/all that apply:

- ☐ Employed Full-Time
- ☐ Employed Part-Time
- ☐ Stay-at-Home-Parent
- ☐ Student
- ☐ Unemployed
- ☐ Not Applicable/Unknown
- ☐ On Temporary Leave (e.g., maternity, paternity, sick, etc.; **please also check status when *not* on leave**)
- ☐ Other (please specify): ______________________________
- ☐ Occupation: ___________________

In which of the following ranges does your annual household income fall (per year/before taxes)?

- [ ] < $ 22 000
- [ ] Between $22,000 and $35 000
- [ ] Between $35 000 and $50 000
- [ ] Between $50 000 and $75 000
- [ ] Between $75 000 and $100 000
- [ ] Between $100 000 and $150 000
- [ ] > $150 000

What language(s) community do you (and your partner) identify with? Check any/all that apply:

- [ ] Anglophone
- [ ] Francophone
- [ ] Allophone
- [ ] Other (please specify): ______________________________

What are your child's ethnic origins? Check any/all that apply:

- [ ] Aboriginal
- [ ] African
- [ ] Arab
- [ ] West Asian
- [ ] South Asian
- [ ] East and Southeast Asian
- [ ] Caribbean
- [ ] European
- [ ] Latin/Central/South American
- [ ] Pacific Islands
- [ ] Canadian
- [ ] Not Applicable/Unknown
- [ ] Other (please specify): ______________________________

What culture(s) do you (and your partner) identify with? Check any/all that apply:

- [ ] Aboriginal
- [ ] African
- [ ] Arab
- [ ] West Asian
- [ ] South Asian
- [ ] East and Southeast Asian
- [ ] Caribbean
- [ ] European
- [ ] Latin/Central/South American
- [ ] Pacific Islands
- [ ] Canadian/American
- [ ] Not Applicable/Unknown
- [ ] Other (please specify): ______________________________

Appendix E: Coding forms

Coding form for the word learning task – Study 1

Coding form for the false belief task – Study 1

Coding form for the knowledge inference task – Study 1 and 2

Coding form for the statistical learning task – Study 1

Coding form for the reliability exposure task – Study 2

Coding form for the gaze following task – Study 2

Coding form for word learning task – Study 3

Coding form for the false belief task – Study 3

Coding form for the knowledge inference task – Study 3

Word Learning Task – Study 1

ID:____________ Lap Baby: Y N Coded by: ___________________________

Comments:____
____

Condition: Unreliable Reliable

Order: ____ **Include:** **Yes** **No** **Reason for Ex**__________________________________

Trial		**Response**	**Correct (Y or N)**	**Trial Type**
1	1st Toy Touched 1st Toy Offered	____________	____________	**F N**
2	1st Toy Touched 1st Toy Offered	____________	____________	**F N**
3	1st Toy Touched 1st Toy Offered	____________	____________	**F N**
4	1st Toy Touched 1st Toy Offered	____________	____________	**F N**
5	1st Toy Touched 1st Toy Offered	____________	____________	**F N**
6	1st Toy Touched 1st Toy Offered	____________	____________	**F N**
7	1st Toy Touched 1st Toy Offered	____________	____________	**F N**
8	1st Toy Touched 1st Toy Offered	____________	____________	**F N**

*F denotes familiar object trial
N denotes novel object trial

Word Learning Task – Study 1

Condition	Correct Object
Novel	
Familiar	

Totals	Correct	Incorrect	Score
Novel			
Familiar			

Did the child disengage from their toy and look at the object being labeled?

Labeling Object	Yes	No
1st time		
2nd time		
3rd time		
4th time		

False Belief Task – Study 1

ID:___________ Lap Baby: Y N Coded by: ___________________________

Comments:____
____

Order: ____ Include: Yes No Reason for Ex________________________________

Did child open boxes during training?	Colour and location of box where E1 first places toy	Colour and location of box where E2 hides toy
Orange: Yes No Green: Yes No	Colour: Orange Green Location: Left Right	Colour: Orange Green Location: Left Right

Response	Score
First touch: ___________	Pass Fail
First open: ___________	Pass Fail

Knowledge Inference Task – Study 1 and 2

ID:____________ Lap Baby: Y N Coded by: ____________________________

Comments:____

Order: ____ Include: Yes No Reason for Ex___________________________________

Target: Hose Bird cage Abacus

Pretest: Did child touch the toy?	Pretest: Score
Ball: Yes No	Pass Fail
Teddy: Yes No	Pass Fail
Car: Yes No	Pass Fail

Test: Response	Test: Score
First Touch: ____________	Pass Fail
First Offer: _____________	Pass Fail

Statistical Learning Task – Study 1

ID:____________ Lap Baby: Y N Coded by: ___________________________

Comments:____
____

Order: ____ Include: Yes No Reason for Ex___________________________________

Trial 1 Minority Majority

Toys: 31: ________________ 7: ________________ Toy chosen: ________________

Test: Response	Test: Score
First touch: _____________	Pass Fail
First offer: _____________	Pass Fail

Trial 2 Minority Majority

Toys: 31: ________________ 7: ________________ Toy chosen: ________________

Test: Response	Test: Score
First touch: _____________	Pass Fail
First offer: _____________	Pass Fail

Reliability Exposure Task – Study 2

ID:___________ Lap Baby: Y N Coded by: ________________________

Comments:____
____

Include: Yes No Reason for Ex______________________________

Warm-up Phase:

Trial	Opened lid (Y or N)	Examine content (Y or N)
1	___________	___________
2	___________	___________

Training Phase:

Examination Score: ______ / 4 trials

Trial	Open Lid (Y or N)	Examined Content (Y or N)	Latency to touch lid	Latency to open lid	Latency to examine content	Pushed away (Y or N)	# of times pushed away	No response (Y or N)
1	_______	_______	_______	_______	_______	_______	_______	_______
2	_______	_______	_______	_______	_______	_______	_______	_______
3	_______	_______	_______	_______	_______	_______	_______	_______
4	_______	_______	_______	_______	_______	_______	_______	_______

***Begin timing right after the experimenter says, "Now it's your turn" and places the container in front of child.**

** Examination of content: peeking into container, leaning forward and looking down at the container, or putting hand inside the container

Gaze Following Task – Study 2

ID:____________ Lap Baby: Y N Coded by: ___________________________

Comments:____

Include: Yes No Reason for Ex___________________________________

CONTROL

Blue Wall:	☐ Yes ☐ No
Orange Wall:	☐ Yes ☐ No
Red Bucket:	☐ Yes ☐ No
Yellow Box:	☐ Yes ☐ No

EXPERIMENTAL

Blue Wall:	☐ Yes ☐ No
Orange Wall:	☐ Yes ☐ No
Red Bucket:	☐ Yes ☐ No
Yellow Box:	☐ Yes ☐ No

Word Learning Task – Study 3

ID:___________ Lap Baby: Y N Coded by: ___________________________

Comments:____
____

Order: ____ Include: Yes No Reason for Ex________________________________

Target object: __________________

Trial		**Response**	**Correct (Y or N)**	**Question Asked?**
1	1st Toy Touched 1st Toy Offered	___________	___________	**Dax Fep**
2	1st Toy Touched 1st Toy Offered	___________	___________	**Dax Fep**
3	1st Toy Touched 1st Toy Offered	___________	___________	**Dax Fep**
4	1st Toy Touched 1st Toy Offered	___________	___________	**Dax Fep**
5	1st Toy Touched 1st Toy Offered	___________	___________	**Dax Fep**
6	1st Toy Touched 1st Toy Offered	___________	___________	**Dax Fep**

Total number of correct trials using **reliable** label: ____________

Total number of completed trials (**reliable**): ____________

Proportion of correct trials using **reliable** label: ____________

Total number of correct trials using **unreliable** label: ____________

Total number of completed trials (**unreliable**): ____________

Proportion of correct trials using **unreliable** label: ____________

Word Learning Task – Study 3

*Did the child disengage from their toy and look at the object being labeled as a **DAX**?*

Labeling Object	Block 1	Block 2
1st time		
2nd time		
3rd time		
4th time		

*Did the child disengage from their toy and look at the object being labeled as a **FEP**?*

Labeling Object	Block 1	Block 2
1st time		
2nd time		
3rd time		
4th time		

False Belief Task – Study 3

ID:____________ Coded by: ______________________________

Comments:____
____

Order: ____ Include: Yes No Reason for Ex___________________________________

Warm-up	Colour and location of box where E1 first places toy	Colour and location of box where E2 hides toy
Duck: Yes No Teddy: Yes No # of trials: ______	Colour: Orange Black Location: Left Right	Colour: Orange Black Location: Left Right

Response	Score
First approach/point: ___________	Pass Fail

Knowledge Inference Task – Study 3

ID:___________ Coded by: ___________________________

Comments:____
____

Order: ____ Include: Yes No Reason for Ex________________________________

Trials	Include	Target	Object – Approach	Score	Wiggly	Attentive	Comments
1	Y N	__________	__________	Pass Fail	Y N	Y N	______________________ ______________________
2	Y N	__________	__________	Pass Fail	Y N	Y N	______________________ ______________________
3	Y N	__________	__________	Pass Fail	Y N	Y N	______________________ ______________________
4	Y N	__________	__________	Pass Fail	Y N	Y N	______________________ ______________________

Proportion to target: __________
Proportion to distractor: __________

Score: Pass Fail