Development of Social Learning in Infants and Young Children

Thesis submitted in partial fulfilment of the requirements for the degree of Doctor of Philosophy by

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Abstract

Social learning is one important way that children learn about the world. This thesis presents and discusses several current social learning theories, exploring how they explain different facets of social learning. In particular, I examined the naïve theory of rational action, the theory of natural pedagogy, the ideomotor approach to social and imitative learning, and the normative account of social learning. Each theory is reviewed on how it explains four facets of social learning: imitation, emulation, action understanding or interpretation, and the consideration of varying social and situational circumstances. The review shows that each theory focuses on only one or two facets, often providing very limited discussion (if any) of the others, and none of the theories systematically varies its predictions of a learner's behaviour as a factor of multiple social and situational circumstances. By means of six empirical studies I show that the social and situational circumstances strongly influence social learning, and that none of the discussed theories can account for the findings at large. I also argue that the current social learning theories explain developmental shifts in different biases that affect social learning rather than core mechanisms of social learning, and that what is needed is a strong social learning theory that explains multiple facets of social learning, in particular making differential predictions as a factor of varying social and situational circumstances.

Keywords: social learning, imitation, emulation, tool-use

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- “Wie lernen Kinder?“ article in MRI News, January 2015.
- *“Talk* to your baby: They might understand” article in EU Horizon Magazine, May 2014.
- “Sprich mit Deinem Baby, es könnte Dich verstehen“ article in Zwergensprache Magazin, August 2014.
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Contents

Chapter 1: The Development of Social Learning in Infancy and Young Childhood

Social learning is acquiring information from others, and can involve observation and teaching. It allows for the rapid acquisition of new information, facilitates the acquisition of complex knowledge, and helps the learning of actions or behaviours that do not have immediate, obvious, or instrumental outcomes, such as cultural knowledge. It has been argued that social learning is advantageous for an individual if a sufficient amount of knowledge is learned asocially by members of the population (i.e., further knowledge is generated) and if the individual is a selective social learner (Laland, 2004). Research in cognitive and developmental science has shown that human infants and children are indeed selective social learners and flexibly switch between different types of learning.

1.1 Purpose and Structure of this Thesis

I argue in this thesis that four recent social learning theories succeed in explaining specific phenomena of social learning but they fail to account for other phenomena because they omit important influences on and *facets* of social learning. In this thesis, the term *facet* of social learning refers to (a) specific behaviours that show that an individual has learned something from another person such as imitation and emulation, (b) behaviours that are interpreted as representing cognitive mechanisms involved in the process of social learning such as gaze alternation used to infer how a learner understands the action of another person, and (c) factors that potentially influence the social learning of an individual such as attention cues from another person or, more generally, the social and situational circumstances of the learning situation.

The empirical research presented in this thesis demonstrates that some, but not all findings can be well explained by the discussed theories. I also argue and present initial empirical research that shows that the social learning theories may rather explain certain developmental peaks for a certain facet of social learning than explaining the underlying cognitive mechanisms of social learning per se.

Specifically, I discuss the naïve theory of rational action (Csibra & Gergely, 2007; Gergely & Csibra, 2003) and the theory of natural pedagogy (Csibra & Gergely, 2006, 2011; Gergely & Csibra, 2005, 2006, 2013), which were recently combined in a two systems account of social learning (Király, Csibra, & Gergely, 2013), as well as the ideomotor approach to social and imitative learning (IMAIL; Paulus, 2014a, 2014b) and the normative account of social learning (Rakoczy & Schmidt, 2013).

All these theories are connected to each other: The naïve theory of rational action was originally proposed in response to research on the *like-me* theory (Gergely, Bekkering, & Király, 2002; Meltzoff, 2005) and was later complemented by the theory of natural pedagogy (Gergely & Csibra, 2005; Király et al., 2013); IMAIL was proposed as a counter theory to the naïve theory of rational action (Paulus, Hunnius, Vissers, & Bekkering, 2011a, 2011b); and the normative account of social learning was proposed partly in reponse to the theory of natural pedagogy (Schmidt, Rakoczy, & Tomasello, 2010). The like-me theory itself was excluded from the discussion in this thesis because it focuses on the development of theory of mind skills rather than on social learning in particular and, thus, goes beyond the scope of this work.

For the purposes of this thesis, I also restrict my argumentation to four facets of social learning: imitation, emulation, action understanding or interpretation, and social and situational circumstances. Social learning is sometimes equated with, or mostly used synonymously with imitative learning (e.g., Paulus, 2014a). However, social learning is more diverse than that. Other researchers have divided social learning into, for example, stimulus enhancement, observational conditioning, and observational learning – only the latter includes imitation (e.g., Heyes, 2012). The choice of these four facets was informed by the choice of theories, as presented above: The naïve theory of rational action mainly combines action understanding with imitation and emulation; the theory of natural pedagogy mainly combines action interpretation with imitation, and, beyond that, with generalisation; IMAIL mainly combines imitation and emulation with neuronal mechanisms; the normative account mainly combines action interpretation with imitation and, beyond that, with protest.

In Chapter 2, I define key terminology of this thesis and present an overview of empirical research on social learning. In Chapter 3, I portray the main arguments of each of the four theories in detail and present an analysis on how well each theory explains the four facets. Chapter 3 also includes a broad description of further recent social learning theories that could complement the present work in future analysis. The following six studies in Chapters 4 to 10 investigated the hypothesis that social learning, as shown by means of imitation, emulation, and action understanding or interpretation, is strongly influenced by the social and situational circumstances,

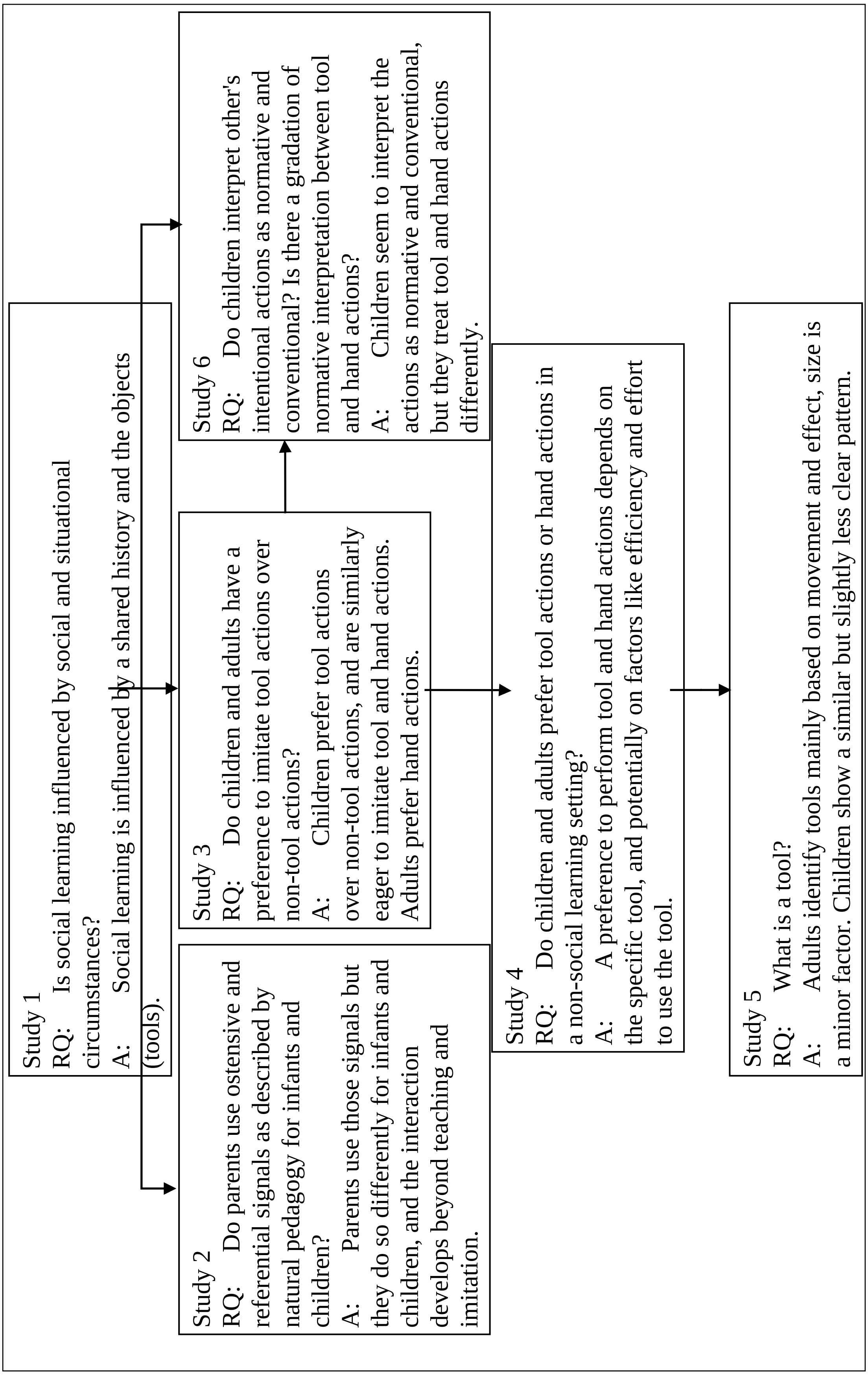


Figure 1. Overview of empirical studies in this thesis.

including the age of the learner and the objects involved in the learning situation. Figure 1 presents an overview of all studies and their relation to each other.

In Study 1 (Chapter 4), I broadly investigated the main hypothesis: social learning is influenced by the social and situational circumstances. In particular, I explored the influence of a shared history between model and learner as an example of social circumstances, and the influence of tool actions in comparison with non-tool actions, as an example of the situational circumstances (i.e., the available objects) on social learning.

As the results of Study 1 confirmed the hypothesis, Study 2 (Chapter 5) further investigated social learning of children from their parent in a natural setting. The theory of natural pedagogy proposes differences in learning outcomes, specifically in imitation behaviour, depending on the communication between model and learner; Study 2 explored whether this type of communication is indeed a natural form of interaction that is whether parents showed ostensive and referential action demonstrations in a natural interaction with their child, and Study 2 explored differences in the interaction depending on the child's age.

Study 3 (Chapter 6) also followed up on the results of Study 1 by further exploring whether children and adults showed a preference to imitate tool actions, hand actions, or non-tool actions. Differences were found between children and adults, with children being equally likely to imitate tool and hand actions but adults evidently preferring to imitate hand actions.

Study 4 (Chapter 7) continued this line of research by investigating whether adults and children preferred to use tools or their hand independently of social learning. The results of Study 4 were somewhat ambiguous for both age groups, indicating that a preference of tool or hand actions depended on the specific tool and not on whether a tool is involved per se.

Study 5 (Chapter 8) then investigated on what basis adults and children identified objects as tools. One of the motivations behind this question is whether any object can be turned into a tool or whether tool identification follows a specific pattern; Study 5 was a rudimentary investigation into this research question.

Following up on Studies 1, 2, and 3, Study 6 (Chapter 9) was designed to investigate children's normative interpretation of tool and hand actions as well as several related factors such as children's tendency to teach others and children's expectation of others' knowledge about normative actions (i.e., the conventionality of normative actions).

Chapter 10 includes an analysis of how the present empirical findings fit in with the four social learning theories and it includes a discussion of possible future directions for theoretical and empirical research on social learning in infancy and childhood.

Chapter 2: Social and Cultural Learning

The ability to learn from others enables the transmission of information across generations and thus, enables cumulative culture (Tennie, Call, & Tomasello, 2010). Cultural knowledge is one example of often complex and *cognitively opaque* information learned socially. Many of our daily actions may not have obvious or instrumental outcomes but may still be culturally important. For example, a naïve observer may not understand the reasons for the behaviour when seeing two people shake hands, but nonetheless it can be important to learn about and follow this convention when trying to establish a business relationship. Learning about cultural knowledge is one form of social learning, but social learning extends beyond this.

2.1 Definition of Key Terminology

Researchers have argued that learning by imitation is essential for maintaining human culture (e.g., Csibra & Gergely, 2006, 2009, 2011). However, imitation is defined differently by different researchers. Many accounts define imitation as an action that is sufficiently similar to, and causally connected to, a previously observed action (see Over & Carpenter, 2012; Paulus, 2011; Zmyj & Buttelmann, 2014, for an overview of different definitions). Alternative definitions of the term refer to the copying of another person's choice (e.g., the model chooses the yellow object over the blue one and the learner imitates by also choosing the yellow object; DiYanni &

Kelemen, 2008) or include mental state reasoning in copying actions (e.g., Tomasello, 1999; Tomasello, Carpenter, Call, Behne, & Moll, 2005).

For the present purposes, the analysis is limited to social learning theories that use the first definition of imitation, referring to the copying of an action using the demonstrated means without the requirement to make any inferences about the model's state of mind. As a consequence, the social learning accounts that use a different definition of imitation, for example those proposed by Tomasello and colleagues (e.g., Tomasello et al., 2005) or Meltzoff and colleagues (e.g., Meltzoff, 2005), or the social learning accounts that do not differentiate between different definitions of imitation, such as those proposed by Laland and colleagues (e.g., Laland, 2004), or Whiten and colleagues (e.g., Whiten, McGuigan, Marshall-Pescini, & Hopper, 2009) are excluded from this initial analysis.

Imitation may be observed in different forms. Copying a model's action with high fidelity is sometimes referred to as *faithful imitation* (e.g., Sakkalou, Ellis-Davies, Fowler, Hilbrink, & Gattis, 2011). *Over-imitation* refers to the reproduction of an action sequence including both causally necessary and unnecessary action steps to elicit an effect (e.g., Brugger, Lariviere, Mumme, & Bushnell, 2007; Horner & Whiten, 2005; Keupp, Behne, Zachow, Kasbohm, & Rakoczy, 2015). *Selective imitation* refers to the copying of demonstrated means to achieve a goal (i.e. imitation) under some conditions, and replication of the action goal using different means (i.e. emulation) under others (e.g., Gergely et al., 2002; Paulus, Hunnius et al., 2011a). If this pattern of copying actions and goals follows the principles of causal efficiency, it is also labelled *rational imitation* (e.g., Gergely et al., 2002). While all these forms reflect social learning, it is faithful imitation that allows for very precise transmission of information between people.

Emulation also reveals social learning. This is the copying of an action outcome using any means (e.g., Király et al., 2013; Paulus, 2011). In empirical research, children are often shown unusual actions (such as pushing a button using the forehead), with the finding that children commonly emulate (usually using the hand; Király et al., 2013). In this thesis I argue that it is important for social learning theories to account for both types of behaviour, as both show learning and children often show both emulation and imitation in these types of studies.

Understanding why another person acts in the observed way can help the learner to decide which aspects to learn from a given situation (Csibra & Gergely, 2007). The understanding of others' actions can take different forms (Uithol, van Rooij, Bekkering, & Haselager, 2011). For example, the learner may recognize the action (e.g., she takes a glass of water or she drinks) or the goal (e.g., she wants to drink or she wants to satisfy her thirst). The goal can vary on a continuum from very concrete to highly abstract; it can be a higher-order action (e.g., grasping a glass with the goal to drink water), an object (e.g., the glass of water is the goal of the grasping action), or a world state (e.g., drinking a glass of water to satisfy one's thirst; Uithol et al., 2011). It has even been proposed that understanding others' minds is causally related to social learning (e.g., Meltzoff, 2005; Tomasello et al., 2005). However, reasoning about observable actions and inferring mental states of others require differentially sophisticated cognitive skills. In this thesis I argue that accounts of social learning are most fruitful when they include a discussion of how children understand or interpret others' actions.

The social and situational circumstances under which the learning takes place are another important facet of social learning. Social learning requires an interaction between the learner and the model, and the situation of this interaction may also have an influence. The interaction can be as minimal as passive observation of the model by the learner (live or on video), or as intense as a lengthy engagement of the learner and model with each other. It can include communication as well as joint action.

The interaction, and thereby the learning, may also be influenced by more general characteristics of the learning situation. For example, the interaction and the situation may include objects (as referents of learning, as props, or as distractors). When considering what influence different types of objects could have on learning, one could for instance explore the influence of tools or tool-use in comparison to non-tool objects because tools and other cultural objects are often proposed to have a special meaning for humans (e.g., Gergely & Csibra, 2006).

The learning situation may also include any number of learners and models, and any number of bystanders. The learner may be influenced by the group affiliation of both model and bystanders (e.g., Buttelmann, Zmyj, Daum, & Carpenter, 2013). Additionally, the learner and model might have a shared history, for example mother and infant, or experimenter and participant from warm-up to test trials (see testimony literature on the influence of a very short history on learning words, e.g., Jaswal & Neely, 2006; Koenig & Harris, 2005; or see, for example, Poulin-Dubois, Brooker, & Polonia, 2011; Zmyj, Buttelmann, Carpenter, & Daum, 2010, for the influence of testimony on imitative learning).

In this thesis I argue that it is important for social learning theories to discuss and make differential predictions of learning based on the interaction between learner and model as well as the circumstances of the interaction, as both may influence the learner's subsequent behaviour in important ways (e.g., see Király et al., 2013, for the influence of communication from the model on learner's imitative behaviour, but see also Schmidt et al., 2010).

It is important to note that many theories of social learning claim to explain the acquisition of knowledge and judge their success on the basis of children's behaviour (e.g., imitation). However, learning does not necessarily require the learner to produce a behaviour; while learners could not produce a behaviour they have not learned, they can learn a behaviour that they do not subsequently produce. Some theories focus on factors that influence when learners are most likely to show what they have learned (e.g., Over & Carpenter, 2012, 2013). In this thesis, I do not go into more detail on showing what one has learned and rather focus on the acquisition of knowledge, but I suggest beyond the arguments made here that strong theories may explain both how learners acquire the knowledge and when they are most likely to exhibit their knowledge by, for example, imitating or emulating. In the following two sections, I present some prior empirical research and the social learning theories that were chosen for discussion in this thesis.

2.2 Empirical Research on Social Learning in Infancy and Young Childhood

Empirical findings on social learning in infancy and young childhood are numerous, sometimes very specific, partly contradicting, and partly controversial. Social learning has been found across all ages (e.g., see Meltzoff & Moore, 1983, for social learning in neonates; e.g., see Leighton, Bird, & Heyes, 2010, for social learning in adults), also in non-human animals (e.g., see Heyes, 2012, for an overview), and for a variety of actions and contexts (see references below). In some research, imitation findings are presented in contrast to emulation findings (e.g., Gergely et al., 2002), or in combination with findings on action interpretation (e.g., Schmidt et al., 2010).

The research mentioned in this thesis by no means presents an exhaustive list of the published research. Rather, the referenced studies represent either important pioneering studies, well-known work in the field, or studies of particular interest to the later discussed theories. In particular, research on action understanding is referenced only if it is relevant to the debated theories; the actual body of research on the topic is vastly greater than presented in this thesis. Research on the social and situational circumstances of social learning is presented within the sub-sections on imitation and emulation, and action understanding or interpretation instead of in a separate sub-section to avoid repetition.

The studies are mentioned at this point without further commentary to provide the reader with largely unbiased information on the phenomena of social learning in infancy and young childhood. Most of the mentioned studies gave rise to or further informed the theories discussed in Chapter 3, which will provide the basis for discussion in this thesis.

2.2.1 Imitation and emulation

2.2.1.1 Neonatal imitation. In some controversial studies, imitation was found very early in development: Human neonates younger than 72 hours after birth (Meltzoff & Moore, 1983) and as young as 12 to 21 days old (Meltzoff & Moore, 1977) were reported to imitate facial and, in the case of the older infants, manual gestures like tongue protrusion, mouth opening, and finger movement. Infants were also reported to show self-correction behaviour; they gradually produced more accurate matches of the demonstrated gesture and their own body posture (Meltzoff & Moore, 1983). Meltzoff and Moore (1983) argued that humans have an innate capacity to imitate. These findings represent a key element in the like-me theory

(Meltzoff, 2005) and the model of active intermodal mapping (Meltzoff & Moore, 1997), which encouraged the research that lay the foundation for the four mainly discussed theories in this thesis but which are only briefly discussed in Chapter 3.5.1 because of their focus on the development of mental reasoning rather than on social learning per se.

Recently, these findings were also challenged by a longitudinal study that indicated that infants aged 1, 3, 6, and 9 weeks old show an array of different responses to social and non-social models rather than a clear imitative response to a social model performing a facial, manual, or vocal gesture (Oostenbroek et al., 2016). Oostenbroek and colleagues (2016) argued that imitation only occurs after the age of 6 months.

Even though empirical findings on imitation in newborns and very young infants are controversial (e.g., Heyes, 2016; Kugiumutzakis & Trevarthen, 2015; Oostenbroek, Slaughter, Nielsen, & Suddendorf, 2013), most researchers would probably agree that imitation can be found early in human development, latest some months before the first birthday of a child. The early onset of imitation illustrates humans' natural predisposition to social learning.

2.2.1.2 The head-touch paradigm. In the study that introduced the head-touch paradigm, 14 months old infants imitated a number of unusual actions after a 1-week delay (Meltzoff, 1988). One of the novel actions was the head-touch action that is turning on a push-light by leaning forwards and touching it with the forehead. Meltzoff (1988) argued that infants as young as 14 months of age are capable of deferred imitation of novelty. Other researchers then investigated different influences on imitation in general and the head-touch task in particular.

In a later version of this experiment, 14-month-olds imitated the unusual head-touch when the model showed no signs as to why she used her head instead of her hands (i.e., hands-free condition), and infants emulated the action by using their hand when the model pretended to be cold and occupied her hands by holding a blanket (i.e., hands-occupied condition), thus having an obvious reason for not using her hands to touch the light (Gergely et al., 2002). Gergely and colleagues (2002) argued that infants imitated selectively based on the rationality of the action. These findings represent key empirical evidence in the formation of the naïve theory of rational action (Csibra & Gergely, 2007; Gergely & Csibra, 2003).

The selectivity of imitation of the head-touch is further determined by communication; infants were more likely to imitate the head-touch in the hands-free condition when the model demonstrated it using ostensive communication, and they rarely imitated the head-touch in both the hands-free and the hands-occupied conditions when they incidentally observed the model perform the head-touch (Király et al., 2013). Király and colleagues (2013) argued that social learning is sub served by a system that integrates two cognitive adaptations to favour rational actions and communicative actions. Indeed, infants were shown to be receptive to ostensive communication from as young as 6 months of age (Senju & Csibra, 2008). These findings represent a key element in the theory of natural pedagogy (Csibra & Gergely, 2006, 2011; Gergely & Csibra, 2005, 2006, 2013).

Additionally, the influence of the presence of the model during knowledge retrieval and the length of a delay on infants' imitation of the head-touch were investigated. Infants received the touch-light to play with either in the presence of the model or while alone with their mother, after a delay of 1 week or 10 min after the demonstration of the head-touch (Király et al., 2013). Neither the presence of the model nor the length of the delay influenced 14-month-olds' imitation pattern.

Király and colleagues (2013) argued that imitation seems to be independent of social cueing during knowledge retrieval and thus serves an epistemic motive (although Király et al., 2013, do not exclude social influences for other age groups and situations).

In again another version of the head-touch paradigm, 14-month-olds showed high imitation rates only when the model put her hands on the table as if to support her own weight while leaning forward to perform the head-touch and the action elicited a salient effect; infants rarely imitated the head-touch when the model crossed her hands in front of her chest or when the action failed to elicit an effect (Paulus, Hunnius, et al., 2011a). Paulus and colleagues (Paulus, Hunnius, et al., 2011a, 2011b) argued that both the way a model performs her action and the subsequent salient effect are crucial factors that enable infants to imitate. These findings represent a key element in the ideomotor approach to social and imitative learning (Paulus, 2014a, 2014b).

In other studies, infants also did not imitate the action when the model's head-touch did not elicit the light effect; for example, the experimenter bent forward until his forehead was in close proximity but never actually touched the light (Király et al., 2013). Csibra and colleagues (Gergely & Csibra, 2005; Király et al., 2013) argued that a person performing an unusual action that has no obvious effect might be completely unintelligible for infants. They concluded that infants may imitate even though the rationality of the action remains cognitively opaque but that the action needs a goal to help the learner identify the relevant aspects to be learned (Gergely & Csibra, 2005; Király et al., 2013).

Furthermore, when 14 months old infants observed more than one action as a means to achieve the goal, for example the model performed the head-touch and also used her hand to switch on the light, they imitated only the more efficient hand action (Gergely & Csibra, 2005). Gergely and Csibra (2005) argued that infants interpreted both actions as equally culturally acceptable and chose the action to be learned based on efficiency. Similarly, when 18 months old infants already knew a more efficient means to the goal, in this case they discovered that the push-light could be illuminated by pressing it with their hand prior to the ostensively communicated demonstration of the head-touch, they were less likely to imitate the head-touch than infants who did not explore the push-light and discover the hand action before the demonstration (Pinkham & Jaswal, 2011). Pinkham and Jaswal (2011) argued that infants prioritize efficient actions over communicative actions when deciding what to learn.

Importantly, in the different versions of the head-touch paradigm (Gergely et al., 2002; Gergely & Csibra, 2005; Paulus, Hunnius, et al., 2011b), infants frequently emulated the head-touch using their hand to illuminate the light irrespective of condition, and in most cases, infants used their hand prior to using their head (Király et al., 2013). Furthermore, even though imitation of actions (i.e., in contrast to, for instance, copying a model's choice of object) is often referred to as *faithful imitation*, and the head-touch paradigm is commonly used as the prime example of imitation, infants imitated the head-touch in the majority of cases with low fidelity using, for instance, their mouth, nose, or cheeks instead of the forehead to touch the push-light (Király et al., 2013).

In summary, the head-touch task emerged as a common paradigm to investigate social learning in infants. Findings from the head-touch paradigm were used in the development of influential social learning theories, such as the naïve theory of rational action and the theory of natural pedagogy. The empirical research reported in this thesis also included the head-touch task in some studies (see Chapters 4 and 6).

2.2.1.3 Over-imitation. Further studies investigated the copying of steps in an action sequence. If the sequence includes causally necessary and causally irrelevant action steps in eliciting an effect, the imitation of all action steps is commonly referred to as over-imitation.

Fifteen-month-olds imitated both actions of a two-step action sequence if (a) both actions were causally necessary to elicit an effect or (b) only the second action was necessary but the first unnecessary action was socially cued (Brugger et al., 2007). Brugger and colleagues (2007) argued that prior knowledge about the physical world (i.e., knowing which actions are causally necessary) as well as social cues influenced infants' imitative behaviour.

In contrast, 3 to 4 years old children imitated clearly unnecessary actions in an action sequence (Horner & Whiten, 2005). Chimpanzees showed a pattern similar to the infants in the study by Brugger and colleagues (2007); they imitated multiple actions in a sequence if the causal necessity of the actions was unclear, but chimpanzees imitated only the necessary actions and omitted the unnecessary actions if the causal necessity was discernible (Horner & Whiten, 2005). Horner and Whiten argued that chimpanzees' imitative and emulative behaviour was determined by the availability of causal information and a bias to act efficiently, whereas social learning in children was not influenced by the availability of causal information with a tendency to over-imitate.

Further research on over-imitation is referenced in the sub-section on action interpretation due to the strong connection made in these studies between over-imitation and the interpretation of actions as normative. Even though over-imitation is not further investigated empirically in this thesis, research on over-imitation is very important to consider for any theoretical argument on social learning. I did not investigate over-imitation in my empirical studies as part of this thesis because of the temporal and resource limits of a PhD.

2.2.2 Action understanding and action interpretation

Processes of action interpretation are relevant for social learning in some circumstances and are thus examined as a facet in this thesis. For example, action interpretation is crucial when the interpretation of a model's action in a certain way influences, or is even at the basis of what is learned. In some of the studies mentioned above, the authors argued that infants imitated selectively based on their understanding of the model's action as efficient or rational, and the understanding of the demonstrated action, and alternative actions, as rational in their own situation.

2.2.2.1 Action understanding. To explore this argument, several studies were conducted measuring infants' gaze to predict the outcome of an agent's actions. For example, 13 months old infants were shown to anticipate the goal of an ongoing action of an animated circle, so long as the agent acted rationally (Bíró, 2012). Bíró (2012) argued that infants are able to interpret the rationality of non-human actors' actions. To avoid repetition and because the particular studies are essential to describe the theoretical argument, further research is described in Chapter 3.1 on the naïve theory of rational action.

2.2.2.2 Action interpretation. In some of the studies mentioned above on the head-touch paradigm, the authors argued that infants selectively imitated communicative actions (e.g., Brugger et al., 2007; Király et al., 2013). The theory of natural pedagogy in particular is based upon the hypothesis that ostensive communication activates in the learner an interpretation bias that determines what aspects of a demonstration the learner pays attention to most closely. In many cases what the learner pays attention to most closely is the action that constitutes important cultural information. Therefore, the same studies are relevant, but not repeated, in this sub-section. Beyond that, studies investigated children's normative interpretation of actions as a determining factor in social learning.

Three and 5 years old children observed an experimenter play games in an over-imitation paradigm (i.e., performing causally necessary and causally irrelevant action steps) while the experimenter marked either the action or the goal as particularly interesting (Keupp, Behne, & Rakoczy, 2013). Imitation proved to be an inconclusive measurement of what children learned as over-imitation rates were generally very high. However, when in a next phase a puppet omitted some action steps, children in both age groups protested more often than when the puppet over-imitated all action steps correctly. When asked, 5-year-olds were able to explicitly state when the puppet made a mistake and when the puppet played correctly, while 3-year-olds were no different from chance on this measure. Keupp and colleagues (2013) argued that children readily made normative interpretations, as shown in their protest behaviour, but that the verbal demands of the explicit judgement might have been too difficult for the 3-year-olds and not for the 5-year-olds.

In another study, 3 years old children showed equivalently high rates of imitative and protest behaviour independent of whether the model had demonstrated the action with or without ostensive communication, and without the use of normative language altogether (Schmidt et al., 2010). Instead, children protested selectively when a puppet performed a different action after the model had performed her action confidently as though this was a common action to perform, but children were much less likely to protest when the puppet performed a different action after the model acted as though she had invented the action on the spot. Schmidt and colleagues (2010) argued that children made a normative interpretation of the model's action based on the perceived intentionality of the action, which potentially also indicates to the learner the conventionality of the action, and that children did not interpret the actions as normative based on ostensive communication.

Three years old children also protested selectively in pretend play contexts depending on whether a puppet joined the game or not (Wyman, Rakoczy, & Tomasello, 2009). In the first experiment of the study, the experimenter and the child played a game using a pretend action on a familiar object; then the puppet appeared and (a) announced to join the game but performed an action that was consistent with the real function of the object instead of the pretend action, or (b) the puppet did not join the game and announced to use the object according to its real function (e.g., to draw with a pen instead of using the pen as a toothbrush). Children protested against the puppet's behaviour when it announced to join the game but not when the puppet did not join the game, even though the puppet performed the same action in both cases. In the second experiment of the study, the experimenter and the child played two different pretend games distinguished by two different contexts using the same plain object; then the puppet appeared and performed one of the pretend actions (a) either in the correct context or (b) in the different context. Children protested against the puppet's behaviour when it performed the pretend action in the different context but not when it performed the same pretend action in the correct context. Wyman and colleagues (2009) argued that children's interpretation of actions as normative is flexible, and children are sensitive to the context in which a certain action counts as normative. For example, norms within pretend play are specific for the context of that pretend play session and do not generalize to reality or another pretend play. Similar results were also found in a study including 3 to 5 years old children in an over-imitation paradigm (Keupp et al., 2015).

Four and 5 years old children showed selective imitation and protest based on the reliability of the model (Rakoczy, Warneken, & Tomasello, 2009). Children were more likely to imitate a reliable model (who had previously given correct information and behaved according to convention) over an unreliable model (who had previously given incorrect information and made mistakes when trying to perform conventional actions, e.g. drawing with a broken pen). Similarly, children protested when the unreliable model made mistakes, and explicitly judged the unreliable model's behaviour as a mistake, while accepting the actions of the reliable model. Rakoczy and colleagues (2009) concluded that children are sensitive to the source of their information and imitate selectively based on selective normative learning.

The empirical research mentioned above provides examples of how action understanding and interpretation essentially influence social learning in a variety of age groups. The normative interpretation bias is further investigated in Study 6 (Chapter 9) of this thesis.

In summary, empirical research on social learning in infants and young children covers imitation, emulation, as well as action understanding and interpretation, and has shown that social learning is sensitive to a variety of social and situational factors including, for example, the shared history between model and learner, communication between model and learner, the knowledge the learner has about the objects involved prior to the new learning situation, the action that is involved including even the precise way the action is performed, among other influences. The empirical research presented in this thesis adds to this by showing that adults naturally adapt social learning situations depending on the age of the learner and showing that social learning varies depending on the objects involved.

Chapter 3: Social Learning Theories

In the sections that follow, I analyse a subset of social learning theories. I focus on the theories' accounts of imitation, emulation, action understanding or interpretation, and the social and situational circumstances of the learning process. I restricted my analysis to those theories that align with the definition of imitation as copying actions from another person without the need to understand the model's intentions. As a result, I examine the naïve theory of rational action (see Chapter 3.1), the theory of natural pedagogy (see Chapter 3.2), the ideomotor approach to social and imitative learning (see Chapter 3.3), and the normative account of social learning (see Chapter 3.4). Unquestionably, the same analysis might be extended to other theories of social learning, such as those proposed by Tomasello and colleagues (e.g., Tomasello, 1999; Tomasello et al., 2005; Tomasello, Savage-Rumbaugh, & Kruger, 1993), Meltzoff and colleagues (e.g., Meltzoff, 2005; Meltzoff & Moore, 1989, 1997), Laland and colleagues (e.g., Laland, 2004), or others (see Chapter 3.5); which might, however, use different working definitions of social learning and imitation including theory of mind skills, and thus go beyond the scope of this thesis. I first examine the selected theories individually, considering how each addresses different facets of social learning, and then compare the theories' explanations (see Chapter 3.6). The reviewed theories differ highly on their main focus of social learning, and the range of social circumstances they apply to.

3.1 The Naïve Theory of Rational Action

One important aspect in learning from other people is to identify the relevant knowledge content. Which parts of what I observe are important and should be learned? According to this account, the principle of rational action helps the learner to identify relevant content, and to understand and evaluate the actions of others, from very early in life (Csibra & Gergely, 2007; Gergely & Csibra, 2003).

The principle of rational action relates three components: the action, the goal, and the situational constraints (Gergely & Csibra, 2003). According to this account, we expect others to perform the most rational means available–the action–to accomplish a goal, given the constraints of the situation. If only two of the three components are present, the principle allows the observer to infer or predict the third (Gergely & Csibra, 2003). Specifically, if a model performs an action that is rational given the situational constraints, a learner will be able to (a) predict which action the model will perform to achieve the same goal even when situational changes require a new action (Gergely, Nádasdy, Csibra, & Bíró, 1995; Southgate, Johnson, & Csibra, 2008), (b) predict the goal of an ongoing, partly hidden, or failed action (Bíró, 2012), and (c) infer hidden aspects of the situation, such as barriers or other constraints, given the observed action and its goal (Csibra, Bíró, Koós, & Gergely, 2003).

The naïve theory of rational action predicts infants' rational imitation and emulation behaviour. When observing a model perform an efficient action, the principle of rational action would lead a learner to imitate this action under similar circumstances. However, when the action is perceived as being inefficient, the learner may instead choose to emulate (Csibra & Gergely, 2013). Similarly, the principle accounts for emulation or lower-fidelity imitation when the situational constraints differ between the model and the learner, or change over time. However, it does not predict over-imitation; on the contrary, according to the principle of rational action, the learner should only copy causally relevant action steps. In other words, the principle of rational action helps a person to identify and learn the relevant aspects of others' actions by evaluating the rationality of the action given the goal and the situational constraints.

The basic cognitive mechanisms that underlie the principle of rational action might be innate (Csibra & Gergely, 2007). However, it requires the observer to apply knowledge of the world, which changes with development and experience. As a result, its application can improve with development (Csibra & Gergely, 2007). Indeed, infants may make mistakes in their expectations of others' actions or goals (Csibra & Gergely, 2007, 2013), and may make predictions or interpretations of actions that even violate physical or biological laws, if the infant has not yet acquired the necessary background knowledge (Southgate et al., 2008).

However, Paulus (2012b) argued that infants would need highly sophisticated cognitive abilities to apply the principle of rational action, such as judging others' action capabilities; forming and relating conceptual representations of others, oneself, and the situational characteristics; or engaging in counterfactual reasoning. He concluded that the principle of rational action could not be applied by young children.

The naïve theory of rational action does not claim to account for all cases of social learning. In some situations, the learner might not have enough information to be able to apply the principle of rational action, so could decide to 'blindly copy' an observed action (Csibra & Gergely, 2007). Under other circumstances, the application of the principle of rational action is not required (Csibra & Gergely, 2007). For instance, if the observed action and outcome are already familiar to learners (e.g., a routine act), they can rely on previously acquired action-effect associations or motor imagery to make sense of the situation and to identify the important aspects for their own actions. Learners can also understand another person's actions when they have performed the action themselves before, and can thus simulate the situation of the model by imagining themselves in the same situation (Csibra & Gergely, 2007). Nonetheless, the principle of rational action is used to assess the rationality of an agent's actions; this also includes non-human actors (Bíró, 2012).

The rationality of the model's previous action influences whether the learner will apply the principle of rational action. Children do not seem to make the same predictions when presented with models that were previously observed acting in a way that is not rational (Southgate et al., 2008). Otherwise, the theory does not specify any factors about the learning situation, the model, or the interaction between the model and the learner.

In summary, the naïve theory of rational action posits that learners interpret the rationality of others' actions in relation to the goal and the situational constraints, and will imitate or emulate a model depending on their interpretation of the model's rationality and their own situational constraints. The naïve theory of rational action applies to situations where the model is expected to act rationally, and how it is applied changes with development.

In other situations, however, a model might be observed not acting rationally or the learner might not be in a position to evaluate the rationality of the model's actions. For situations in which a model performs a cognitively opaque action and teaches the learner, as often observed between parents and offspring, the theory of natural pedagogy (e.g., Csibra & Gergely, 2006) was proposed to complement the naïve theory of rational action.

3.2 The Theory of Natural Pedagogy

The theory of natural pedagogy describes a special type of communication for the transmission of knowledge (Csibra & Gergely, 2006, 2011; Gergely & Csibra, 2005, 2006, 2013). Natural pedagogy is argued to have evolved to allow humans to quickly learn relevant, culturally important, and generalizable knowledge rather than factual information. It does not claim to explain all social learning, applying only in certain cases. Examples of the type of knowledge that is learned in this way include, but are not restricted to: generic information; actions without immediate rewards; cognitively opaque knowledge such as arbitrary or normative conventions; behavioural traditions; and novel means actions (Csibra & Gergely, 2006; Gergely & Csibra, 2005, 2006, 2013).

Under this account, the teacher explicitly manifests knowledge for the learner using a special type of communication (Csibra & Gergely, 2006, 2011; Gergely & Csibra, 2005, 2006, 2013), and the learner responds with a clear epistemic motive to learn (Gergely, Egyed, & Király, 2007; Király et al., 2013). Precisely, the learner focuses on the knowledge content rather than on social motivational information, that is the acquisition of knowledge is the primary goal and social motives such as affiliation with the model are, if at all, secondary; for example, the learner may apply his acquired knowledge irrespective of whether the model is present or not. Natural pedagogy primarily supports knowledge transmission from parent to child or, more generally, from expert to novice, rather than between peers (Csibra & Gergely, 2006, 2011; Gergely & Csibra, 2013).

Teaching takes the form of a clearly marked and foregrounded demonstration. The teacher communicates that she is teaching and manifests knowledge for the learner, but also specifies both the recipient and the item of teaching (Csibra &

Gergely, 2006, 2009, 2011). Demonstrations include ostensive and referential cues as well as salient knowledge manifestations such as slowed-down, schematic, or exaggerated movements (Csibra & Gergely, 2011; Gergely & Csibra, 2005). Pedagogical communication does not need to involve language, but it is necessarily ostensive and referential (Csibra & Gergely, 2011; Gergely & Csibra, 2013). Ostensive cues include direct gaze, (learner-directed) speech, and contingent responsivity (such as dyadic interaction or primary intersubjectivity). Referential cues can have a symbolic, iconic, or indexical nature and include, in their simplest form, deictic gestures such as gaze-shift, pointing, or showing objects (Csibra & Gergely, 2006). Importantly, natural pedagogy does not include just any form of communication or teaching; for example, it excludes conditioning, scaffolding, and communication for cooperation or about episodic information (Csibra & Gergely, 2011; Gergely & Csibra, 2013).

The pedagogical communication activates a *pedagogical stance* in the learner. That is, natural pedagogy leads to an interpretation bias in learners (Gergely & Csibra, 2006) which guides them to attend to and learn those aspects of the demonstration that are new and relevant, and to ascribe cultural relevance to that new information (Csibra & Gergely, 2006). In particular, learners have the assumption that the demonstrated knowledge is public and culturally shared, such that other individuals of the culture would hold it and could manifest it at any time (Csibra & Gergely, 2006, 2011; Gergely & Csibra, 2005, 2006, 2013; Gergely et al., 2007). The acquired knowledge is also generalized “to new occasions, new locations, new objects, new contexts, etc.” (Csibra & Gergely, 2009, p. 148). Generalization of knowledge is an additional facet of social learning that is emphasized by the theory of natural pedagogy, expanding social learning beyond imitation, emulation, and action understanding.

Although natural pedagogy is hypothesized to be based on an innate system, some aspects are subject to development. For example, infants' identification of possible cues to reference depends on their cognitive development (Csibra & Gergely, 2006). In addition, development is required to overcome the default position of attributing relevance to communicated information. As a starting point, the learner unconditionally trusts the teacher, and children first have to learn when not to trust a communicative other (Csibra & Gergely, 2006; Gergely et al., 2007) and when to inhibit their tendency to over-generalize ostensively communicated knowledge in order to accept episodic information from a communicative other (Gergely & Csibra, 2013).

By definition, a transfer of knowledge that includes pedagogical communication, in the sense of an explicit knowledge manifestation, is an example of natural pedagogy (Csibra & Gergely, 2006). Within this definition, natural pedagogy proposes active participation of the teacher in the learning process. Due to the importance of the communicative exchange, the theory of natural pedagogy is distinct from other theories. Natural pedagogy sets clear criteria for the social circumstances under which it may be applied and, as a result, it does not apply to cases of, for example, learning from passive observation of a model or even cases when a learner observes an interaction between another learner and a model. Natural pedagogy does not make predictions about learning as a factor of, for instance, the objects involved or the shared history of learner and model.

3.2.1 The two systems account of the naïve theory of rational action and the theory of natural pedagogy

In social learning, the theory of natural pedagogy and the naïve principle of rational action interact (Király et al., 2013). The learner may acquire two kinds of information: (1) the goal of the model's action, and (2) the means that the model uses to achieve the goal. If a model performs an action that has a novel goal, and uses a rational action to achieve it, the learner will focus attention on the novel goal and may rationally imitate (under similar situational constraints) or emulate (under different situational constraints) to achieve the same goal. However, if the model's action cannot be explained by the principle of rational action, and the model activates the learner's pedagogical stance by teaching, the learner will interpret the action as novel and relevant information, and may imitate it (Gergely & Csibra, 2005, 2006; Király et al., 2013). Thus, imitation is guided by the rationality of the action on the one hand, and the pedagogical stance on the other. Gergely and Csibra (2005) argued that "Imitative learning of a new behaviour will occur *precisely* when the choice or particular manner of the action is *unpredictable – i.e., cognitively 'opaque' – to the infant* and, as such, it qualifies as part of the 'new and relevant' information manifested by the ostensive 'teaching' act" (p. 475). Selective imitation and emulation can also be explained in a step-wise interpretation of others' actions in terms of goals and sub-goals; the primary goal may be to elicit the effect (leading to emulation), and the sub-goal may be to copy the observed means (leading to imitation; Király et al., 2013).

A pedagogical demonstration in itself is not sufficient to evoke imitation of just any action. When infants observe more than one action as a means to achieve a goal, such as an efficient action and a less efficient action, they tend to imitate only the efficient one (Gergely & Csibra, 2005). Similarly, if they already know a more efficient means to the goal, infants are less likely to imitate a less efficient teacher (Pinkham & Jaswal, 2011). Thus, learners do not “blindly” copy any action demonstrated pedagogically but can apply the principle of rational action to override explicit pedagogical cues. As a result, the learner may fail to acquire less efficient but (culturally) important information.

Empirical research suggests that for natural pedagogy, the learner may need to perceive a goal for the demonstrated action (Király et al., 2013). As delayed rewards, arbitrary actions, and cultural traditions often do not have clear goals, this finding is in contrast to one of the main claims of the theory: pedagogical communication facilitates imitative learning of cognitively opaque actions. Regardless, Király and colleagues (2013) argued that actions without an obvious effect might be unintelligible to some learners. Additionally, if a pedagogically taught action is culturally important, it would be most helpful if the learner imitated it faithfully. However, infants in empirical studies often re-enact the taught action with low fidelity (Király et al., 2013).

In summary, the theory of natural pedagogy accounts for selective imitation and action interpretation after a teaching event. Natural pedagogy also proposes that knowledge learned in this way is generalized and assumed to be culturally shared. It accounts for a change in learning due to cognitive development, for instance by taking the learner’s prior knowledge into account when predicting what information is most likely to be learned from teaching. However, natural pedagogy only applies to very specific cases of social learning and the transfer of a specific type of knowledge, namely cultural and generalizable information.

3.3 The Ideomotor Approach to Social and Imitative Learning

The ideomotor approach to social and imitative learning (IMAIL; Paulus, 2014a, 2014b) posits that imitation and emulation can be explained in terms of automatic activation of bidirectional action-effect associations. IMAIL states that two mechanisms together underlie infants' social learning: motor resonance and action-effect learning (Paulus, Hunnius, et al., 2011a). Motor resonance is the core mechanism that enables the learner to acquire action-effect associations through observing another person's action and its effect (Paulus, Hunnius, et al., 2011a; Paulus, van Dam, Hunnius, Lindemann, & Bekkering, 2011). When the learner subsequently intends to elicit the same effect, the action-effect association facilitates an imitative response (Paulus, 2012a). As such, IMAIL combines the ideomotor approach to action control (Aschersleben, 2006) with the account of motor resonance (Paulus, 2012a).

Under this approach, action-effect associations are acquired through pairing of an action with its effect. Due to motor resonance, the motor code corresponding to an action is automatically activated when merely observing another person perform that same action (Paulus, 2012a). If the motor code and the cognitive representation of the effect are repeatedly activated together, a specific action-effect association is formed (Paulus, van Dam, et al., 2011). When the learner aims to elicit the effect, the action (i.e. imitation or emulation) is automatically performed. The learning process itself is non-intentional, and learners might not even be aware that they are learning (Paulus, 2014a, 2014b).

Paulus (Paulus, 2014b) argued that IMAIL accounts for all cases of imitative learning. While IMAIL may explain some high fidelity imitation well, it is less clear how it accounts for rational imitation, lower-fidelity imitation, or over-imitation. If action-effect associations acquired through motor resonance lead to the action response, and the action response is automatically triggered by a desire for the effect, then the imitative response should closely match the observed behaviour. It is thus unclear how IMAIL can predict low-fidelity imitation. Furthermore, in over-imitation, the model performs multiple action steps, but it is not clear how action sequences can be encoded and represented in action-effect associations. While it is plausible that the learner might experience motor resonance for multiple steps in an action sequence, in IMAIL the salient effect is crucial for the formation of an action-effect association and, thus, for imitation. In cases of over-imitation, however, the effect usually co-occurs with the last action step, leading to the prediction that learners should imitate only this last action. While IMAIL predicts selective imitation based on motor resonance and a salient effect, it does not predict or explain rational imitation. In fact, Paulus (2012b) argued that young children do not have the cognitive capacities to imitate rationally.

On the other hand, IMAIL explains why emulation may co-occur with imitation (Paulus, Hunnius, et al., 2011b). According to the ideomotor principle, the representation of the action effect is directly connected to the associated motor code of the action. If the learner has previously seen the same effect being caused by another action, the established action-effect association might compete with the newly built action-effect association and, therefore, learners may perform both "old" and "new" actions (Paulus, Hunnius, et al., 2011a). In cases where a learner acquires multiple action-effect associations for the same effect using different actions, it is not clear how the learner "decides" which action to perform. One possible solution is that action-effect associations acquired by personally performing the action are stronger than associations acquired by observing another person perform the action (Paulus, 2014a). Other possibilities, if the competing associations were all acquired by observation, are that the strength of the motor activation depends on the number of observations, or on the delay between observation and imitation (Paulus, 2014a).

IMAIL, by definition, describes a gradual learning process, as action-effect associations are acquired by repeated observation. It therefore cannot easily apply to novel or changing situations (Csibra & Gergely, 2013). It also cannot adequately explain processes such as goal prediction of non-human agents, because motor resonance only occurs for actions of biological agents (Uithol et al., 2011). Similarly, IMAIL is restricted to cases where the observed action is already part of the observer's motor repertoire, because otherwise the observer would not have a matching motor code that can be activated (Paulus, 2012a). Finally, the observation of a salient effect is crucial for the acquisition of action-effect associations (Paulus, Hunnius, et al., 2011a). As a consequence, IMAIL is restricted to explaining a subset of social learning cases, and imitation is strongly influenced by the learner's own motor development (Paulus, 2014a).

IMAIL does not discuss how social and situational circumstances might influence social learning. However, Paulus (2014b) proposed a strong connection between perceptual encoding of the observed action and the learner's attention to, for example, features of the situation (e.g., familiarity with the model, or novelty of the object). In addition, the underlying mechanisms of imitation in infancy might be different from those in adulthood (Paulus, Hunnius, et al., 2011b), with motor resonance being the basic mechanism in infancy (Paulus, 2014a). Likewise, Paulus, Hunnius, and colleagues (2011b) argued that at some point in development other factors, such as the principle of rational action, pedagogical communication, understanding of causal relations, and functional object knowledge might influence imitative behaviour. Future research would benefit from including systematic predictions on how learning is influenced by those circumstances.

In summary, IMAIL explains imitative learning through the acquisition of action-effect associations by observation. It also explains emulative learning through the re-activation of previously acquired action-effect associations. However, IMAIL only applies to cases where the model's action is part of the learner's own motor repertoire and elicits a salient effect. This excludes the learning of actions that contain novel movements, and of actions that have a delayed or no salient effect, such as many cultural practices. To be learned, actions and effects need to repeatedly co-occur. IMAIL does not consider how the learner might understand the model's actions, or how other social and situational circumstances might influence learning.

3.4 The Normative Account of Social Learning

In recent years, a normativity account has been proposed to explain social learning (Rakoczy & Schmidt, 2013). Under the lean account of normativity, young children are proposed to have a default tendency to interpret others' intentional actions as conventional, and in many situations these conventional actions are interpreted as normative (Keupp et al., 2013). Under the rich account of normativity, children are proposed to have a default tendency to interpret others' actions as normative and not merely as conventional (Schmidt et al., 2010). In other words, children take a *normative stance* towards the world.

According to normativity, children do not simply copy intentional acts of others, but learn about general forms of actions with a normative dimension (Rakoczy et al., 2009). This leads to a categorization of the action as appropriate or inappropriate, as right or wrong. The normative dimension is different from a merely conventional dimension (Rakoczy, Warneken, & Tomasello, 2008, 2009); whereas conventionality refers to ways something is usually done, normativity refers to how something ought to be done. Keupp and colleagues (2013; Schmidt et al., 2010) argued that children are *promiscuous normativists* who readily make normative interpretations of others' actions.

The interpretation of an action as normative, in turn, influences learners' imitation of the action. For example in over-imitation, learners interpret the whole action sequence as one overarching action where the single action steps, whether causally necessary or irrelevant, are conventionally necessary. As such, the single action steps are normatively essential and obligatory in the reproduction of the complete action sequence (Keupp et al., 2013). Similarly, the normative account explains faithful imitation as copying a normative convention. However, it may not explain rational imitation, and its explanation of selective imitation is currently restricted to imitating intentional actions and not imitating accidental actions (e.g., Schmidt et al., 2010). Selective imitation may also be explained by learners' sensitivity to, for example, the source of information based on factors such as the reliability of the model (Rakoczy et al., 2009). Yet, systematic predictions of selective normative learning have currently not been proposed. The normative account may, nevertheless, explain the co-occurrence of emulation and imitation; emulation may be observed because learners change existing conventional norms or invent new norms, or because they decide when to abide by these norms and when not to follow them (S. Keupp, personal communication, June 19, 2015).

The normative dimension has the consequence that others are supposed to abide by the norms (Keupp et al., 2013). Therefore, in addition to imitation, researchers assess learners' spontaneous responses to a third party performing an action that deviates from the demonstrated one. Under a normative interpretation, the learner might react with protest, critique, or correcting behaviour to the third person's mistake, and might also explicitly call the behaviour wrong (Keupp et al., 2013). Thus, normativity extends the study of social learning beyond imitation and conventional knowledge (Keupp et al., 2013). Protest is another behaviour that can reflect what one has learned, and is closely connected to the learner's interpretation of the model's action.

Individual differences might influence learners' behaviour. Some learners might detect norm violations but not actively enforce them on others (Wyman et al., 2009). The motivation to enforce norms might depend on individual temperament, linguistic competence, causal and rational considerations, or social motivational factors (Keupp et al., 2013; Rakoczy et al., 2009). Norm enforcement could also be connected to experience, observation of consequences of norm violations, or a broader assumption that all human actions have a normative dimension. The latter would also influence and explain children's strong tendency to imitate others' actions.

It is important to consider that there are different types of norms, and that norms are context-specific (Keupp et al., 2013). In its current form, the normative account only makes predictions about learning conventional norms. Whether learners differentiate between different types of norms, such as moral norms, conventional norms, or natural contingencies, or whether they consider the source of the norm (e.g., higher authorities or norms emerging from interaction between peers; see Wyman et al., 2009 for an overview on different norms) is thus a question for future research. Empirical research, however, shows that children are sensitive to the context in which a certain action counts as normative (Keupp et al., 2013) and will enforce norms accordingly (e.g., whether the third party joins the same or a different game; Wyman et al., 2009).

With respect to the interaction between the model and the learner, the normative account only requires the model to perform her action confidently, as if it is a common action to perform (Schmidt et al., 2010). Apart from the model's intentional behaviour, children do not need ostensive communicative cues or even normative cues to interpret an action as normative (Schmidt et al., 2010). Currently though, it remains unclear how (or whether) children differentiate between a model acting conventionally or merely showing an individual preference.

The normative account explains children's readiness to (over-)imitate, and offers an account of how children interpret others' actions. Moreover, it includes protest as a behavioural outcome of social learning. Normativity also makes some predictions about children's differential learning depending on specific situations and interactions with the model, for example whether a model communicates an intention to act, or whether the model is reliable, and in this way, normativity explains selective imitation under some conditions. However, normativity does not systematically predict differential learning depending on more complex situations and interactions, nor does it offer systematic predictions about emulation.

3.5 Further Social Learning Theories

The social learning theories that were presented in Sections 3.1 to 3.4, and that are further discussed in Section 3.6, share the definition of imitation as the copying of an action using the demonstrated means without the requirement to make any inferences about the model's state of mind (e.g., Paulus, 2011). However, other social learning theories with different working definitions are also very influential. As examples of influential social learning theories with a different definition of imitation, this section briefly describes the like-me theory (e.g., Meltzoff, 2005), Tomasello and colleagues' account of social and cultural learning (e.g., Tomasello, 1999; Tomasello et al., 2005), the account of social learning strategies (e.g., Laland, 2004), and the affiliative account of social learning (e.g., Over & Carpenter, 2012, 2013).

The like-me theory in Section 3.5.1 and Tomasello and colleagues' account of social learning in Section 3.5.2 were excluded from further analysis within this thesis (for the analysis see Section 3.6 and Chapter 10) because their definition of imitation includes mental state reasoning in copying actions. Furthermore, the account of social learning strategies in Section 3.5.3 was excluded from further analysis because it does not differentiate between imitation as copying actions with or without mental state reasoning and imitation as copying of another person's choice (e.g., choosing an object of the same colour as the model did; DiYanni & Kelemen, 2008). Finally, the affiliative account of social learning in Section 3.5.4 was excluded from further analysis because it is an example of a social learning theory that focuses on when a learner is most likely to show what he has learned. The social learning theories mentioned in this thesis by no means present an exhaustive list of the published research. Rather, the referenced theories represent some of the most recent and some of the most influential theories in the field; the actual body of theoretical research on the topic is vastly greater than presented in this thesis.

3.5.1 The like-me theory

The like-me theory (Meltzoff, 2005) focuses on the learner's representation of the relationship between herself and the model. Meltzoff (2013) proposed that humans have an innate "feeling of interpersonal connectedness" (p. 139). The like-me theory (Meltzoff, 2005) suggests that infants perceive others as being "like" themselves and they also perceive themselves as being "like" the other. This comparison is made through infants' ability to relate representations of others to representations of themselves. This mechanism is also the root of imitation, as described in the model of "active intermodal mapping" (AIM; Meltzoff & Moore, 1997).

According to the AIM model (Meltzoff & Moore, 1997) infants use perceptual information to form visual representations of others. They also form representations of their own unseen bodily state. These two representations are then compared in an intermodal framework. If they do not match, the infant tries a new body configuration (i.e., producing an action) and compares again. A feedback loop allows this action to form part of new sensory information. This process enables the child to correct her own behaviour, if necessary, and to gradually create a more accurate match between the representations of herself and of the target, with the goal to establish equivalence between the two. Meltzoff and Moore (1997) argue that the intermodal system is innate, whereas the action execution is processed through learned movements. In summary, the AIM model offers an explanation for early imitation, including facial imitation, that contrasts with traditional accounts of exclusively learned or exclusively innate mechanisms (Meltzoff & Moore, 1997; see also Rizzolatti, Fogassi, & Gallese, 2001).

As they gain experience, infants become able to relate their own mental states to their bodily states, and come to project their own mental states to others who behave like they did. This process has been argued to be an essential base to developing an understanding of other people's internal states, and a prerequisite to developing further theory of mind skills including engaging in mentalistic reasoning about others' beliefs, desires, and intentions (Meltzoff, 2005; see also Parker-Rees, 2007). As the like-me theory focuses on mentalistic reasoning rather than on social learning independently of theory of mind skills it is excluded from further analysis within this thesis.

3.5.2 The theory of cultural learning

The theory of cultural learning by Tomasello and colleagues (e.g., Tomasello, 2016; Tomasello, Kruger, & Ratner, 1993) emphasizes the distinction between cultural learning as a uniquely human type of learning that is the prerequisite for cumulative culture, and between other forms of social learning. Cultural learning entails social imitation learning, collaborative learning, and instructed learning. Imitative learning, according to this theory, is one form of cultural learning that is aimed at learning what a model intends to do. As such, imitation includes the action and the goal that the model intends to achieve with her actions. Another form of social learning, but not cultural learning, is emulation learning. Emulation refers to cases when an observer copies the result of a model's action with her own method. The theory of cultural learning (Tomasello, 2016) also accounts for normative learning as described in Section 3.4, and imitative learning to identify with and affiliate with the model as described in Section 3.5.4 as forms of a special type of imitation learning called social imitation. Social imitation primarily serves the function to affiliate with social groups and demonstrate group identity, in contrast to imitation learning as described earlier in this section, which could be referred to as instrumental imitation, which is used to acquire new information and increase personal success in problem-solving tasks. Additionally, the theory of cultural learning explains in its own terms the principles behind social learning as described by the naïve theory of rational action: Tomasello (2016) argues that children imitate and emulate "rationally" based on how they interpret the intentions of the model. For example, in the head-touch study with the model having her hands free or occupied (Gergely et al., 2002), infants selectively imitated the model when she had her hands free because they could perceive the model's intention to use her head instead of her hands (i.e., this intention was not clear to infants in the hands occupied condition; Tomasello, 2016).

The theory of cultural learning further emphasizes collaborative learning as one type of cultural learning that is essential in creating and maintaining cumulative culture (Tomasello, 2016). Collaborative learning implies social learning by and through cooperation in peer groups. Another focus of the theory of cultural learning, besides (social) imitation learning and collaborative learning, is on instructed learning. Instructed learning means to learn generic information from teaching, as is also described by the theory of natural pedagogy. These facets of the theory of cultural learning, that is, social imitation learning, collaborative learning, and instructed learning, have also been investigated in and contrasted with social learning in other animals, particularly in nonhuman primates (e.g., for an overview see Tomasello, 2010).

One important difference between the cultural learning account and the other theories that are discussed in this thesis is the understanding of imitation as a type of social learning that requires the learner to understand the model's perception and the intentionality of her actions (Tomasello, Kruger, & Ratner, 1993). Tomasello, Kruger, and Ratner (1993) claimed that learners form a cognitive representation of the model's action and the action goal together with information on the model's perspective. It was claimed that, because those sophisticated perspective-taking skills are a requirement for imitation learning according to the theory of cultural learning, infants are only able to imitate from the age of 9 months (Tomasello, Kruger, & Ratner, 1993).

As a consequence of the definition of cultural learning, certain behaviours qualify as social learning but not as cultural learning even though, superficially, they may look the same to somebody who observes the learner. For example, (a) behaviour that includes the copying of a model's actions without understanding the model's intention would not be classified as imitation but, for instance, as mimicry. As such, copying behaviour still qualifies as social learning but not as cultural learning. Similarly, (b) some instances of learning that include pedagogical communication would count as social learning but not as cultural learning. For example, it would be referred to as scaffolded learning and not as instructed learning when the learner acquires the information individually while the model assists in guiding the learner's attention to the appropriate objects (Tomasello, Kruger, & Ratner, 1993). Instructed learning according to the theory of cultural learning requires the learner to also learn something about the model through comparing what the model understands about the task with what the learner understands about the task, that is, the learner is required to compare his own perspective with that of the model. As the theory of cultural learning, by definition, includes perspective taking for a behaviour to qualify as imitation, it is excluded from further analysis within this thesis. However, in a next step, the same analysis that was used in this thesis could be extended to the theory of cultural learning.

3.5.3 Social learning strategies

The account of social learning strategies (Laland, 2004) views social learning from a comparative perspective, pointing out differences and similarities between human behaviour and non-human animals' behaviour, as well as comparing social and asocial learning types. While the other theories within this thesis discuss the importance of social learning for the development of human children and for cumulative culture, the account of social learning strategies points out that social learning is not adaptive *per se*, and it discusses under which circumstances social learning is more or less adaptive than asocial learning. Within this discussion, the account of social learning strategies debates a number of social and situational circumstances that strongly influence social learning. While I argue in this thesis that the discussed social learning theories would benefit from a more systematic inclusion of the social and situational circumstances into their theories of social learning behaviours, which is also the core argument of the account of social learning strategies, I do not further discuss this theory because its definition of social learning is, very broadly, copying others and, therefore, it is different from the definition that is used within the other discussed theories (i.e., including a discrimination between, for example, imitation and emulation as two different ways to learn socially), which makes a comparison between the discussed theories and the account of social learning strategies particularly difficult.

The account of social learning strategies considers the adaptability of social learning within the whole population as an exploitation of knowledge without producing any new information, while asocial learning is viewed as producing knowledge. As such, only a certain amount of social learning within the population is desirable, and social learning is most adaptive when used selectively. Much theoretical research on social learning strategies has been derived from evolutionary game theory (Kendal, Coolen, & Laland, 2009; Laland, 2004). When applying a social learning strategy, the individual is not required to be aware of the strategy or its underlying mechanisms (Kendal, Coolen, & Laland, 2009).

The account of social learning strategies discusses (a) conditions under which an individual chooses to learn socially over learning asocially, so-called “when” strategies, and (b) who learners choose to copy from, so-called “who” strategies. Kendal, Coolen, van Bergen, and Laland (2005; also see Kendal, Coolen, & Laland, 2009) present a comprehensive review on when learners choose to acquire information socially or asocially: (a) animals choose social information over asocial information when social learning is less costly than asocial learning (e.g., rats copied the food choice of a demonstrator when presented with novel food choices that they would otherwise have to spend time on to determine the palatability of), or (b) animals choose social information over asocial information when they are uncertain as to what to do because (i) they lack prior information, (ii) the accumulated knowledge of conspecifics proves more reliable than own previous experience, or (iii) the knowledge based on their prior experience proves to be outdated. Animals were also shown to prefer social information over asocial information (c) when dissatisfied in their current situation. Moreover, Kendal, Coolen, and Laland (2009) also present a review on who learners choose to acquire information from when learning socially: (a) learners prefer to copy what the majority does (although this social learning strategy is highly context dependent and only little empirical evidence was found to support this), (b) learners prefer to copy the most successful individual, and (c) learners prefer to copy familiar individuals.

A more extensive model of social learning strategies and a review of empirical research on social learning strategies in humans is presented in Rendell and colleagues (2011). In brief, Rendell and colleagues (2011) show that research on social learning strategies in humans resulted in ambiguous findings; for instance, adults have been shown to switch between the copy-the-majority strategy and its opposite, anti-conformity, depending on the social contexts and the participant’s mood. Common methods of investigation include the examination of micro-societies, transmission chains, and strategic games. In addition, Rendell and colleagues (2011) reviewed research that showed that the use of social learning strategies also changes with development. A review of how the account of social learning strategies can be applied to developmental psychology is presented in Wood, Kendal, and Flynn (2013). Wood and colleagues (2013) discuss empirical research showing that children flexibly display model-based cultural transmission biases in social learning, and the authors draw parallels between these biases and how their required cognitive abilities develop in childhood.

According to this account (Kendal, Coolen, & Laland, 2009), social learning strategies may have evolved due to costs that are associated with acquiring or using information through personal sampling. Even though many animals use social learning strategies, such as fish, birds, and monkeys; humans may be the only species that has developed cumulative culture because of a "cognitive deficit" in other animals that does not let them evaluate the relative costs of others' and their own actions (Kendal, Coolen, & Laland, 2009). While social learning strategies have been shown to be advantageous in many contexts, they may also prevent an individual from learning relevant new information when, for instance, the individual chooses to copy what the majority does without realising that better alternative behaviours are available, or when an individual chooses to copy a familiar, high-status individual instead of a very innovative unfamiliar, low-status individual with better information (Kendal, Coolen, & Laland, 2009). All in all, social learning strategies are ambiguous, conditional, and context specific, and it is not yet clear how they combine in more complex environments than a controlled laboratory setting or very structured situations in the wild (Kendal, Coolen, & Laland, 2009). The account of social learning strategies was excluded from further analysis in this thesis because it does not differentiate between different forms of copying such as imitation as copying actions (with or without mental state reasoning) and imitation as copying of another person's choice.

3.5.4 The affiliative account of social learning

The affiliative, or social-motivational, account of imitation integrates an epistemic motive and a social motive to imitate another person (Over & Carpenter, 2013). It has been argued that imitation fulfils an important function in both learning and in social interactions (Over & Carpenter, 2012, 2013). Over and Carpenter (2012) have extended the like-me account of social learning (e.g., Meltzoff, 2005) and the theory of cultural learning (e.g., Tomasello, Kruger, & Ratner, 1993) to explain what motivates a person to imitate another person. Their conceptual papers do not discuss the cognitive mechanisms that underlie imitation but rather explore which functions imitation serves in learning and social interactions. The authors argue that other social learning accounts, including like-me, natural pedagogy, and normative accounts, cannot account for empirical findings that show that children imitate faithfully under some conditions and they imitate selectively choosing what (if anything) to imitate under other conditions.

Over and Carpenter (2012) argue that the degree of fidelity or selectivity of imitation is affected by (1) the learning goal, which means the degree to which the child has the goal to learn something new in the situation, (2) the social goal, which means how much the child identifies with and wants to affiliate with the model and the relevant social group, and (3) the social pressure that the child experiences in the situation. These goals and pressures are not necessarily consciously held but can influence whether the learner imitates the observed action faithfully or selectively.

When faced with the goal to learn new information from the model and the situation (1), imitation serves an instrumental function, and children will focus on factors that allow them to achieve the desired outcome, frequently leading to selective imitation or emulation. In that case, children may, for instance, learn a new skill or how an object works.

When holding the goal to affiliate with others (2), imitation serves a social function, namely that the imitator has the goal to (a) identify with and (b) affiliate with the model (Over & Carpenter, 2012). The reasons behind social goals to imitate can be prosocial, affiliative, or selfish. When children have high social goals, they will be motivated to copy others faithfully in order to show that they are like the model or group with which they seek to affiliate. The identification claim (a) predicts that the imitator wants to be like the model. In many cases, this drive to identify with the model also has a communicative component. The imitator shows that he is like the model. The imitator tries to have an effect on another person, who can be the model or a third person. The affiliation claim (b) builds on the identification of the imitator with the model and predicts that the imitator wants to affiliate with the model. Again, the imitator communicates that he is like the model in order to facilitate the affiliation. The social goal can be pursued consciously or unconsciously.

The affiliative account predicts differential behaviour of the learner based on the interaction between learning (1) and social goals (2). The social goal of imitation can be the primary goal of the imitator, it can be a goal alongside the goal to learn, or it can be a secondary, insignificant goal compared to the goal to learn. If the child's primary goal is to learn, imitation is predicted to be exploitative and individualistic. The child will pay most attention to relevant aspects of the demonstration, specifically how the effect is achieved. When the child's goal is instrumental, Over and Carpenter (2012, 2013) predict that children will in most cases imitate selectively, but might imitate faithfully if they find it difficult to identify the relevant content of the demonstration. When holding both learning and social goals simultaneously, children will be influenced by social factors like group membership and cultural norms. Their learning then applies to how they can be like the other members of their social group. The account predicts that children will likely imitate faithfully, and even correct others who perform the action differently. If the child primarily pursues social goals over learning goals, the child is most likely to imitate faithfully. An exact matching of the model's behaviour shows that the child wants to be like the model and it communicates social information: "I am like you and we have a common topic for our interaction". Development might influence children's preferences for social or instrumental goals.

The third factor that determines the fidelity of imitation is the experienced degree of social pressure (3). A high degree of social pressure is associated with high fidelity of imitation. On the one hand, this is determined by the expectations of the model and the social group towards the imitator. On the other hand, the social pressure depends on how the imitator experiences it internally with or without explicit behaviour from the social group contributing to it. Over and Carpenter (2012) argue that, for example, teaching can increase the feeling of social pressure, but also sanctions or active encouragement influence social pressure. When faced with social pressures such as teaching situations, children may seek to conform to the expectations of their audience by faithfully imitating (Over & Carpenter, 2012, 2013).

In sum, according to the social-motivational account, the fidelity of imitation is influenced by external factors, like the social pressure from the model or the cultural group, and by internal factors, like the child's motivation to learn something about the physical or social world. Imitation is subject to the child's interpretation of the situation and the social pressure, and the child's identification with the model and the social group. For an overview on how empirical studies can be interpreted to fit this model, see Over and Carpenter (2012). Because the affiliative account of social learning focuses on when a learner is most likely to show what he has learned, it was excluded from further analysis in this thesis.

3.6 Discussion of Social Learning Theories

The theories discussed above provide different accounts of social learning. Each explains some form of imitation, and most also provide an account of emulation or action understanding. The theories make differential predictions about social learning depending on some detail of the social and situational circumstances, although no theory fully explores their influence on learning. Table 1 presents an overview of the main points of the theories categorized into the reviewed facets of imitation, emulation, action understanding or interpretation, and social circumstances, as well as proposed additional facets of social learning. In the following sections, I compare the theories and discuss the accounts of each facet individually.

Table 1

Overview of Selected Social Learning Theories

	Rational action	Natural pedagogy	IMAIL	Normativity
Imitation	Predicts rational imitation of efficient actions	Imitation is facilitated by pedagogical communication	Imitation is caused by bidirectional action-effect associations acquired through motor resonance	(Over-)imitation is due to the understanding of the action as normative
Emulation	Predicts emulation of irrational actions, and of efficient actions under different situational constraints	Rational action can "override" pedagogy (e.g., knowledge of more efficient action)	Emulation is caused by competing action-effect associations or low motor resonance	No systematic prediction
Action understanding/ interpretation	Actions are understood in relation to their goals and the situational constraints	Bias to interpret taught actions as relevant, culturally shared, and generalizable	None; actions are encoded in terms of their effects	Bias to interpret intentional actions as conventional and normative
Further facets	(None)	Generalization	(None)	Protest
Social and situational circumstances	Subject to cognitive development; Interaction not specified	Model pro-actively teaches the learner using pedagogical communication, clear interaction necessary; Subject to cognitive development	Observed actions must elicit a salient effect; Action needs to be part of learner's motor repertoire, therefore subject to motor development; Interaction not specified	Sensitive to social factors such as reliability of the model, but predictions not systematically varied; Usually described as interaction between learner and model (e.g., in a game context), but not further specified

3.6.1 Overview of social learning theories

Each of the reviewed theories focuses on a different facet in their account of social learning: Rational action emphasizes action understanding; natural pedagogy focuses on imitation and generalization; IMAIL highlights imitation; and normativity emphasizes action interpretation and protest. The theories also differ in the role they ascribe to cognition and development in social learning.

The naïve theory of rational action (e.g., Csibra & Gergely, 2007) primarily offers an account of action understanding and prediction. It focuses on the learner's understanding of the efficiency of actions as well as the prediction of others' actions. Under this account, learners selectively imitate rational actions and emulate less efficient actions, or they emulate due to a change in situational constraints. The theory does not consider the interaction between the learner and the model, or other social circumstances that might influence learning. However, it can also be applied to understanding actions of non-human agents. For cognitively opaque actions, the naïve theory of rational action is complemented by the theory of natural pedagogy.

The theory of natural pedagogy (e.g., Csibra & Gergely, 2006) proposes that children learn from others through teaching interactions in which the model uses ostensive and referential communication. This leads the learner to interpret the model's action as relevant, culturally shared, and generalizable, and it facilitates imitation. The theory of natural pedagogy itself does not explain emulation, but the pedagogical interpretation bias can be overruled by the principle of rational action, such as when learners already know a more efficient means to the goal. Importantly, the theory of natural pedagogy argues that the learner also generalizes the information. Although the model is proposed to be an active participant, the theory does not more specifically address the interaction between learner and model, or the social circumstances of the learning. It is applicable only to a limited number of social learning situations, namely when the model teaches the learner.

IMAIL (e.g., Paulus, 2014a) focuses on the acquisition of bidirectional action-effect associations through motor resonance as the basis of social learning. IMAIL predicts selective imitation and emulation based on the learner's motor capabilities, a salient action effect, and competing action-effect associations. It does not offer clear explanations on action understanding, and the social circumstances of the learning situation are not systematically discussed. However, learners may only acquire actions in connection with a salient effect, and only those actions that they have, in principle, performed before.

Finally, the normative account (e.g., Schmidt et al., 2010) emphasizes action interpretation and protest. It argues for a predisposition to interpret others' intentional actions as conventional and normative. As a result, learners are predicted to (over-) imitate, to expect others to perform the same actions, and to show protest to a third person performing a mistake. Presently, normativity does not systematically explain emulation. Although normativity predicts sensitivity to the social contexts in which the learning, and the subsequent application of knowledge, take place, ideas on how the social and situational circumstances shape learning are not discussed more broadly.

The theories provide different accounts of whether and how cognitive development influences social learning. The naïve theory of rational action, the theory of natural pedagogy, and the normative account describe social learning as a result of more or less complex cognitive computations. The naïve theory of rational action argues that the learner evaluates the rationality of the demonstrated action, with evaluation performance improving with cognitive development. In natural pedagogy, two mechanisms operate by default: the learner detects the model's teaching signals, and subsequently interprets demonstrated actions as relevant, generalizable, and culturally shared. Cognitive development influences natural pedagogy; a person can learn to inhibit the generalization bias when needed (e.g., to learn situation specific knowledge). In normativity, the learner identifies the model's action as intentional, and is then biased to interpret it as conventional and normative. In contrast, IMAIL reduces the underlying mechanisms of social learning to systems that elicit imitation and emulation as automatic responses; it argues that social learning depends on, and improves with, the learner's motor capabilities, although it may be influenced by other cognitive abilities.

Another important difference between the theories is the developmental stage addressed by each. As the theories are supported by empirical evidence from different age groups, it is possible that they identify developmental shifts rather than explaining social learning in general. For example, IMAIL may account for some aspects of later learning, but may be restricted for very early imitation because it predicts that children will not learn an action that they have not in principle performed before. Studies on natural pedagogy and rational action commonly include children aged 9 months up to 2 years, while other studies showed that, for example, 3-year-olds imitate intentional actions at ceiling level with or without teaching (Schmidt et al., 2010). Due to task demands including linguistic skills, the normative interpretation is difficult to test in very young children and infants; empirical work often includes 4 to 5 years old children.

I argue that the core mechanisms of social learning may be entirely different from those proposed in the discussed theories: rather than explaining the true core mechanisms of social learning, the theories may explain mechanisms that are particularly dominant developmental influences at certain critical ages, that is the proposed mechanisms undergo developmental shifts and when investigated during their critical ages they could create the impression that they are the core mechanisms because they might cover up the true core mechanisms of social learning. However, as different mechanisms seem to be particularly dominant during different developmental stages (e.g., at 5 years of age, children's learning seems to be influenced strongly by a tendency to interpret others' intentional actions as normative), one should ask whether they also represent core mechanisms during other developmental stages (e.g., whether social learning is also strongly influenced by a normative interpretation bias at ages 18 months and 60 years). I argue that none of the discussed theories explains the true core mechanisms of social learning, but instead they identify important developmental shifts and peaks of social learning.

In conclusion, the theories differ on the focus that they take in social learning and the influence of cognitive development. These differences make it difficult to fully compare details of the theories. The theories may also complement rather than contradict each other on some grounds. The sub-sections that follow discuss how the theories differ on their explanations of each facet of social learning.

3.6.2 Imitation

The theories of social learning differ in their accounts of imitation. Each one explains some imitation behaviours (e.g., selective imitation, over-imitation), but none fully account for all of them. They also differ in whether learners acquire the action to be imitated as a means to elicit an effect or as a means in itself.

According to the naïve theory of rational action, imitation is the result of the learner evaluating the rationality of the model's action and considering his own situational constraints. Under this account, the action is a mere means to an end; if the model's action is also rational in the learner's situation, it will be imitated. If it is not rational, or there is a more efficient means available, the learner will choose to emulate. The learner's main interest is in the goal, and an action is chosen (i.e. imitation or emulation) according to its rationality. The naïve theory of rational action explains rational imitation, but does not offer an account of over-imitation or other forms of selective imitation.

IMAIL also describes imitation as a means to an end, but here it is proposed to be an automatic behaviour rather than an active choice of the learner. According to IMAIL, learners are primarily interested in the effect and encode the action as its means. When they later intend to elicit the effect, they automatically perform the action (i.e. imitation, or emulation in the case of competing action-effect associations). According to IMAIL, imitation is the result of primarily neuro-motor processes. It explains some cases of selective imitation, but not rational imitation, over-imitation, or less faithful cases of imitation.

The theories of natural pedagogy and normativity describe imitation as being based on an interpretation bias. Learners interpret taught actions or intentional actions, respectively, as conventional and, therefore, as worth reproducing. Consequently, learners are focused on the action itself. Natural pedagogy describes the acquisition of conventional knowledge through communication. It predicts some cases of selective imitation, and may predict faithful imitation and over-imitation, as well as rational imitation in conjunction with the naïve theory of rational action. Additionally, it proposes that the learner interprets taught actions as generalizable; therefore, imitation is necessary but not sufficient to confirm the type of social learning that is targeted by the theory of natural pedagogy, and imitation must be complemented by behaviour showing generalization.

In contrast, the normative account adds that cultural knowledge is not only conventional but is also normative. The expectation that others perform the same action may demonstrate conventionality, but protest or correction show a normative stance. As a result, imitation is again insufficient to differentiate whether children interpret an action as conventional or as normative, and, instead, the significance of protest is put forward. The normative account explains (over-)imitation and some cases of selective imitation, but not rational imitation or other forms of selective imitation. In summary, under the theories of natural pedagogy and normativity, imitation is the result of an interpretation bias of others' actions. Importantly, these two accounts focus on additional behaviours that reflect social learning: generalization and protest.

Faithful imitation, over-imitation, selective, and rational imitation are different forms of imitation behaviour reflecting social learning. None of the reviewed theories currently offers explanations and predictions for all of the different forms. While the theories of IMAIL, natural pedagogy, and rational action make some systematic predictions about selective imitation, over-imitation is neglected. On the other hand, normativity offers an explanation of over-imitation, but provides only scarce systematic predictions about selective imitation, limited to cases such as accidental actions and unreliable models. Future research would benefit from more systematic explanations and predictions regarding all forms of imitation.

3.6.3 Emulation

Learning and imitation are very often equated in empirical research on social learning. Imitation is one good indicator of learning, but other behaviours such as protest, generalization, or emulation also show learning. While imitation shows the person has learned a specific action, emulation can reflect the learning of effects and of goals.

The theory of natural pedagogy and the normative account neither predict, nor offer a systematic explanation for emulation. IMAIL and the naïve theory of rational action do provide reasons for why and how a learner might emulate a model's actions. Similar to its account of imitation, IMAIL describes emulation as the result of action-effect associations acquired during prior learning. In contrast, rational action proposes that the learner emulates in order to perform the most rational action given the situation, such as if the situation is different for the model and the learner, or if the model's action was irrational. As social learning can be reflected in emulation behaviour, comprehensive theories of social learning would account for emulation as well as other facets of social learning.

3.6.4 Action understanding and interpretation

The theories offer different explanations of how the learner understands or interprets the model's actions. The naïve theory of rational action offers an account of how learners come to understand others' actions. It argues that learners make sense of actions in relation to the actor's goal and situational constraints. This action understanding, in turn, influences what information the learner acquires and the predictions that the learner makes about the model's future behaviour, the situation, and the goal. In this way, for the naïve theory of rational action, action understanding is the core process underlying social learning.

Natural pedagogy and normativity, on the other hand, propose a default interpretation bias. Indeed, natural pedagogy argues that the learner often has no understanding of the action, because it primarily applies to the transmission of cognitively opaque knowledge. Instead, it posits that humans have a natural bias to interpret others' taught actions as relevant, culturally shared, and generalizable.

Similarly, normativity postulates that intentional actions are naturally interpreted as conventional and normative. These theories see the learner's subsequent behaviour (e.g., imitation or protest) as a result of the interpretation bias.

In contrast, IMAIL focuses on the learner's behaviour as an outcome of neuro-motor processes that are largely independent of other cognitive abilities. According to IMAIL, social learning is not more broadly influenced by action understanding or interpretation, but actions are simply understood in terms of their effects. As a result, IMAIL does not offer a clear model of action understanding or interpretation.

3.6.5 Social and situational circumstances

Another important facet in social learning is the context of learning. Empirical research has shown that whether and what an observer learns from a model is influenced by the circumstances including the history, the people, and the objects involved. In this thesis I discuss that, as the social circumstances of learning differ, stronger theories of social learning integrate these circumstances into their explanations. Theories that do not specify the conditions in which they apply are vulnerable to being over-encompassing by, for example, allowing specific predictions in some cases but being unable to derive predictions in others, or by leading to overly vague or false predictions. In my view, the naïve theory of rational action and IMAIL, and to a lesser extent normativity, can be viewed as examples of potentially over-encompassing theories.

Empirical research has shown that learning depends on many factors, including the model (e.g., models from in-group vs. out-group, see Buttelmann et al., 2013; Schmidt, Rakoczy, & Tomasello, 2012; adult vs. child model, see Rakoczy, Hamann, Warneken, & Tomasello, 2010; familiar model vs. stranger, see Shimpi, Akhtar, &

Moore, 2013), the object of learning (novel objects vs. familiar objects, see Pinkham & Jaswal, 2011; for research on tools vs. non-tools, see Chapters 4, 5, and 9), the interaction between model and learner (e.g., live vs. on video, see O'Doherty et al., 2011; incidental observation vs. teaching, see Király et al., 2013), the shared history of model and learner (e.g., when the learner judges the reliability of the model, see Rakoczy et al., 2009), among others.

To avoid overlooking important influences and, thus, being over-encompassing, a theory benefits from specifying how the social circumstances may impact learning. For example, the naïve theory of rational action and IMAIL give no further specifications on the social circumstances of learning. Under the naïve theory of rational action, a learner may understand, make future predictions about, and imitate a model who acts rationally; a model who does not act rationally may be emulated. Although the theory considers the developmental stage of the learner, it does not consider other influences on learning, such as the interaction between the model and learner, or the objects involved. Similarly, IMAIL claims to account for all cases of social and imitative learning (Paulus, 2014a, 2014b), only predicting no (imitative) learning when the learner does not experience motor resonance or the model's action does not elicit a salient effect. As a result, neither theory predicts the differences, for example, between learning from video and a live interaction (O'Doherty et al., 2011), or between learning from a familiar person and a stranger (Shimpi et al., 2013).

The normative account is a further example of a potentially over-encompassing theory as it claims that the actions of an intentionally acting model are interpreted as following a conventional norm. However, the account has begun to integrate influences from the social circumstances, for example by making differential predictions for reliable and unreliable models (e.g., Rakoczy et al., 2009). Future research should develop this further.

I argue that a strong theory of social learning should not simply define the social circumstances that it can be applied to. Instead, it should systematically vary its explanations and predictions as a factor of the social circumstances. For example, the theory of natural pedagogy and IMAIL claim to explain learning in limited contexts only (i.e. in teaching situations or for actions that elicit a salient effect, respectively). These theories could expand by making predictions for other cases as well; for example, how is learning different when observing a situation of another learner being taught or of incidental observation? Similarly, how can actions without immediate salient effects be learned or what makes an effect salient according to IMAIL?

I am aware that the respective authors of the theories intentionally made the choice to apply their theories to only those contexts and not others but by offering explanations and making predictions of learning as a function of the social circumstances a theory can be applied to a greater variety of cases, and science advances by improving, developing, or substituting existing theories. For example, the naïve theory of rational action predicts that a learner will imitate the rational action of a model if this action is also rational in his own situation; similarly, a learner is predicted to emulate a model’s rational action if he has more rational means available. This theoretical detail allows for very precise predictions of a learner’s behaviour based on the physical characteristics of the situation. However, by expanding the theory to allow for predictions as a function of the social circumstances the theory will apply to a greater variety of contexts. For example, if a learner has two equally rational means available to reach a goal, a hypothesis about how the learner might act cannot be formulated based on the naïve theory of rational action and, instead, one needs to rely on a different, independent theoretical account to formulate a hypothesis. However, if a prospective naïve theory of rational action considered the social and situational circumstances of learning, one could potentially hypothesize that the learner might choose an action, for instance, based on his interaction with the model, or based on the objects involved (e.g., using a tool). These arguments are consistent with the naïve theory of rational action in the sense that they do not contradict the theory, but they are currently not an integrative part of the theory either; meaning that a hypothesis cannot be derived from the theory in its current state and, instead, one needs to rely on a different theory to predict the learner's behaviour.

For another example, IMAIL describes learning solely of actions that elicit a salient effect, which excludes cases of learning many cultural habits and practices. Additionally, the learner needs to observe the action multiple times and these actions need to be part of the learner's own motor repertoire; this excludes cases of learning from single observations and of learning novel actions. Explanations on how a learner could acquire actions without salient effects and novel actions would expand the theory's reach. While IMAIL is limited to actions that elicit a salient effect and induce motor resonance in the learner, it has been claimed to account for learning of all those actions irrespective of the social circumstances. Thus, IMAIL is an example of both a theory that neglects social circumstances and a theory that could expand its reach by making systematic predictions instead of limiting its criteria for application.

Interestingly, natural pedagogy emphasizes that the model actively presents the information to be learned. This active participation of the teacher is one important difference between the theory of natural pedagogy and other social learning theories that primarily focus on the learner. The theory of natural pedagogy is the only reviewed theory that clearly proposes an interaction critical to social learning, while at the same time the interaction itself and other circumstances, such as the objects involved, are overlooked in the conceptual analysis. In particular, because natural pedagogy has been argued to have evolved from human tool-use (Gergely & Csibra, 2006), the theory should include predictions on how learning about tools may differ from learning about non-tool objects. Similarly, I argue that a strong social learning theory should systematically vary its explanations based on factors such as culture, communication, interaction, object-specific influences, shared history, and other social and situational circumstances. While it might not be possible to account for all potential influences on social learning, I argue that the current state of the discussed social learning theories is unsatisfactory because even broad factors are not included (such as tool-use, see for example Study 1 in Chapter 4).

3.6.6 Conclusions and general hypotheses

I reviewed four recent social learning theories: The naïve theory of rational action, the theory of natural pedagogy, IMAIL, and the normative account of social learning. All four theories use the same definition of imitation as copying actions. In the review, I focused on how the theories explain the acquisition of knowledge as reflected in four facets, namely imitation, emulation, action understanding or interpretation, and the social and situational circumstances of learning. I identified generalization and protest as additional facets. Each theory explains some form of imitation, and most also provide an account of emulation or action understanding. The theories make differential predictions about learning depending on some detail of the model-learner interaction or other circumstances, although no theory fully explores the social and situational circumstances despite the evidence from empirical research showing that the social and situational circumstances pose an important factor in social learning.

The following six empirical studies investigated the hypothesis that social learning, as shown by means of imitation, emulation, and action understanding or interpretation, is strongly influenced by the social and situational circumstances beyond the circumstances already considered by the theories. More precisely, the following studies explored the influence of the objects involved in the learning situation, the shared history between model and learner, and the age of the learner.

Firstly, is social learning influenced by the social and situational circumstances? The theory of natural pedagogy proposes that teaching increases learner's imitation behaviour. Study 1 shows how teaching and, additionally, a shared history with the teacher and the use of tools affects 18-month-olds' imitation and emulation behaviour. Secondly, how do parents teach their children new actions? In Study 2, the naturalistically occurring use of ostensive and referential actions demonstrations from parents for their child is explored, and similarities and differences in teaching are presented depending on the child's age of 18 months or 4 years. Furthermore, do learners indeed prefer to learn about tool-use? Study 3 followed up on the tool-use findings of Study 1 by further exploring children's and adults' preferences to imitate tool actions, non-tool actions, or hand actions. Study 4 then extended the research on tool-use independently of social learning: Do children and adults prefer to use a tool over using their hand? On a more general basis, Study 5 rudimentarily explored the question of: How do adults and children identify an object as tool? Considering the normative account of social learning and the results of Studies 1 and 3 (i.e., children were more likely to imitate tool actions than non-tool actions), Study 6 explored the normative dimension of tool-use.

Chapter 4: Is Social Learning Influenced by a Shared History with the Model and the Use of Certain Objects? (Study 1)

The first study initially and broadly explored the argument made throughout the thesis that social learning is influenced by the social and situational circumstances of learning. In particular, Study 1 investigated if and how a shared history between model and learner, and the objects involved influence what a child learns. Study 1 focused on the theory of natural pedagogy and involved children aged 18 months. Within this thesis, Study 1 served as the foundation for the following studies and the theoretical argument in general: The results showed that social learning is indeed influenced by the social and situational circumstances beyond the circumstances that are considered in the current social learning theories. For example, the theory of natural pedagogy can be applied in teaching situations and makes differential predictions about learning depending on the communication between model and learner; Study 1 showed that social learning is additionally influenced by the objects the child learns about. As another example, the naïve theory of rational action allows for differential predictions on social learning depending on the rationality of the actions that are learned; Study 1 again showed that objects can influence learning beyond the rationality of the action. As a consequence, the results of Study 1 showing the influences of some social and situational circumstances on learning challenge the existing social learning theories within their proposed scope.

Study 1 explored (a) the main argument of the theory of natural pedagogy by investigating if children would be more likely to imitate a model who used ostensive and referential communication while performing her actions than a model who did not use this type of communication, (b) if the shared history between model and learner influenced learning as one example of how the social circumstances influence social learning by investigating if children would be more likely to imitate a familiar model than a stranger, and (c) if the objects used by the model influenced what a child learns by investigating if children would be more likely to imitate tool actions than non-tool actions.

According to the theory of natural pedagogy, learning would be influenced by the model-learner interaction with more imitation following teaching compared to incidental observation. In relation to the shared history of model and learner, or the objects that were used, the literature on the theory of natural pedagogy does not provide information that can be used for a precise prediction of differential learning; therefore, according to the theory, I predicted that learning would not be affected by the shared history or the objects, and thus children would be equally likely to imitate the model irrespective of whether the model was a familiar person or a stranger, and irrespective of whether the actions involved tools or non-tool objects.

Although, under a broad interpretation of the natural pedagogy account, one could argue that the shared history might have an influence in the short term if the learner took a "pedagogical stance" with the teacher (Gergely & Csibra, 2006) and remained in this stance for as long as the interaction lasted even if the teacher did not continue to use pedagogical communication; then, in the present study, children would be more likely to imitate a familiar model in the incidental condition than a stranger model in the incidental condition. The shared history would not have an influence on imitation in the teaching condition, as there is no reason to assume that additional ostensive and referential signals during an interaction would lead to more imitation (i.e., signals during warm-up plus signals during testing do not add up to twice the amount of imitation but signals in general, either during warm-up or during testing or both increase imitation).

Similarly, under a broad interpretation of the natural pedagogy account, one could argue that tools are "inherently cultural" and that tools themselves might count as pedagogical cues leading to higher imitation rates because the interpretation bias, as proposed by the natural pedagogy account, might have evolved from human tool-use (Gergely & Csibra, 2006). If this were true, participants would (a) imitate tool-use even in the incidental condition to a similar degree as they would imitate any action in the teaching condition or (b) participants would at least be more likely to imitate tool-use than non-tool actions in the incidental observation condition.

If IMAIL were correct, children would imitate all actions alike, irrespective of shared history, communication, or objects because motor resonance is expected for all actions and the actions are demonstrated equally often. However, one could argue that participants might have seen similar actions to the tool actions in this study before and thus, under a broad interpretation of IMAIL, participants would more readily have formed action-effect associations for the tool actions than for the non-tool actions building on existing action-effect associations from similar, previously observed, tool actions and effects; in that case, imitation rates would be higher in the tool conditions than in the non-tool conditions.

According to the normative account, children were also predicted to imitate all actions alike. The model performed the actions in all conditions confidently, marking them as a familiar action and, thus, children would interpret the actions as conventional and normative in all conditions irrespective of the familiarity with the model, the interaction, or the objects.

If the naïve theory of rational action were correct, participants would emulate using their hand, thus perform the most rational action available, rather than imitate all actions because the demonstrated actions were unusual, such as using the forehead or the arm to press a button. Again, they would be more likely to emulate in all conditions irrespective of the social circumstances; even in the teaching conditions children would rather emulate than imitate, according to the naïve theory of rational action, because it was proposed that even though the naïve theory of rational action and the theory of natural pedagogy combine, if at all, rational action overrides pedagogy (Gergely & Csibra, 2005) and not the other way around.

Importantly, the present study was designed to test the theory of natural pedagogy and a possible influence of social and situational circumstances on learning beyond teaching versus incidental observation; the study was not specifically designed to test any of the other above mentioned theories, even though I presented possible hypotheses based on these theories. If the results did not match the predicted results this could be due to other reasons than the theories being wrong; for example, regarding the naïve theory of rational action, children might not have emulated rather than imitated the actions because their "rational stance" did not get activated; the model would have had to act rationally before performing the novel actions to activate the rational stance first (Southgate et al., 2008).

To test the main argument of the theory of natural pedagogy that teaching increases imitation behaviour, a model demonstrated four unusual actions for infants either using ostensive and referential cues (teaching condition), or performing the actions without the use of any of those cues (incidental observation condition). To test whether a shared history with the model influenced learning, the model either introduced herself to the participant in a warm-up session and played freely with the child before starting the experiment (familiar model condition), or the participant first met the model at the start of the experiment (stranger model condition). To explore the influence of objects on learning, the model performed unusual actions directly using a part of their body such as the arm on the toy stimuli in two trials (non-tool condition), and the model used a tool to perform unusual actions on toy stimuli in another two trials (tool condition). In all conditions, infants' subsequent imitation and emulation behaviour was measured to assess learning.

4.1 Method

4.1.1 Participants

Altogether, 59 infants (28 girls, 31 boys, M_{age} = 78.4 weeks, SD_{age} = 2.5 weeks, age range: 72–83 weeks) participated in the study. To investigate the influence of the shared history between model and learner, and the effect of communication on social learning, 16 participants were assigned to the familiar model condition with eight participants in each of the conditions teaching (4 boys, M_{age} = 79.1 weeks, SD_{age} = 1.5 weeks) and incidental observation (4 boys, M_{age} = 79.0 weeks, SD_{age} = 2.6 weeks); 35 participants were assigned to the stranger model condition with 19 participants in the teaching condition (9 boys, M_{age} = 79.5 weeks, SD_{age} = 2.5 weeks) and 16 participants in the incidental observation condition (9 boys, M_{age} = 76.8 weeks, SD_{age} = 2.1 weeks). An additional eight participants were assigned to the baseline condition (5 boys, M_{age} = 77.6 weeks, SD_{age} = 2.1 weeks) which resembled the familiar model teaching condition. All participants observed two tool and two non-tool actions over four trials to investigate the effect of objects on learning.

Children came from mixed socioeconomic backgrounds in East Kent and were recruited via the Kent Child Development Unit database. Ten additional children were excluded from the data analysis due to fussiness (*n* = 2), parental or sibling interference (*n* = 3), or experimental error (*n* = 5). All children received a small gift for their participation in the study.

4.1.2 Materials

The study included four target objects and two tools. All stimuli resembled toys. Each target object featured a salient effect, such as lighting up, and additional non-target effects, such as making a noise. Table 2 includes a picture and detailed description of each stimulus. Additionally, simple two- to three-piece animal puzzles were used during warm-up.

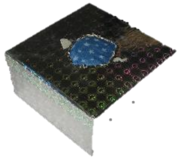
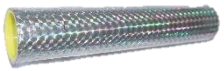
4.1.3 Design and procedure

The study followed a 2 between-subjects (shared history: familiar model vs. stranger model) x 2 between-subjects (communication: teaching vs. incidental observation) x 2 within-subjects (objects: tool action vs. non-tool action) design.

Children interacted with one (familiar model condition) or two (stranger model condition) experimenters in the course of the experiment. The two experimenters who collected the data were both female, in their early 20s, and current or previous students of the University of Kent. Both women acted as experimenters in both parts of the study, with one of them being the experimenter in the test trials for

Table 2

Stimuli used in Study 1 with Description of Salient Target Effects, Other Effects of the Toys, and the Actions Demonstrated by the Experimenters

Stimulus	Picture	Salient target effect	Other possible effects	Non-tool action	Tool action
Turtle		Squeaks when yellow button is pressed	Moving head and feet make different sounds, spins like a top	Button pressed with forehead	Silver tool used to press button
Lightbox		Lights up when blue spot is pressed	Rattles when shaken, covered in shiny paper	Blue spot pressed with forehead	Silver tool used to press blue spot
White Dog		Wiggles when tail is pulled	Ears crinkle when touched, cuddly toy	Elbow used to pull tail	Blue tool used to pull tail
Green Dog		Barks when nose is pressed	Ears and bone crinkle, feet make varying sounds when pressed, squeaks when belly is pressed, cuddly toy	Elbow used to press nose	Blue tool used to press nose
Silver tool		No target effect	Rattles when shaken, shiny paper		Used with turtle or lightbox
Blue tool		No target effect	Glitters		Used with white dog or green dog

38 participants of the final sample and the other woman being the experimenter in the test trials for 21 participants of the final sample.

The experiment consisted of a warm-up phase followed by two blocks of trials, and lasted between 30 and 40 min. Each block of trials included:

(1) three action demonstrations for a first toy,

(2) three action demonstrations for a second toy,

(3) a 4-min delay,

(4) a 60-s action phase for the first toy, and

(5) a 60-s action phase for the second toy.

Across both blocks of trials, all participants observed action demonstrations using a tool on two toys and non-tool action demonstrations on another two toys. Between participants, each toy was used in tool demonstrations and in non-tool demonstrations with the same salient target effect being elicited. The actions and the salient target effects are described for each toy in Table 2.

4.1.3.1 Warm-up. Firstly, the experimenter played freely with the child during a warm-up phase. When the experimenter had the impression that the child felt comfortable, she introduced the animal puzzles into the warm-up play. The experimenter helped the child solve the puzzles and she thereby used a variety of pedagogical signals, such as eye-contact, the child's name, infant directed speech, pointing, and verbal expressions like "Look, these pieces go together". The experimenter continued with this task until the participant responded to multiple of the signals, for example by returning the eye-contact, following the pointing, and responding to the verbal instructions.

After the puzzle task, the experimenter asked the child to sit on the parent's lap at the table and announced that she (familiar model condition) or her friend (stranger model condition) would return shortly to play another game. The experimenter then left the room.

4.1.3.2 Test trials. A few seconds after the experimenter from the warm-up phase left, the experimenter for the test trials entered the room and sat opposite the child at the table. To start the first block of trials, the experimenter took the first stimulus (i.e., in the non-tool condition only the toy) or the first stimuli (i.e., in the tool condition the toy and the tool; for ease of reading, I will continue to use the singular "stimulus" which may refer to only the toy, or the toy and the tool depending on the object condition) out of a box, showed it to the participant, and three times performed an unusual tool or non-tool action to elicit the salient effect of the respective toy. The experimenter then returned the first stimulus to the box and retrieved the second stimulus. She demonstrated the assigned target action for that toy three times and then returned it to the box.

Following the action demonstrations for the first two stimuli, the experimenter retrieved an iPad from the box and played a video of a popular TV series such as "Charlie and Lola" or "Peppa Pig" for the child for 4 min. The delay was scheduled to match the procedure other researchers had implemented when investigating social learning, although different researchers have used different durations for the delay (e.g., Király et al., 2013).

After the delay, the experimenter retrieved the first stimulus again and placed it in front of the participant for the 60-sec action phase. The participant received the chance to play freely with the stimulus during the action phase and distraction from the stimulus was kept to a minimum. The experimenter looked only at the stimulus for the entire action phase. Only if the child did not do anything for 5 sec or more, did the experimenter interact with the participant: In that case, the experimenter drew the child's attention back onto the stimulus, for example, by touching the toy and saying "This is interesting. What does it do?" (i.e., in the teaching condition; in the incidental observation condition the experimenter touched the toy and hummed as described below). The participant was not instructed to perform a certain action but only to engage with the stimulus again if he did not play with the stimulus in any way for 5 sec. After the action phase for the first stimulus ended, the experimenter stored the stimulus back in the box, retrieved the second stimulus, and placed it in front of the child for the second action phase that followed the same principles as the first action phase.

The second action phase was directly followed by the second block of trials, which started with three action demonstrations on the third stimulus, followed by three action demonstrations on the fourth stimulus, a 4-min delay, the 60-sec action phase for the third stimulus, and the experiment ended with the 60-sec action phase for the fourth stimulus.

4.1.3.3 Shared history conditions. In the familiar model condition, the experimenter for the warm-up phase and the experimenter for the test trials was the same person. In the stranger model condition, the experimenters were two different persons. It was ensured that the participant did not meet the experimenter for the test trials in the stranger model condition before the start of the test trials.

4.1.3.4 Communication conditions. In the teaching condition, the experimenter introduced herself upon entering the room, smiled at the participant, and then sat opposite the child at the table. The experimenter used pedagogical signals before and during the three action demonstrations for each stimulus; specifically, the experimenter said the child's name, engaged in eye-contact, said "watch this" or "look", and pointed at the toys.

In the incidental observation condition, the experimenter did not speak or use pedagogical signals (e.g., have eye-contact with the participant, use infant-directed speech) during test trials. The experimenter entered the room looking at the floor, sat opposite the participant, and performed all actions without acknowledging the presence of the child. To match the time with the teaching conditions and ensure the child's attention, the experimenter in the incidental observation condition hummed every time that the experimenter in the teaching condition talked.

4.1.3.5 Baseline condition. The procedure in the baseline condition matched the procedure of the familiar model teaching condition, except that the experimenter did not demonstrate any action in the test trials. The experimenter used the same pedagogical signals as in the teaching conditions but instead of performing a tool or non-tool action, the experimenter just looked at the toys for as long as the respective action takes to perform.

4.1.3.6 Object conditions. The order of tool and non-tool actions was systematically varied. The systematic variation of orders of toys and actions for the 16 participants in the familiar model condition and 16 participants in the stranger model condition included 8 different orders of toys with one tool action and one non-tool action in each block of trials. The full counterbalancing of toys with tool and non-tool actions, in the stranger model condition only, included an additional 8 different orders of toys with the two tool actions in one block and the two non-tool actions in the other block of trials for the other 19 participants in the stranger model condition.

The full counterbalancing of tool and non-tool actions was enacted only in the stranger model condition because this condition would not be affected by the additional variable of the shared history of model and learner. The full counterbalancing included 16 different orders of toys that ensured that each toy was presented first, second, third, and fourth equally often with a tool action and with a non-tool action. The systematic variation with 8 different orders also ensured that each toy was presented first, second, third, and fourth equally often with a tool action and with a non-tool action but in this set-up, a tool action was always coupled with a non-tool action in each block of trials. This way, fewer participants were required for the familiar model condition.

4.1.4 Coding and reliability

All sessions were video recorded and coded by a single observer. For each stimulus, the 60-sec action phase of child's play with the toy was coded for imitation, emulation, and all actions. A second independent observer coded for imitation and emulation of a sample of 50 % of all sessions for reliability. Agreement between coders was very good for all measures with Cohen's Kappa = .881 and ICC(3, 1) = .964.

Coding started as soon as the stimulus was first within reach of the child at the start of the action phase, irrespective of whether the child reached for the stimulus immediately or not, and lasted for 60 sec. The coding of imitation and emulation followed strict rules that were established for each stimulus and each type of action (i.e., tool action and non-tool action).

4.1.4.1 Imitation. Imitation was coded if the child's action closely matched the experimenter's action. For the non-tool actions on the turtle and the lightbox, the action only counted as imitation if the child touched the toy with her forehead; kissing the toy or bringing it close to her face but not touching it was not coded as imitation. For the non-tool actions on the green dog and the white dog, the child's action only counted as imitation if the child used a part of her arm including her wrist but not her hand to press down onto the dogs. The tool-actions on all stimuli were only coded as imitation if the tool touched the target spot on the toy (e.g., for the turtle: imitation was only coded if the silver tool touched the yellow button of the turtle but not if the tool touched the head or a leg of the turtle).

In a first step, two different imitation scores were obtained directly from the coding: Participants received a dichotomous score of 0 or 1 for each stimulus depending on whether they imitated at least once on that trial during the respective 60-sec action phase, and they received a score for each stimulus that indicated the number of times that the participant imitated on that trial during the 60-sec action phase (i.e., number of imitative acts).

In a second step, every participant received scores that were computed by combining the scores of separate stimuli. Participants received *proportion scores of trials on which children imitated at least once* over all four stimuli (0, .25, .5, .75, and 1), the tool trials only (0, .5, and 1), and the non-tool trials only (0, .5, and 1). The proportion scores indicated on how many trials out of 4 trials (i.e., all stimuli) or out of 2 trials (i.e., the tool actions or the non-tool actions only) the participant imitated at least once. The proportion scores were computed out of the dichotomous scores for each stimulus and were used to explore the proportion of trials on which imitation was observed across the experiment.

Simultaneously, participants also received scores of *number of imitative acts* over all four stimuli, the tool actions only, and the non-tool actions only that indicated the number of times that the participant imitated any target action, the tool actions, and the non-tool actions, respectively, during the experiment. The scores of number of imitative acts were used to explore how often children imitated the target actions in general–Did they just try out the actions once and then never do them again, or did they copy and repeat the actions multiple times?

To investigate how many participants showed imitation behaviour at least once across the experiment, across the tool trials only, and across the non-tool trials only, the *number of imitators* was calculated. To investigate if children tended to imitate many actions if they imitated at all, that is if children could potentially be classified into the categories of frequent imitators and non-imitators, the *number of imitated trials* was calculated. This score indicated on how many trials a child imitated if the child imitated at least once during the experiment. This score was different from the proportion scores of trials on which children imitated at least once because the proportion scores also included the data from the non-imitators, whereas the number of imitated trials included only the imitators.

4.1.4.2 Emulation. Emulation was coded if the child performed an alternative action from the one demonstrated that would, if successful, have led to the elicitation of the same salient effect. In most cases, children used their hand for emulation. In some cases, however, children also performed other emulative actions, such as pressing the turtle’s yellow button with their foot. Whether the child was successful in eliciting the salient effect (e.g., turning on the light of the lightbox) was not a criterion for coding imitation or emulation.

Analogous to the imitation scores, in a first step of the analysis, participants received dichotomous emulation scores of 0 or 1 for each stimulus depending on whether they emulated at least once during the respective 60-sec action phase, and they received an emulative acts score for each stimulus that indicated the number of times that the participant emulated during the 60-sec action phase. These scores were obtained directly from the coding.

In the second step of the analysis, participants also received the computed scores for *proportion of trials on which the participant emulated at least once* over all four stimuli (0, .25, .5, .75, and 1), the tool actions only (0, .5, and 1), and the non-tool actions only (0, .5, and 1), as well as the scores of *number of emulative acts* over all four stimuli, the tool actions only, and the non-tool actions only. Likewise, the *number of emulators* and the *number of emulated trials* were calculated. All emulation scores were equivalent to the imitation scores.

<u>4.1.4.3 All actions.</u> Additionally, all actions that the child performed on the stimuli were coded by the single observer to measure the children's general engagement with the stimuli. The score for all actions indicated how many actions the child performed on each stimulus; this included acts of imitation, acts of emulation, but also any other action on the stimulus, such as shaking the silver tool 15 times, moving the turtle's legs 3 times, touching the lightbox 18 times in a drumming movement, throwing the white dog to the floor once, etc. Participants performed equal numbers of all actions on the stimuli in all conditions (M = 67.61, SD = 29.92, $p > .35$).

4.2 Results

In the present study, possible effects of communication (teaching vs. incidental observation), a shared history between model and learner (familiar model vs. stranger model), as well as the use of different objects (tool actions vs. non-tool actions) on social learning were investigated, in particular on 18-month-olds imitation and emulation behaviour. Table 3 and Table 4 show the mean proportion scores of trials on which participants imitated and emulated at least once, the numbers of imitative and emulative acts, as well as the numbers of imitators and emulators, and the numbers of imitated and emulated trials for each condition separately for the shared history conditions (Table 3) and the object conditions (Table 4), each divided by the communication conditions.

Table 3

Descriptive Statistics for the Imitation and Emulation Variables per Conditions of Shared History and Communication

	Familiar model		Stranger model	
Variable	Teaching	Incidental observation	Teaching	Incidental observation
$M_{imitation}$	.66 (.13)	.34 (.27)	.41 (.27)	.22 (.21)
Imitative acts	19.13 (7.36)	14.13 (10.30)	18.25 (27.97)	9.25 (12.66)
Imitators[a]	8	6	7	5
Imitated trials[b]	2.63 (0.52)	1.83 (0.75)	1.86 (0.90)	1.40 (0.55)
$M_{emulation}$	.53 (.16)	.56 (.18)	.59 (.33)	.41 (.33)
Emulative acts	10.63 (4.47)	11.00 (6.66)	10.00 (6.85)	5.75 (5.47)
Emulators[a]	8	8	7	6
Emulated trials[b]	2.13 (0.64)	2.25 (0.71)	2.71 (0.95)	2.17 (0.98)

Note. Standard deviations are in parentheses. $M_{imitation}$ / $M_{emulation}$ = mean proportion scores of trials on which participants imitated or emulated at least once, respectively. [a]The number of participants in each condition was $n = 8$. [b]The maximum number of trials in each condition was 4 trials.

Table 4

Descriptive Statistics for the Imitation and Emulation Variables per Conditions of Objects and Communication

	Teaching (*n* = 19)		Incidental observation (*n* = 16)	
Variable	Tool actions	Non-tool actions	Tool actions	Non-tool actions
$M_{imitation}$	.68	.21	.66	.09
	(.34)	(.30)	(.40)	(.20)
Imitative acts	13.05	3.84	11.56	0.25
	(12.90)	(11.02)	(10.67)	(0.58)
Imitators	17	7	13	3
Imitated trials[a]	1.53	1.14	1.62	1.00
	(0.51)	(0.38)	(0.51)	(0.00)
$M_{emulation}$	.47	.71	.53	.50
	(.31)	(.35)	(.43)	(.37)
Emulative acts	3.37	7.79	4.38	7.81
	(3.25)	(7.00)	(6.76)	(10.48)
Emulators	15	17	11	12
Emulated trials[a]	1.20	1.59	1.55	1.33
	(0.41)	(0.51)	(0.52)	(0.49)

Note. Standard deviations are in parentheses. $M_{imitation}$ / $M_{emulation}$ = mean proportion scores of trials on which participants imitated and emulated at least once, respectively. [a]The maximum number of trials in each condition was 2 trials.

4.2.1 Did children learn from the model?

When investigating any form of learning, it is important to test that what a participant learned in the study, in this case the demonstrated actions, was actually new information for the participant. In the baseline condition, eight children were presented with the same stimuli that were used in the experimental conditions but children in the baseline condition were not taught any of the target actions nor any of the salient target effects of the toys to test whether participants would naturally perform any of the target actions, or discover any of the target effects.

4.2.1.1 Salient target effects. Discovering and eliciting the salient target effects of the toys, without using the taught target actions of the experimental conditions, in the baseline condition is equivalent to emulation in the experimental conditions. No child in the baseline condition discovered the salient target effects of the Green Dog nor the White Dog, five children performed an action to elicit the salient target effect of the Turtle (number of acts: M = 5.75, range: 1 – 27 times), and four children performed an action to elicit the salient target effect of the Lightbox (number of acts: M = 1.75, range 1 – 8 times).

4.2.1.2 Target actions. Performing the same actions in the baseline condition that were used in the target action demonstrations in the experimental conditions is equivalent to imitation in the experimental conditions. No child in the baseline condition performed any of the target actions (i.e., tool or non-tool action) on the White Dog, one child performed the target tool action five times on the Green Dog, one child performed the target non-tool action once on the Turtle, and one child performed the target non-tool action twice on the Lightbox. Consequently, the actions used in the demonstrations can be considered unusual and, thus, are qualified to serve as actions to be taught in a learning situation.

4.2.2 Is social learning influenced by communication and by the shared history between model and learner?

To investigate the effects of a shared history between model and learner (familiar model vs. stranger model) and communication (teaching vs. incidental observation), participants were assigned to one of four groups: familiar model teaching condition, familiar model incidental observation condition, stranger model teaching condition, and stranger model incidental observation condition. The factor communication was hypothesized to influence learning based on the theory of natural pedagogy with more imitation following teaching compared to incidental observation. The factor shared history was hypothesized to not influence learning under most theoretical accounts with small exceptions as described in the introduction to Study 1.

4.2.2.1 Order effects and choice of participants. Because not the full counterbalancing of order of toys and actions but only a systematic variation of orders was used with the participants in the familiar model conditions, but the full counterbalancing of orders was used with the participants in the stranger model conditions, an ANOVA was calculated to investigate possible effects of counterbalancing between participants in the stranger model conditions who were presented with the stimuli in the same orders as participants in the familiar model conditions and participants in the stranger model conditions who were presented with the stimuli in the additional 8 orders that were not used in the familiar model conditions. The ANOVA yielded a significant effect between groups for the mean proportion scores of trials on which participants imitated at least once, $F(1, 33) = 4.89$, $p = .034$, with higher imitation rates in the additional orders ($M_{imitation} = .50$, $SD_{imitation} = .25$) than in the systematic variation ($M_{imitation} = .31$, $SD_{imitation} = .25$). All other effects were not significant (imitative acts: $p = .794$, proportion scores of trials on which participants emulated at least once: $p = .294$, emulative acts: $p = .077$). Because of the difference in imitation behaviour within the group of participants in the stranger model conditions, the analysis to investigate the possible effects of communication and a shared history between model and learner included all participants in the familiar model conditions ($n = 16$) but only the 16 participants in the stranger model conditions who received the same systematic variation of orders of stimuli and target actions as the participants in the familiar model conditions.

4.2.2.2 Imitation. The influence of the between-subjects factors of shared history (familiar model vs. stranger model) and communication (teaching vs. incidental observation) on children's imitation behaviour was investigated by calculating a 2 x 2 MANOVA for the mean proportion scores of trials on which participants imitated at least once and for the number of imitative acts. This analysis revealed differences between groups regarding on how many trials participants imitated on average and no differences regarding how many times participants imitated the target actions.

The MANOVA revealed for the mean proportion scores of trials on which participants imitated at least once no significant interaction between shared history and communication, $F(1, 28) = 0.62$, $p = .437$, $\eta_p^2 = .02$, but a main effect of shared history, $F(1, 28) = 5.60$, $p = .025$, $\eta_p^2 = .17$, and a main effect of communication, $F(1, 28) = 9.96$, $p = .004$, $\eta_p^2 = .26$. Participants in the familiar model conditions ($M_{\text{imitation}} = .50$, $SD_{\text{imitation}} = .26$) imitated on average on more trials than participants in the stranger model conditions ($M_{\text{imitation}} = .31$, $SD_{\text{imitation}} = .25$). Also, participants in the teaching conditions ($M_{\text{imitation}} = .53$, $SD_{\text{imitation}} = .24$) imitated on average on more trials than participants in the incidental observation conditions ($M_{\text{imitation}} = .28$, $SD_{\text{imitation}} = .24$). The MANOVA revealed no significant effects for the number of imitative acts (interaction between shared history and communication: $F(1, 28) = 0.12$, $p = .736$, $\eta_p^2 = .004$, shared history: $F(1, 28) = 0.24$, $p = .628$, $\eta_p^2 = .01$, communication: $F(1, 28) = 1.42$, $p = .243$, $\eta_p^2 = .05$). Participants imitated the target actions on average 15 times ($SD = 16.27$) across all conditions.

Independent-samples *t*-tests were calculated separately for participants in the teaching conditions and participants in the incidental observation conditions to investigate a difference between the shared history conditions. If participants took a pedagogical stance with the model during warm-up, participants in the familiar model incidental observation condition should be more likely to show imitation than participants in the stranger model incidental observation condition; no difference was predicted for participants in the teaching conditions. The *t*-tests revealed a significant difference for the teaching conditions, $t(14) = 2.40$, $p = .031$, with imitation on more trials from participants in the familiar model teaching condition ($M_{imitation} = .66$, $SD_{imitation} = .13$) than participants in the stranger model teaching condition ($M_{imitation} = .41$, $SD_{imitation} = .27$). No difference was found for participants in the incidental observation conditions, $t(14) = 1.05$, $p = .312$ ($M_{imitation} = .28$, $SD_{imitation} = .24$).

The influence of the between-subjects factors of shared history (familiar model vs. stranger model) and communication (teaching vs. incidental observation) on children's imitation behaviour was also investigated by calculating Pearson Chi-Square tests for the number of imitators and a 2 x 2 ANOVA for the number of imitated trials. These analyses revealed no significant differences between groups regarding how many participants imitated at least once during the experiment and significant differences regarding on how many out of 4 trials these participants imitated.

Pearson Chi-Square tests revealed that the number of imitators did not vary significantly between conditions for shared history, $\chi^2(1, N = 32) = 0.82$, $p = .365$, with 26 out of 32 participants imitating at least once during the experiment across all conditions. Pearson Chi-Square tests showed a statistical trend for the number of imitators in the communication conditions, $\chi^2(1, N = 32) = 3.28$, $p = .070$, with 15 out of 16 participants imitating at least once in the teaching conditions and 11 out of 16 participants imitating at least once in the incidental observation conditions.

The ANOVA revealed for the number of imitated trials for the imitators only no significant interaction between shared history and communication, $F(1, 22) =$

0.36, p = .554, η_p^2 = .02, but a main effect of shared history, F(1, 22) = 4.65, p = .042, η_p^2 = .17, and a main effect of communication, F(1, 22) = 5.02, p = .035, η_p^2 = .19. Participants who imitated at least once in the familiar model conditions (M = 2.29, SD = 0.73) imitated on average on more trials than participants who imitated at least once in the stranger model conditions (M = 1.67, SD = 0.78). Also, participants who imitated at least once in the teaching conditions (M = 2.27, SD = 0.80) imitated on average on more trials than participants who imitated at least once in the incidental observation conditions (M = 1.64, SD = 0.67).

4.2.2.3 Emulation. The influence of the between-subjects factors of shared history (familiar model vs. stranger model) and communication (teaching vs. incidental observation) on children's emulation behaviour was investigated, similar to the imitation behaviour, by calculating a 2 x 2 MANOVA for the mean proportion scores of trials on which participants emulated at least once and for the number of emulative acts, as well as by calculating Pearson Chi-Square tests for the number of emulators and a 2 x 2 ANOVA for the number of emulated trials.

The MANOVA revealed no significant effects for the mean proportion scores of trials on which participants emulated at least once (interaction between shared history and communication: F(1, 28) = 1.42, p = .243, η_p^2 = .05, shared history: F(1, 28) = 0.26, p = .613, η_p^2 = .01, communication: F(1, 28) = 0.73, p = .401, η_p^2 = .03). Participants emulated on average on 52% of trials ($SD_{emulation}$ = .26) across all conditions. The MANOVA also revealed no significant effects for the number of emulative acts (interaction between shared history and communication: F(1, 28) = 1.21, p = .280, η_p^2 = .04, shared history: F(1, 28) = 1.96, p = .173, η_p^2 = .07, communication: F(1, 28) = 0.85, p = .364, η_p^2 = .03). Participants emulated the target actions on average 9 times (SD = 6.04) across all conditions.

Pearson Chi-Square tests showed a statistical trend for the number of emulators in the shared history conditions, χ^2 (1, N = 32) = 3.31, p = .069, with all 16 participants emulating at least once during the experiment in the familiar model conditions and 13 out of 16 participants emulating at least once during the experiment in the stranger model conditions. Pearson Chi-Square tests revealed that the number of emulators did not vary significantly between conditions for communication, χ^2(1, N = 32) = 0.37, p = .544, with 29 out of 32 participants emulating at least once during the experiment across all conditions.

The ANOVA revealed for the number of emulated trials for the emulators only no significant effects (interaction between shared history and communication: F(1, 25) = 1.22, p = .281, η_p^2 = .05, shared history: F(1, 25) = 0.69, p = .415, η_p^2 = .03, communication: F(1, 25) = 0.48, p = .495, η_p^2 = .02). Participants who emulated at least once in the experiment did so on average on 2.31 trials (SD = 0.81).

<u>4.2.2.4 Comparison of imitation and emulation.</u> According to the naïve theory of rational action, participants were predicted to perform the most rational actions to elicit the demonstrated salient effects on the stimuli; that is they were predicted to be more likely to emulate the unusual actions than to imitate the less rational demonstrated actions, irrespective of the factors communication or shared history. Paired-samples t-tests were calculated to compare the mean proportion scores of trials on which participants imitated and the mean proportion scores of trials on which participants emulated, as well as to compare the number of imitative acts and the number of emulative acts. Participants imitated ($M_{\text{imitation}}$ = .41, $SD_{\text{imitation}}$ = .27) on significantly fewer trials than they emulated ($M_{\text{emulation}}$ = .52, $SD_{\text{emulation}}$ = .26), t(31) = 2.40, p = .023, but they performed significantly more imitative acts (M = 15.19, SD = 16.27) than emulative acts (M = 9.34, SD = 6.04), t(31) = 2.06, p = .048.

An exact McNemar test revealed no significant difference between the number of imitators and emulators, $p = .453$. Twenty-four children imitated and emulated at least once, two children imitated at least once but did not emulate, five children emulated at least once but did not imitate, and one child did neither imitate nor emulate any action. A paired-samples *t*-test revealed for the 24 children who imitated and emulated at least once during the experiment's four trials that they tended to imitate ($M = 2.08$, $SD = 0.78$) on fewer trials than they emulated ($M = 2.46$, $SD = 0.72$), $t(23) = 1.81$, $p = .083$.

To investigate the effect of shared history on children's differential imitation and emulation, the same analysis was used separately for participants in the familiar model condition and participants in the stranger model condition. Participants in the familiar model condition imitated ($M_{imitation} = .50$, $SD_{imitation} = .26$) on as many trials as they emulated ($M_{emulation} = .55$, $SD_{emulation} = .16$), $t(15) = 0.59$, $p = .566$, but they tended to perform more imitative acts ($M = 16.63$, $SD = 9.03$) than emulative acts ($M = 10.81$, $SD = 5.48$), $t(15) = 2.11$, $p = .053$. Participants in the stranger model condition, on the other hand, imitated ($M_{imitation} = .31$, $SD_{imitation} = .25$) on significantly fewer trials than they emulated ($M_{emulation} = .50$, $SD_{emulation} = .33$), $t(15) = 3.50$, $p = .003$, and they performed an equal number of imitative acts ($M = 13.75$, $SD = 21.48$) and emulative acts ($M = 7.88$, $SD = 6.38$), $t(15) = 1.16$, $p = .265$. Exact McNemar tests revealed no significant differences between the number of imitators and emulators in the familiar model condition, $p = .500$, nor in the stranger model condition, $p = 1.000$.

To investigate the effect of communication on children's differential imitation and emulation, the same analysis was used separately for participants in the teaching condition and participants in the incidental observation condition. Participants in the teaching condition imitated ($M_{imitation} = .53$, $SD_{imitation} = .24$) on as many trials as they emulated ($M_{emulation}$ = .56, $SD_{emulation}$ = .25), $t(15) = 0.49$, p = .633, and they performed an equal number of imitative acts (M = 18.69, SD = 19.76) and emulative acts (M = 10.31, SD = 5.59), $t(15) = 1.72$, p = .107. Participants in the incidental observation condition, on the other hand, imitated ($M_{imitation}$ = .28, $SD_{imitation}$ = .24) on significantly fewer trials than they emulated ($M_{emulation}$ = .48, $SD_{emulation}$ = .27), $t(15)$ = 2.93, p = .010, and they performed an equal number of imitative acts (M = 11.69, SD = 11.43) and emulative acts (M = 8.38, SD = 6.48), $t(15) = 1.12$, p = .279. Exact McNemar tests revealed no significant differences between the number of imitators and emulators in the teaching condition, p = 1.000, nor in the incidental observation condition, p = .375.

4.2.3 Is social learning influenced by communication and by the objects that the person learns about?

In the second part of the analysis, the influence of the within-subjects factor objects (tool actions vs. non-tool actions) and the between-subjects factor communication (teaching vs. incidental observation) on children's imitation and emulation behaviour was investigated. The factor communication was hypothesized to influence learning based on the theory of natural pedagogy with more imitation following teaching compared to incidental observation. The factor objects was hypothesized to not influence learning under most theoretical accounts with small exceptions as described in the introduction to Study 1. Table 4 shows the mean proportion scores of trials on which participants imitated and emulated at least once, the numbers of imitative and emulative acts, as well as the numbers of imitators and emulators, and the numbers of imitated and emulated trials separately for each communication and object condition.

4.2.3.1 Order effects and choice of participants. In the first part of the analysis, no interaction was found between the factors shared history and communication, meaning the two variables had an independent influence on learning, and thus the data could be collapsed across the shared history conditions for this part of the analysis to increase the number of participants when investigating the factors objects and communication. However, only participants in the stranger model conditions (n = 35) received the full counterbalancing of order of toys and actions; participants in the familiar model conditions (n = 16) received the toys and actions in a systematically varied order with only half the counterbalancing. An ANOVA revealed a significant order effect for participants in the stranger model condition with imitation on more trials from participants who observed the two tool actions on one block of trials and the two non-tool actions on the other block of trials (n = 19, $M_{imitation}$ = .50, $SD_{imitation}$ = .25) compared to participants who observed one tool action and one non-tool action on each block of trials (n = 16, $M_{imitation}$ = .31, $SD_{imitation}$ = .25).

This order effect was further explored on the level of tool and non-tool actions. A MANOVA revealed a significant effect for the tool actions, $F(1, 33) = 4.91$, p = .034, η_p^2 = .13, but not for the non-tool actions, $F(1, 33) = 1.72$, p = .198, η_p^2 = .05. Participants who observed both tool actions on one block of trials and both non-tool actions on the other block of trials imitated on more tool trials ($M_{imitation}$ = .79, $SD_{imitation}$ = .30) than participants who observed a tool action and a non-tool action on each block of trials ($M_{imitation}$ = .53, $SD_{imitation}$ = .39). No difference was found for the non-tool actions ($M_{imitation}$ = .16, $SD_{imitation}$ = .26). Furthermore, t-tests showed that participants who observed the tool actions on the first block of trials did not differ in their tool imitation behaviour from participants who observed the tool actions on the second block of trials, $t(17) = .47$, p = .642.

Because of the order effect on participant's imitation of tool-actions, the analysis of the influence of the factors objects and communication only included data from participants in the stranger model conditions and not from participants in the familiar model conditions to ensure similar numbers of participants in each order of stimuli and actions. Some results are also presented separately for the two blocking conditions to fully explore the order effect.

4.2.3.2 Imitation. The influence of the within-subjects factor objects (tool actions vs. non-tool actions) and the between-subjects factor communication (teaching vs. incidental observation) on children's imitation behaviour was investigated in 3 steps: (1a) Independent-samples *t*-tests were calculated for the mean proportion scores of all trials on which participants imitated at least once and for the number of all imitative acts to investigate a difference between participants in the teaching condition and participants in the incidental observation condition. (1b) A Pearson Chi-Square test was calculated for the number of imitators and an independent-samples *t*-test was calculated for the number of imitated trials to investigate differences between participants in the teaching condition and participants in the incidental observation condition regarding how many participants imitated at least once during the experiment and on how many out of four trials these participants imitated. (2a) Paired-samples *t*-tests were calculated to compare the mean proportion scores of trials on which participants imitated tool actions and non-tool actions, as well as to compare the number of imitative acts on tool trials and on non-tool trials. (2b) The McNemar test was used to investigate whether participants were more likely to be tool imitators than to be non-tool imitators, and a paired-samples *t*-test was calculated to investigate whether imitators of tool and non-tool actions were more likely to imitate tool actions than non-tool actions. (2c) A paired-samples *t*-test was used to investigate whether tools have a similar function as prescribed to pedagogical signals, that is increasing children's imitation behaviour: imitation of tool actions was compared to imitation of non-tool actions in the incidental observation condition only. (3a) Independent-samples *t*-tests were calculated for the mean proportion scores of tool trials on which participants imitated at least once and for the number of imitative tool acts to investigate a difference between participants in the teaching condition and participants in the incidental observation condition. (3b) A Pearson Chi-Square test was calculated for the number of tool imitators and an independent-samples *t*-test was calculated for the number of imitated tool trials to investigate differences between participants in the teaching condition and participants in the incidental observation condition regarding how many participants imitated a tool action at least once during the experiment and on how many out of 2 trials these participants imitated the tool actions. (3c) Independent-samples *t*-tests were calculated for the mean proportion scores of non-tool trials on which participants imitated at least once and for the number of imitative non-tool acts to investigate a difference between participants in the teaching condition and participants in the incidental observation condition. (3d) A Pearson Chi-Square test was calculated for the number of non-tool imitators and an independent-samples *t*-test was calculated for the number of imitated non-tool trials to investigate differences between participants in the teaching condition and participants in the incidental observation condition regarding how many participants imitated a non-tool action at least once during the experiment and on how many out of 2 trials these participants imitated the non-tool actions.

Independent-samples *t*-tests (1a) revealed no significant differences between participants in the teaching condition and participants in the incidental observation condition for the mean proportion scores of all trials on which participants imitated at least once, $t(33) = 0.80$, $p = .427$, nor for the number of all imitative acts, $t(33) = 0.90$, $p = .377$. Participants imitated on average on 41% of trials ($SD_{imitation} = .26$) and participants performed on average 14.57 imitative acts ($SD = 16.68$). Because of the order effect and because a main effect for the communication factor was found in the first part of the analysis, the *t*-tests were repeated separately for participants who observed two tool actions or two non-tool actions on each block of trials, and for participants who received one tool action and one non-tool action on each block of trials. Again, no significant differences were found between participants in the teaching condition and participants in the incidental observation condition (all $p > .1$).

The Pearson Chi-Square test (1b) revealed that the number of imitators did not vary significantly between conditions for communication, $\chi^2(1, N = 35) = 0.48$, $p = .489$, with 30 out of 35 participants imitating at least once during the experiment across both conditions. The independent-samples *t*-test also revealed no significant effect for the number of imitated trials for the imitators only for the factor of communication, $t(28) = 0.47$, $p = .639$. Participants who imitated at least once in either condition imitated on average on 1.93 trials ($SD = 0.87$) out of 4 trials.

Paired-samples *t*-tests (2a) revealed that imitation was performed on significantly more tool trials ($M_{imitation} = .67$, $SD_{imitation} = .36$) than non-tool trials ($M_{imitation} = .16$, $SD_{imitation} = .26$), $t(34) = 8.61$, $p < .001$, and significantly more often on tool trials ($M = 12.37$, $SD = 11.78$) than non-tool trials ($M = 2.20$, $SD = 8.23$), $t(34) = 5.18$, $p < .001$.

The Exact McNemar test (2b) revealed a significant difference between the number of tool imitators and non-tools imitators, $p < .001$. Ten children imitated on both tool and non-tool trials, 20 children imitated on tool trials only, null children imitated on non-tool trials only, and five children did not imitate any action. The paired-samples *t*-test revealed for the ten children who imitated on tool trials and non-trials that they imitated on more tool trials (M = 1.80, SD = 0.42) than on non-tool trials (M = 1.10, SD = 0.32), $t(9) = 4.58$, $p = .001$.

The paired-samples *t*-test (2c) to compare imitation of tool actions to imitation of non-tool actions in the incidental observation condition only revealed a significant effect, $t(15) = 6.26$, $p < .001$. Children in the incidental observation condition imitated on more tool trials ($M_{imitation} = .66$, $SD_{imitation} = .40$) than on non-tool trials ($M_{imitation} = .09$, $SD_{imitation} = .20$).

Independent-samples *t*-tests (3a) for the mean proportion scores of tool trials on which participants imitated at least once and for the number of imitative tool acts revealed no significant differences between participants in the teaching condition and participants in the incidental observation condition, $t(33) = 0.22$, $p = .824$ (i.e., mean proportion scores of tool trials on which participants imitated at least once) and $t(33) = 0.37$, $p = .715$ (i.e., number of imitative tool acts). Participants imitated on average on 67.1% of tool trials ($SD_{imitation} = .36$) and they performed on average 12.37 imitative tool acts (SD = 11.78).

The Pearson Chi-Square test (3b) revealed that the number of tool imitators did not vary significantly between conditions for communication, $\chi^2(1, N = 35) = 0.48$, $p = .489$, with 30 out of 35 participants imitating a tool action at least once during the experiment across both conditions. The independent-samples *t*-test also revealed no significant effect for the number of imitated tool trials for the tool imitators only for the factor of communication, $t(28) = 0.46$, $p = .651$. Participants who imitated a tool action at least once in either condition imitated on average on 1.57 trials (SD = 0.50) out of 2 trials.

Independent-samples *t*-tests (3c) for the mean proportion scores of non-tool trials on which participants imitated at least once and for the number of imitative non-tool acts also revealed no significant differences between participants in the teaching condition and participants in the incidental observation condition, $t(33) = 1.31$, $p = .198$ (i.e., mean proportion scores of non-tool trials on which participants imitated at least once) and $t(33) = 1.30$, $p = .203$ (i.e., number of imitative non-tool acts). Participants imitated on average on 15.7% of non-tool trials ($SD_{imitation} = .26$) and they performed on average 2.20 imitative non-tool acts ($SD = 8.23$).

The Pearson Chi-Square test (3d) revealed that the number of non-tool imitators did not vary significantly between conditions for communication, $\chi^2(1, N = 35) = 1.39$, $p = .238$, with 10 out of 35 participants imitating a non-tool action at least once during the experiment across both conditions. The independent-samples *t*-test also revealed no significant effect for the number of imitated non-tool trials for the non-tool imitators only for the factor of communication, $t(8) = 0.63$, $p = .545$. Participants who imitated a non-tool action at least once in either condition imitated on average on 1.10 trials ($SD = 0.32$) out of 2 trials.

4.2.3.3 Emulation. The influence of the within-subjects factor objects (tool actions vs. non-tool actions) and the between-subjects factor communication (teaching vs. incidental observation) on children's emulation behaviour was investigated, identical to the imitation behaviour, in 3 steps: (1) the emulation variables were investigated using all trials to detect differences between participants in the teaching condition and participants in the incidental observation condition, (2) participants' emulation behaviour was investigated comparing emulation of tool actions to emulation of non-tool actions, and (3) emulation of tool actions and emulation of non-tool actions was investigated separately to compare emulation of participants in the teaching condition and participants in the incidental observation condition.

Independent-samples *t*-tests (1) revealed no significant differences between participants in the teaching condition and participants in the incidental observation condition for the mean proportion scores of all trials on which participants emulated at least once, $t(33) = 0.77$, $p = .447$, nor for the number of all emulative acts, $t(33) = 0.26$, $p = .797$. Participants emulated on average on 56% of trials ($SD_{\text{emulation}} = .29$) and participants performed on average 11.63 emulative acts ($SD = 11.55$). A Pearson Chi-Square test revealed that the number of emulators did not vary significantly between conditions for communication, $\chi^2(1, N = 35) = 0.03$, $p = .855$, with 31 out of 35 participants emulating at least once during the experiment across both conditions. An independent-samples *t*-test also revealed no significant effect for the number of emulated trials for the emulators only for the factor of communication, $t(29) = 0.90$, $p = .375$. Participants who emulated at least once in either condition emulated on average on 2.52 trials ($SD = 0.89$) out of 4 trials.

Paired-samples *t*-tests (2) revealed that emulation was performed on an equal number of tool and non-tool trials, $t(34) = 1.54$, $p = .133$, but that participants performed significantly more emulative acts on non-tool trials ($M = 7.80$, $SD = 8.63$) than on tool trials ($M = 3.83$, $SD = 5.10$), $t(34) = 2.86$, $p = .007$. An exact McNemar test revealed no significant difference between the number of tool emulators and non-tools emulators, $p = .453$. Twenty-four children emulated on both tool and non-tool trials, two children emulated on tool trials only, five children emulated on non-tool trials only, and four children did not emulate any action. A paired-samples *t*-test revealed for the 24 children who emulated on tool trials and non-trials that they emulated on an equal number of tool and non-tool trials ($M = 2.88$, $SD = 0.61$), $t(23) = 1.31$, $p = .203$. A paired-samples *t*-test to compare emulation of tool actions to emulation of non-tool actions in the incidental observation condition only revealed no significant effect, $t(15) = 0.27$, $p = .791$. Children in the incidental observation condition emulated on average on 51.56% of trials ($SD_{emulation} = .32$).

Independent-samples *t*-tests (3) for the mean proportion scores of tool trials on which participants emulated at least once and for the number of emulative tool acts revealed no significant differences between participants in the teaching condition and participants in the incidental observation condition, $t(33) = 0.46$, $p = .648$ (i.e., mean proportion scores of tool trials on which participants emulated at least once) and $t(33) = 0.58$, $p = .569$ (i.e., number of emulative tool acts). Participants emulated on average on 50.00% of tool trials ($SD_{emulation} = .36$) and they performed on average 3.83 emulative tool acts ($SD = 5.10$). A Pearson Chi-Square test revealed that the number of tool emulators did not vary significantly between conditions for communication, $\chi^2(1, N = 35) = 0.47$, $p = .492$, with 26 out of 35 participants emulating a tool action at least once during the experiment across both conditions. An independent-samples *t*-test revealed a statistical trend for the number of emulated tool trials for the tool emulators only for the factor of communication, $t(24) = 1.88$, $p = .072$. Tool emulators in the incidental observation condition ($n = 11$, $M = 1.55$, $SD = 0.54$) tended to emulate tool actions on more trials than tool emulators in the teaching condition ($n = 15$, $M = 1.20$, $SD = 0.41$).

Independent-samples *t*-tests for the mean proportion scores of non-tool trials on which participants emulated at least once and for the number of emulative non-tool acts also revealed no significant differences between participants in the teaching condition and participants in the incidental observation condition, $t(33) = 1.75$, $p = .090$ (i.e., mean proportion scores of non-tool trials on which participants emulated at least once) and $t(33) = 0.01$, $p = .994$ (i.e., number of emulative non-tool acts). Participants emulated on average on 61.4% of non-tool trials ($SD_{emulation} = .37$) and they performed on average 7.80 emulative non-tool acts ($SD = 8.63$). A Pearson Chi-

Square test revealed that the number of non-tool imitators did not vary significantly between conditions for communication, $\chi^2(1, N = 35) = 1.28$, $p = .258$, with 29 out of 35 participants emulating a non-tool action at least once during the experiment across both conditions. An independent-samples *t*-test also revealed no significant effect for the number of emulated non-tool trials for the non-tool emulators only for the factor of communication, $t(27) = 1.35$, $p = .189$. Participants who emulated a non-tool action at least once in either condition emulated on average on 1.48 trials (SD = 0.51) out of 2 trials.

<u>4.2.3.4 Comparison of imitation and emulation.</u> According to the naïve theory of rational action, participants were predicted to perform the most rational action to elicit the demonstrated salient effects on the stimuli; that is they were predicted to be more likely to emulate the unusual actions than to imitate the less rational demonstrated actions, irrespective of communication or objects. Paired-samples *t*-tests were calculated comparing the mean proportion scores of trials on which participants imitated to those on which participants emulated, as well as comparing the number of imitative acts to the number of emulative acts. Participants imitated ($M_{\text{imitation}} = .41$, $SD_{\text{imitation}} = .26$) on fewer trials than they emulated ($M_{\text{emulation}} = .56$, $SD_{\text{emulation}} = .29$), $t(34) = 3.82$, $p = .001$, but they performed an equal number of imitative and emulative acts, $t(34) = 0.94$, $p = .355$ (imitative acts: $M = 14.57$, $SD = 16.68$, emulative acts: $M = 11.63$, $SD = 11.55$).

An exact McNemar test revealed no significant difference between the number of imitators and emulators, $p = 1.000$. Twenty-eight children imitated and emulated at least once, two children imitated at least once but did not emulate, three children emulated at least once but did not imitate, and two children neither imitated nor emulated any action. A paired-samples *t*-test revealed for the 28 children who imitated and emulated at least once during the experiment's four trials that they imitated (*M* = 2.00, *SD* = 0.86) on fewer trials than they emulated (*M* = 2.68, *SD* = 0.77), $t(27) = 4.16$, $p < .001$. To investigate the effect of communication on children's differential imitation and emulation, the same analysis was used separately for participants in the teaching condition and participants in the incidental observation condition which revealed the same pattern of results.

To investigate the effect of objects on children's differential imitation and emulation, the same analysis was used separately for tool and non-tool trials. Paired-samples *t*-tests revealed that participants imitated on more tool trials ($M_{imitation} = .67$, $SD_{imitation} = .36$) than they emulated on tool trials ($M_{emulation} = .50$, $SD_{emulation} = .36$), $t(34) = 3.76$, $p = .001$, and they performed more imitative tool acts (*M* = 12.37, *SD* = 11.78) than emulative tool acts (*M* = 3.83, *SD* = 5.10), $t(34) = 4.08$, $p < .001$; but participants imitated on fewer non-tool trials ($M_{imitation} = .16$, $SD_{imitation} = .26$) than they emulated on non-tool trials ($M_{emulation} = .61$, $SD_{emulation} = .37$), $t(34) = 7.29$, $p < .001$, and they performed fewer imitative non-tool acts (*M* = 2.20, *SD* = 8.23) than emulative non-tool acts (*M* = 7.80, *SD* = 8.63), $t(34) = 2.92$, $p = .006$.

Exact McNemar tests revealed no significant difference between the number of tool imitators and tool emulators, $p = .125$, and a significant difference between the number of non-tool imitators and non-tool emulators, $p < .001$. Twenty-six children both imitated and emulated tool actions, four children imitated but did not emulate tool actions, null children emulated but did not imitate tool actions, and five children did neither imitate nor emulate tool actions. In comparison, 10 children both imitated and emulated non-tool actions, null children imitated but did not emulate non-tool actions, 19 children emulated but did not imitate non-tool actions, and six children did neither imitate nor emulate non-tool actions. Paired-samples *t*-tests revealed for the 26 children who imitated and emulated at least once on the two tool trials that they imitated (*M* = 1.65, *SD* = 0.49) on more tool trials than they emulated on tool trials (*M* = 1.35, *SD* = 0.49), *t*(25) = 2.86, *p* = .008. Paired-samples *t*-tests revealed for the 10 children who imitated and emulated at least once on the two non-tool trials that they imitated (*M* = 1.10, *SD* = 0.32) on fewer non-tool trials than they emulated on non-tool trials (*M* = 1.70, *SD* = 0.48), *t*(9) = 2.71, *p* = .024.

4.3 Discussion

Study 1 investigated one of the main arguments of the theory of natural pedagogy that ostensive and referential communication from the model to the learner increases the learner's imitation behaviour, and Study 1 also explored the argument that social learning is further influenced by the social and situational circumstances of learning, in particular by a shared history between model and learner, and the objects involved. Different hypotheses on infants' imitation and emulation behaviour were formulated based on different arguments from the theory of natural pedagogy, IMAIL, the normative account, and the naïve theory of rational action (see introduction to Study 1).

Eighteen-month-olds were presented with four unusual actions that were demonstrated for them (a) accompanied by ostensive and referential cues, or in an incidental observation situation, (b) by a familiar model or a stranger model, and (c) the actions included tool-use or were non-tool actions. Participants (a) were more likely to imitate unusual actions following teaching compared to incidental observation in some cases but not in other cases, (b) participants were more likely to imitate a familiar model than a stranger, (c) participants were much more likely to imitate tool actions than non-tool actions, and (d) participants were more likely to imitate than emulate tool actions and they were less likely to imitate than emulate non-tool actions.

4.3.1 Shared history between model and learner

Infants' imitation behaviour was influenced by the short-term shared history of model and learner independently of communication. Even though the same number of participants imitated in the familiar model condition and in the stranger model condition, and they performed the same number of imitative acts, imitation was observed on more trials in the familiar model condition than in the stranger model condition. Thus, infants were more likely to imitate a familiar model than a stranger. Similar findings were also reported in the Experiments 2 and 3, in the interactive conditions, in the study by Shimpi, Akhtar, and Moore (2013).

Study 1 shows that social learning is influenced by the shared history between model and learner. No differences in imitation behaviour between participants in the familiar model condition and participants in the stranger model condition were predicted following arguments from the naïve theory of rational action and IMAIL, and the present findings cannot be explained by those two theories. The finding of more imitation in the familiar model condition than in the stranger model condition was also not directly predicted by the theory of natural pedagogy nor the normative account. However, different post hoc explanations should be considered.

One could argue that participants took a pedagogical stance (Gergely & Csibra, 2006) with the model during warm-up and remained in this stance for as long as the experiment lasted. If children were to take a pedagogical stance with a teacher in the warm-up phase of the experiment and they were to keep it for a short period of time (i.e., about 15 – 20 min in the present study), the effect of a pedagogical stance would be observable most strongly in the incidental observation condition because participants would be more likely to imitate a person who they established a pedagogical stance with (i.e., the familiar model) also when she stops using pedagogical signals (i.e., in the incidental observation condition) than a stranger model who they did not establish a pedagogical stance with and who does not use pedagogical signals. Therefore, if this was the case, participants in the familiar model incidental observation condition were predicted to be more likely to show imitation than participants in the stranger model incidental observation condition. No difference was predicted for participants in the teaching conditions because pedagogical signals are not expected to add up leading to even more increased imitation behaviour but signals, whether given during warm-up or testing, are expected to increase imitation in general.

The results, however, show the opposite pattern: Participants in the familiar model teaching condition imitated on more trials than participants in the stranger model teaching condition and no difference was found for participants in the incidental observation conditions. This finding contradicts the broad interpretation of the theory of natural pedagogy regarding the pedagogical stance. Thus, the outcome of more imitation in the familiar model condition than in the stranger model condition cannot be explained by the pedagogical stance.

Alternatively, one could argue that, according to the theory of natural pedagogy, teaching is most fruitful for the knowledge transmission between parent and child, or expert and novice. Familiarity with the model in the present study might have created an impression of the model as knowledgeable in the child, and familiarity might therefore have increased imitation above the facilitation of imitation through pedagogical communication alone. Again, this explanation cannot directly be derived from the theory and is a post hoc explanation based on inferences from minor statements of the theory. This explanation is, however, connected to the argument that children first imitate a teaching person promiscuously and need to learn when to accept conventional, generalizable information from a teacher and when to treat the taught information as episodic or personal preference (Csibra & Gergely, 2006; Gergely & Csibra, 2013; Gergely et al., 2007).

If familiarity in this study led to the impression of a knowledgeable teacher, and contrariwise the stranger model is perceived as less knowledgeable, that would mean that children switch from promiscuously accepting cultural knowledge (i.e., according to the theory of natural pedagogy; Csibra & Gergely, 2006; Gergely & Csibra, 2013; Gergely et al., 2007) to cynically accepting cultural information from teachers within the first 1.5 years of life. Further research is needed to confirm or refuse this argument. For example, the paradigm of a familiar model and a stranger model could be used to compare the imitation behaviour of 18-month-olds to younger infants; although it is difficult to determine at what age infants would be expected to promiscuously imitate any teacher (i.e., also a stranger model) as the authors of the theory do not give any specifics on this argument.

A similar argument was recently made according to the normative account: Learning has been argued to be influenced by the reliability of the model (Rakoczy et al., 2009). In this study, familiarity with the model might have affected children’s impression and trust of the model which, in turn, might have increased imitation similar to the explanation of a normative interpretation being influenced by trust perception. Although this explanation might be plausible also for imitation in 18-month-olds, it cannot, in its current state, be directly derived from the normative account. Theoretical development of the normative account is ongoing and the theory might allow for this or a similar explanation soon.

To take the argument further, a complete social learning theory might allow for differential predictions of imitation behaviour based on a shared history that is connected to the learner's perception of the model as knowledgeable or trustworthy, or connected to a different argument that explains why children in the present study were more likely to imitate a familiar model than a stranger. To claim that the normative account could make this argument for children in the tested age group is currently critical because the crucial argument of the normative account, that other's actions are not only interpreted as conventional but also as normative, has not been confirmed in children younger than 2 years of age (i.e., as far as I am aware, no study has yet shown that children under the age of two make normative interpretations). However, the possibility that the normative account could explain the results of Study 1 should not be completely abandoned, for example, if implicit measures could be used to show a normative understanding in younger infants.

In summary, Study 1 shows that social learning is influenced by the shared history between model and learner; 18-month-olds were more likely to imitate a familiar model than a stranger model. The naïve theory of rational action and IMAIL do not offer a theoretical explanation for this finding. Also, this finding cannot satisfactorily be explained by the current accounts of the theory of natural pedagogy nor the normative account. Although, possible future changes to these two theories may allow for an explanation based on the learner's perception of the familiar model as knowledgeable or trustworthy. I argue that a complete theory of social learning should account for an influence of the shared history between model and learner on learning.

4.3.2 Communication

Differing results were found when analysing the data regarding an influence of communication on infants' imitation behaviour. In the first part of the analysis, using only data from participants who received the stimuli and observed the demonstrated actions in a systematically varied order with always one tool action and one non-tool action on each block of trials, participants in the teaching conditions imitated on average on more trials than participants in the incidental observation conditions. Similar results were found in Experiment 1, in the hands free conditions, in the study by Király and colleagues (2013). No differences were found in the present study between communication conditions regarding the number of imitative acts and a statistical trend indicated that more children imitated in the teaching conditions than in the incidental observation conditions. However, in the second part of the analysis, using data from participants who received the stimuli and observed the demonstrated actions in the fully counterbalanced order with one half of participants observing one tool action and one non-tool action on each block of trials, and the other half of participants observing two tool actions on one block of trials and two non-tool actions on the other block of trials, no differences between participants in the teaching condition and participants in the incidental observation condition were found.

The first analysis revealed that children were more likely to imitate unusual actions that were presented with ostensive and referential signals than unusual actions that were presented without those signals. Thus, the study offers some support for one of the main arguments of the theory of natural pedagogy according to which teaching increases imitation behaviour. This result was not predicted by IMAIL, the normative account, nor the naïve theory of rational action. The only difference between the teaching condition and the incidental observation condition was the communication that the model used, and thus, IMAIL cannot explain the differential finding based on motor resonance or action-effect associations. Similarly, as the actions were the same unusual, and inefficient, actions in both conditions, the naïve theory of rational action also cannot explain the observed difference in imitation behaviour.

Research in favour of the normative account has indeed revealed that 3-year-olds showed equivalently high rates of imitation independent of whether the model had demonstrated the action with or without ostensive communication, and instead, children protested selectively based on the perceived intentionality of the action (Schmidt et al., 2010). It was argued that the learner interpreted the conventionality of the action based on the perceived intentionality rather than ostensive communication (Schmidt et al., 2010). As the present study shows a difference in imitation behaviour depending on ostensive communication in 18-month-olds, one could argue that the normative account is limited to explain findings during a certain phase in development that includes 3-year-olds but excludes 18-month-olds.

An alternative explanation according to the normative account could be that children indeed imitate and protest selectively depending on the interpretation of an action as conventional and normative but that this interpretation bias is subject to different cues at different stages in development, particularly that ostensive communication cues the conventionality interpretation in infants before they can reliably interpret the intentionality of the model; however, future research is needed to investigate this hypothesis and, most problematically, this research would need to show that infants indeed have a normative interpretation of others' actions.

Regardless, the second analysis revealed no difference in imitation behaviour depending on ostensive communication, indicating that the effect of communication on learning is subject to further influences. What was different between the first analysis and the second analysis that might have led to these different results? Different data was used for the two analyses: The first analysis used data from 32 participants in the conditions familiar model teaching, familiar model incidental observation, stranger model teaching, and stranger model incidental observation (i.e., 8 participants in each condition). These participants observed one tool action and one non-tool action on each block of trials, presented in a systematically varied order of toys and actions. The second analysis used data from 35 participants in the conditions stranger model teaching and stranger model incidental observation. The second analysis included the same 16 participants from the stranger model conditions who were included in the first analysis; the data from the familiar model conditions was excluded for the second analysis, and instead, 19 additional participants were included who observed two tool actions on one block of trials and two non-tool actions on the other block of trials. Altogether, the 35 participants who were included for the second data analysis were presented with the toys and actions in fully counterbalanced orders. The actions and toys itself were the same for all participants of the study; the only difference was the chunking of demonstrations into mixed chunks with different types of actions on each block of trials (i.e., one tool action and one non-tool action) or separate chunks with two actions of the same type on each block of trials (i.e., two tool actions on one block and two non-tool actions on the other block of trials).

This means that all participants who were included in the first analysis and half the participants who were included in the second analysis observed one tool action and one non-tool action before they got the chance to act on the stimuli for the first time (i.e., mixed chunks), and none of the participants in the first analysis but half the participants in the second analysis observed either tool actions or non-tool actions but not both types of actions (i.e., separate chunks) before they got the chance to act on the stimuli for the first time. The second analysis showed that participants who were presented with separate chunks were equally likely to imitate non-tool actions but they were more likely to imitate tool actions, irrespective of which type of action was presented first, than participants who were presented with mixed chunks. In other words, the order in which the new information was presented for children (i.e., in mixed chunks or in separate chunks) had an influence on children's imitation behaviour of tool actions. Further research is needed to investigate this result.

To outline the results on the influence of communication on social learning, some support was found for the theory of natural pedagogy by showing that ostensive and referential signals increase 18-month-olds imitation behaviour. Neither the naïve theory of rational action, IMAIL, nor the normative account may satisfactorily explain this finding. However, this effect of communication may be masked or even eliminated by the choice of actions or the order in which different types of actions are presented for infants. Nonetheless, the present study shows that social learning is influenced by the social and situational circumstances such as the interaction, or communication, between model and learner, and that complete social learning theories should account for these influences to allow for the precise prediction of children's behaviour following social learning.

4.3.3 Objects

In Study 1, infants' imitation behaviour was influenced by the objects involved in the learning situation; participants were strongly more likely to imitate tool actions than non-tool actions. This effect was found for all imitation measures: imitation was performed on three times more tool trials than non-tool trials, participants performed on average 12 tool acts compared to 2 non-tool acts, more children imitated tool-use than non-tool actions with 20 children who imitated only tool actions compared to null children who imitated only non-tool actions (i.e., out of 35 children), and the children who imitated on both tool and non-tool trials (n = 10) did so on more tool trials than non-tool trials.

According to (a) the normative account and (b) the naïve theory of rational action, no difference in imitation behaviour between tool actions and non-tool actions was predicted because (a) the model performed the actions equally confidently, and thus, participants should have interpreted both types of actions as conventional and worth imitating, and (b) because both types of actions were inefficient in comparison with using the hand to elicit the toys' salient effects and, thus, participants were expected to emulate rather than imitate with no prediction on differential imitation depending on the type of action. Neither the normative account nor the naïve theory of rational action offer an explanation of the finding that tool actions were imitated more often than non-tool actions.

Also, according to IMAIL no difference in imitation behaviour between tool actions and non-tool actions was predicted because motor resonance was expected for both types of actions and the actions were demonstrated equally often. However, participants might have previously observed actions that were very similar to the tool actions in the present study but it might be unlikely that they have previously observed actions similar to the non-tool actions in the present study and, thus, one could argue that participants more readily formed action-effect associations for the tool actions than for the non-tool actions building on existing action-effect associations from similar, previously observed tool actions and effects. This advantage to build action-effect associations for the tool actions over non-tool actions could post hoc explain the difference in imitation behaviour between tool actions and non-tool actions.

Similarly, according to the theory of natural pedagogy, no difference in imitation behaviour between tool actions and non-tool actions was predicted because both types of actions were either taught or observed incidentally, and imitation should vary depending on pedagogical communication that elicits an assumption in the child that the demonstrated action is relevant and worth imitating, irrespective of what type of action is demonstrated. However, one might argue that tools, as cultural artefacts, have a similar function as pedagogical signals and, thus, facilitate imitation by activating a relevance assumption in the learner even without pedagogical communication. If this was the case, participants would have imitated tool-use in the incidental observation condition to a similar degree as they would have imitated any action in the teaching condition, or participants would at least have been more likely to imitate tool-use than non-tool actions in the incidental observation condition. With a result following one of these predictions, one could argue that the use of a tool constitutes a pedagogical signal in itself. Indeed, children in the incidental observation condition imitated on more tool than on non-tool trials. However, if we accepted the explanation of more imitation of tool actions than non-tool actions because the use of a tool constitutes a pedagogical signal and, thus increases imitation, then this study would show that the pedagogical signal *tool-use* proved to be far more efficient than the pedagogical signals most often discussed, such as eye contact, contingent responsivity, the learner's name, child-directed speech, and pointing because the effect of pedagogical communication was masked, or eliminated, with a full counterbalancing of order of tool and non-tool actions.

In summary, Study 1 shows that children imitate unusual tool actions much more readily than unusual non-tool actions. This effect was not predicted by and cannot satisfactorily be explained by the theory of natural pedagogy, the naïve theory of rational action, IMAIL, nor the normative account. Instead, I argue that this study shows that children seem to prefer learning about tools and tool actions.

It is important to note that Study 1 does not allow for the conclusion that children prefer to use tools; that hypothesis is further explored in Study 3 in which children were presented with three different methods to elicit an effect on a toy: with an unusual tool action, with the common hand action, and with an unusual non-tool action, and children's preferred method was measured. Study 4 further investigated whether children and adults would rather use their hand or a tool to solve a task when given the choice between these two methods and without demonstrating the methods for them. Study 5 is in initial investigation into how an object gets identified as a tool based on its properties size, movement, and effect. Finally, Study 6 is an initial investigation into the conventional and normative interpretation of tool and hand actions.

In any case, Study 1 shows that social learning is strongly influenced by the objects and actions involved in the learning process. Tools in particular seem to take an exceptional position in social learning. Complete theories of social learning should consider this phenomenon in their explanations.

4.3.4 Imitation and emulation

So far, in this discussion I focused on the effects of the factors shared history, communication, and objects on imitation behaviour. However, another important behaviour showing social learning is emulation. When comparing emulation behaviour between conditions, irrespective of the imitation behaviour, Study 1 showed that participants' emulation behaviour did not differ as a factor of shared history nor communication. Participants emulated on average on half of all trials. Also, emulation was performed on an equal number of tool and non-tool trials but participants performed twice as many emulative acts on non-tool trials compared to tool trials.

Study 1 also showed that children overall emulated on more trials than they imitated. Though, overall participants performed more imitative acts than emulative acts in the first analysis but overall an equal number of imitative and emulative acts in the second analysis, and there was an equal number of imitators and emulators in this study. The more detailed analysis for the shared history conditions showed that participants in the stranger model condition showed a differential pattern of more trials with emulation than trials with imitation with an equal number of imitative and emulative acts in comparison to participants in the familiar model condition who imitated on the same number of trials as they emulated but who tended to perform more imitative than emulative acts. The more detailed analysis for the communication conditions showed that participants in the teaching condition also imitated on as many trials as they emulated (similar to participants in the familiar model condition) with an equal number of imitative and emulative acts compared to participants in the incidental observation condition who, again, showed the differential pattern of more trials with emulation than imitation with an equal number of imitative and emulative acts (similar to participants in the stranger model condition). The more detailed analysis of the object factor showed that participants imitated on more tool trials than they emulated on tool trials and they performed three times more imitative tool acts than emulative tool acts. Overall, 75% of children both imitated and emulated tool actions. In contrast, participants imitated on three times fewer non-tool trials than they emulated on non-tool trials, and they performed three times fewer imitative non-tool acts than emulative non-tool acts.

Overall, only about 30% of children both imitated and emulated non-tool actions, and about 50% of children emulated but did not imitate non-tool actions compared to null children who imitated but did not emulate non-tool actions.

The theory of natural pedagogy and the normative account do not discuss emulation learning. Although, in a recent paper discussing the theory of natural pedagogy, it was proposed that children learn from others in steps (Király et al., 2013): children foremost learn about the outcome or goal of an action from the model (leading to emulation) and, only under certain circumstances, do children also learn the action itself as a means to the goal in a second step (leading to imitation). Indeed, in this study about one third of participants both imitated and emulated non-tool actions, which could be interpreted as following both steps of learning about the outcome and the action; about half of participants only emulated non-tool actions, which could be interpreted as following only the first step of learning about the outcome and omitting the second step of learning about the action; and none of the participants imitated without emulating the non-tool actions, which would have been interpreted as following the second step and omitting the first step. However, the analysis on the tool actions revealed a different pattern of imitation and emulation with more imitation than emulation on tool trials, which would have been interpreted as following the second step and omitting the first step, and which should not happen according to the argument of learning from others in steps. This tool result is also in contrast to findings from Király and colleagues (2013) who reported that 100% of children in their study emulated and they did so before they imitated the unusual action that was, however, a non-tool action. This theoretical excursion, among other points, also shows the theory of natural pedagogy's close connection to the naïve theory of rational action.

According to the naïve theory of rational action, it was hypothesized that children would generally, and irrespective of the social circumstances, be more likely to emulate rather than imitate the actions because the demonstrated actions were unusual and the most rational action to perform in all trials would be to use the hand. Although the tool actions do not seem very costly (and might thus be considered as more or less rational), they are much more difficult to perform for young children than simply using their hand. Yet children in this study were more likely to imitate than emulate tool actions, which speaks against the prediction made according to the naïve theory of rational action. However, more children emulated than imitated on non-tool trials and much more emulation than imitation was observed on non-tool trials, which confirms the prediction made according to the naïve theory of rational action. Overall, the naïve theory of rational action cannot explain this differential finding depending on the objects and actions that participants learned about because both tool and non-tool actions were inefficient and should have been emulated rather than imitated, and not only the non-tool actions as found in Study 1. In conclusion, tool actions seem to make a special case for social learning which cannot be explained by the naïve theory of rational action.

According to IMAIL, emulation would have been predicted under the assumption that participants did not experience motor resonance for the demonstrated actions or the effects were not salient to build an action-effect association. The latter argument can be rejected because the stimuli that were used in the study contained salient visual and auditory effects. The first argument cannot reliably be accepted or rejected on the basis of the obtained data because motor resonance was not measured or controlled. However, the findings that participants imitated on more tool trials than they emulated on tool trials, and that participants emulated on more non-tool trials than they imitated on non-tool trials, could show, according to IMAIL, that children were less likely to experience motor resonance on non-tool trials than on tool trials, and that three demonstrations of the unfamiliar and unusual non-tool actions might have been too few to form action-effect associations so that children did not learn the non-tool actions and, instead, performed alternative actions to elicit the desired effect.

According to the normative account, emulation would only have been predicted under the assumption that children did not interpret the model's action as intentional and, thus not worth replicating, leading to alternative ways to elicit the effect (i.e., emulation), or, following recent development of the normative account, under the assumption that the model was perceived as not trustworthy. Neither of the two explanations can be confirmed or rejected with full confidence based on this study, as neither of the two were tested in this study. However, children should have perceived the model as acting intentionally, because the actions were performed confidently in all conditions. Also, there is no reason to assume that children perceived the model as not trustworthy irrespective of the conditions shared history and communication but depending on performing a tool or non-tool action (i.e., the only difference in emulation behaviour was observed between tool and non-tool actions). Therefore, the normative account cannot explain the emulation findings in this study.

Considering that about 90% of children emulated in this study, and they did so on half of the trials, shows that emulation learning is a very important aspect of social learning. In contrast to imitation, emulation behaviour was not influenced by the social and situational circumstances shared history and communication, and emulation was only marginally influenced by the objects and actions that infants learned about. These findings suggest that imitation and emulation are potentially two behaviours independent of each other that both show social learning. Based on

Study 1 it does not seem reasonable to assume that children would emulate instead of imitating, or that imitation is something like a further step after emulation, but that imitation and emulation independently show learning. What is more, emulation is a frequent behaviour following social learning, and tool actions take a distinct position in both imitation and emulation learning. Nevertheless, few social learning theories explain emulation learning at all.

4.3.5 Conclusions

To summarize, Study 1 showed that learning is influenced by the social and situational circumstances. In particular, the influence of the learner's shared history with the model (familiar model vs. stranger model), the influence of communication in the interaction between model and learner (teaching vs. incidental observation), and the influence of the type of object and action that the child learned about (tool action vs. non-tool action) on social learning were tested. Indeed, the results confirm that imitation is influenced by all three factors: participants were more likely to imitate a familiar model than a stranger model, they were more likely to imitate following teaching than incidental observation, and they were more likely to imitate tool actions than non-tool actions. Furthermore, emulation behaviour was influenced by the type of action that was demonstrated with more imitation than emulation of tool actions, and less imitation than emulation of non-tool actions, as well as more emulative acts on non-tool trials compared to tool trials. Currently, neither the theory of natural pedagogy, the naïve theory of rational action, IMAIL, nor the normative account can satisfactorily explain all the findings in this study. The following studies in this thesis further investigated the factors communication in interaction (Study 2), tool-use (Studies 3 through 5), and normative learning about tools (Study 6).

Chapter 5: How Do Parents Teach Their Children New Actions? (Study 2)

This study investigated social learning in interactions between a parent and their child. Study 1 replicated previous findings showing that children are sensitive to ostensive and referential signals: Eighteen-month-olds were more likely to imitate an unusual action if it was presented with ostensive and referential signals than without. The present study explored parents' use of ostensive and referential signals for knowledge transmission, and their child's responses in a more natural setting.

The theory of natural pedagogy proposes that humans are naturally inclined to teach others particularly that parents teach their children (Csibra & Gergely, 2006, 2011; Gergely & Csibra, 2013). The present as well as previous research has shown that infants are receptive to this form of teaching (e.g., Király et al., 2013). However, research has also shown that social learning in 3-year-old children was less strongly influenced by ostensive communication (Schmidt et al., 2010) but the theory of natural pedagogy does not restrict its application to a certain age range.

Study 2 explored whether teaching as described by the theory of natural pedagogy, using ostensive and referential communication for demonstrations of knowledge, is indeed a natural form of interaction that is whether parents showed ostensive and referential action demonstrations in a natural interaction with their child. Study 2 also explored differences in the interaction depending on the child's age of 19 months or 4 years. The study further explored if teaching, as described by the theory of natural pedagogy, is displayed by children for their parent's benefit.

For this purpose, dyads of a parent and their child were instructed to play freely with two toys. Parents previously received information on the function of one of the toys so that parents were in a position to teach their child “how this toy works” if they wanted to and the dyads could explore the other toy together.

According to the theory of natural pedagogy, parents were expected to demonstrate actions for their child using ostensive and referential signals. Children were expected to imitate the demonstrated actions. No age differences were predicted between children aged 19 months and children aged 4 years. In addition, children were not necessarily expected to but might have demonstrated actions for their parent using ostensive and referential signals themselves. In such a case, parents were expected to imitate the demonstrated actions.

Due to the explorative nature of the study and the vast data collected with this study design, no hypotheses were formulated for IMAIL, the naïve theory of rational action, and the normative account of social learning. Rather, the data analysis focused on obvious social learning opportunities, the use of ostensive and referential signals, and the immediate development of the interaction between parent and child following the learning opportunity.

5.1 Method

5.1.1 Participants

Sixteen 19-month-olds (M_{age} = 579 days, SD_{age} = 42 days, age range: 499–664 days) and seventeen 4-year-olds (M_{age} = 50.47 months, SD_{age} = 2.60 months, age range: 47–58 months) participated in the study. Together with the 19-month-olds, fifteen mothers and one father participated; together with the 4-year-olds, fourteen mothers, two fathers, and one foster father participated in the study. All dyads except for two spoke German; one dyad spoke English and one dyad spoke Spanish. Families came from mixed socioeconomic backgrounds in Munich and were recruited via the KuLe-Kinder database. An additional two children were excluded from the data analysis due to sibling interference. All children received a gift for their participation in the study.

5.1.2 Materials

The study included two toys. Both toys could be played with in numerous ways and allowed for creative exploration alone or together with a second person. The toys are depicted in Figure 2. The demonstrated target action of the large box included pulling the handle on one side of the box resulting in bells ringing inside the box. The demonstration of the board included moving the car with the red button pointing towards the bell across the rippled side of the board against the bell resulting in a bright ringing sound. The bell on the board did not produce a sound when touched with a finger, but it rang when quickly touched with fingernails or any other hard material such as the wooden car.

5.1.3 Design and procedure

Parent and child were welcomed in a child-friendly laboratory room. The warm-up and information phase entailed free-play of the child with the experimenter to get accustomed to the new room. Parent and child were informed that they would shortly get two novel and unique toys that they could play with together for 10 min. The parents were then told to carefully watch two videos that would show them the

Figure 2. Photographs of the two stimuli used in Study 2. Left photograph: Large box with bells inside that ring when handle as seen on the right side is pulled fast. Right photograph: Board with bell in the top left corner that rings only when touched with hard material such as the car as seen in the middle of the board.

novel toys so they would know what to expect. The experimenter was taking care that the child could not see the videos and the videos did not have sound.

Each video showed one toy from different angles. One of the videos also included two demonstrations of the same action with the toy. It was counterbalanced between participants which video was presented first and which video included the demonstration so that every parent received an action demonstration for one toy only and the other toy was presented visually but no actions were performed on this toy in the video.

Parents and children then received the chance to freely play with the toys for 10 min. The experimenter remained in the room but did not usually engage with the families during this phase of the experiment. In some rare cases, the experimenter asked the parent to re-direct the child's attention back to the two toys or encouraged the participants to continue playing when they seemed insecure; for example, when the child made loud noises and the parent looked questioningly or apologizing at the experimenter, the experimenter said that it was okay to be loud and that they could continue playing.

5.1.4 Coding and reliability

All sessions were video recorded. The coding entailed detailed descriptions of all actions performed by parent and child, obvious changes in facial expressions of the participants, as well as a transcript of participants' verbalisations. Due to the vast amount of data, excerpts of the transcripts were chosen as examples of social learning situations for the data analysis. All primary coding (i.e., coding of one observer) was checked and, if necessary, amended by a second coder. No inter-coder reliability scores were attained due to the qualitative nature of the data.

5.2 Results

In the present study, parents' natural use of ostensive and referential communication for their child was explored. Excerpts of detailed transcripts as examples of social learning situations are presented separately for the age groups 19-month-olds and 4-year-olds. Every child was given a fictitious name for the analysis to simplify the presentation of results and to avoid confusion between dyads. The examples within this thesis were chosen semi-randomly: the first example was chosen by randomly drawing this dyad's printed coding file from the complete pile of coded sheets, and the other examples were chosen by randomly drawing from a pile of coded sheets that only included participant dyads whose parents had also observed the demonstration of the board to allow for comparison between the examples separately for 19-month-olds and 4-year-olds. The following examples include translations of the verbal expressions from German into English.

5.2.1 Recurring behaviours

The qualitative data analysis revealed that the interactions between parent and child were complex with recurring behaviours for all participants. While all of the following behaviours could be observed in all dyads, some of them were qualitatively different depending on the age of the child. The recurring behaviours are described in the following sub-sections to present the reader with a general overview of the behaviours observed throughout the complete data set, and the behaviours are also pointed out embedded into the narratives of three participants of the study that are presented in this thesis as examples of the greater qualitative analysis.

5.2.1.1 Exploration. In all dyads both parents and children explored the toys; for the 19-month-olds, parents and children often explored the toys together, and parents kept close distance to their child responding very quickly to the child's utterances and movements; for the 4-year-olds, parents and children sometimes explored the toys together and sometimes explored the toys individually. While parents of the 19-month-olds were physically close to their child nearly all of the time, parents and 4-year-olds frequently stood at opposite sides of the toys.

5.2.1.2 Pedagogical action demonstrations/teaching. All parents of 4-year-olds and 14 out of 16 parents of 19-month-olds used ostensive and referential communication together with action demonstrations at some point during the experiment. All of these parents also taught the action that they had observed in the videos. In dyads with 19-month-olds, parents frequently taught their child actions and they did so relatively quickly. In comparison, parents of 4-year-olds commonly first guided and directed their child verbally to perform actions in order to discover the toys' function single-handedly.

5.2.1.3 Guiding and directing. Parents showed a considerable amount of guiding and directing their child. This behaviour usually occurred before demonstrating an action. All parents of 4-year-olds and 13 out of 16 parents of 19-month-olds showed this behaviour. Parents guided their child stepwise to the action in order to discover the toys' function single-handedly, for example by touching the bell and asking "What is it?" Parents of 4-year-olds commonly guided their child to the action by asking questions such as how something works and what something could do. Guiding and directing often started on a broad level and gradually became more specific. Parents of 19-month-olds seemed to direct their child more by actions and sounds, rather than verbal instructions, and they also regularly used guiding and directing after action demonstrations.

5.2.1.4 Imitation and variation. All children imitated some of their parent's actions at some point during the experiment. However, not all imitated actions were previously taught by the parent (e.g., parents were performing actions while exploring the toy for themselves or simply without explicit teaching, and their child incidentally observed them and imitated the action shortly after), and also not all teaching from the parent lead to imitation behaviour in the child. Besides imitation, all dyads including 4-year-olds and 14 of the 16 dyads including 19-month-olds exhibited a behaviour that I labelled variation. Variation was performed frequently within dyads by both parents and children. In the three participant examples in Sections 5.2.2 and 5.2.3 either the parent, the child, or both performed an action and later varied it. However, the variation was also influenced by the child's age. For example, Alena's mother in Section 5.2.2.1 varied the angle in which she moved the car across the board but Alena reacted with a pause and so her mother returned to performing the original action again. Ben's mother in Section 5.2.2.2 also varied the action until she had tried four different variations of the action but Ben never imitated any of it. She even tried a different action (i.e., moving the car across the tracks) which Ben also did not imitate. For most of the time mother used two variations of the car against the bell action, then she tried the car on the tracks action, and only briefly before she stopped the game with the board altogether did she try two further variations of the car against the bell action. On the other hand, Charlie and his mother in Section 5.2.3.1 both varied the action: Charlie's mother tried two different angles, whereby Charlie reacted by asking her a question about another object in the room and then tried the action using different speed and force himself while his mother was still looking in the direction of the other object.

5.2.1.5 Temporal space. Another recurring behaviour was labelled temporal space. All 4-year-olds and 15 of the 16 children aged 19 months claimed temporal space at some point during the experiment. Following teaching, 4-year-olds often immediately imitated their parent's actions, then performed some other action, and then returned to imitate the actions again. Infants, on the other hand, usually first performed a different action before imitating their parent's action (if at all). Two children in Sections 5.2.2 and 5.2.3, Alena and Charlie, even looked around the room seemingly looking at nothing in particular for a few seconds before returning to the game with their mother. Parents usually granted their child some temporal space but then also guided their attention back onto the toy.

5.2.2 Nineteen-month-olds

5.2.2.1 Alena. The first dyad was composed of a girl, Alena, with her mother A. Mother A was generally in close contact with Alena: she frequently called her daughter to show her something new and she commonly reacted fast to any utterance or move of Alena. She also used infant directed speech at all times with Alena.

At the beginning of the free play phase, mother A called Alena, pointed at the board and said “look, look, Alena, look, what is this” but Alena was looking at the box and started to try to climb up onto it. Mother A then turned to Alena and the box. Mother A immediately said “what is this” and then lifted Alena onto the box to sit on it. She then said “look at what this is, watch it”, pointed briefly at the spheres, and after Alena turned towards her mother, she touched the spheres and said again “what is this”. Mother A then waited a few seconds while Alena touched the spheres. When Alena started jumping on the box, mother A said “this is funny” and shortly after “what is this, [3s] mh, look at what one can do with it” before she tried to move a sphere through a ring unsuccessfully and said “or not possible”.

In this moment, Alena had felt the blue strap with her hand and asked “wha da” to which her mother answered “I don’t know what this is for. Let me see” and moved around the box towards the strap. When mother A arrived at the side of the box, she bent down and said “look here. Watch what this is over here” while she looked at Alena and coaxed her over with a finger move gesture which turned into a finger point at the wooden doll handle accompanied by a gaze shift. She then said again “look here, what is this you think”. She lifted the handle and handed it to Alena. In the following interaction, mother A let Alena explore the handle and whenever Alena paused mother A attracted her attention to another feature of the handle, for example "look what this is. Do you know what it is? What is this" while pointing at the bells that were attached to the string holding the handle.

In both of these examples (i.e., the spheres and the handle), mother A frequently used ostensive and referential communication, then let Alena explore the objects that she had guided her attention to, and she further guided Alena's attention to ever new aspects. Mother A also tried to perform an action with the spheres after she had called Alena's attention but the action was unsuccessful and she quickly turned away.

After they had explored the features of the handle, a 10 s pause unfolded during which Alena seemed to look at nothing in particular and sat still, and mother A observed Alena. Mother A ended the pause by saying "do you want to have a look over there" and looking at the board.

After the dyad arrived at the board, Alena immediately started moving the car across the tracks and then held it out to her mother; mother A then asked her "what does it do" and briefly touched the car. At the same moment Alena started touching the bell and mother A also started touching it without it ringing. Mother A then took the car from Alena, moved it against the bell once and then said "look at th-". Alena said "off off" and mother A replied, "I don't think it comes off". Mother A then said "look. [2s] what it, this can- [2s during which mother A moved the car against the bell twice] do you hear this [2s] take your hand away" and then she moved the car against the bell twice making it ring. In conclusion, mother A used ostensive and referential signals, and she demonstrated an action as described by the theory of natural pedagogy. However, no eye contact was yet established between mother and Alena during this teaching interaction.

Mother A then put the car back on the tracks and both looked at the board for 3 s before Alena turned to the side seemingly looking at nothing in particular and mother A turned in synchrony to look at Alena. They remained in this pose for 3-4 s (i.e., temporal space) and then mother A asked “Can you do it too?” to which Alena responded with a confident “yes” and mother A replied “yes? Then go ahead.” Alena did not respond immediately, so mother A handed her the car and said “take this”. Alena briefly moved the car at random across the board, took a step back holding the car, and then tapped the car on top of the bell. In conclusion, a short pause followed the teaching before Alena imitated the mother’s action with low fidelity.

Mother A watched Alena and laughed pleasantly when Alena tapped the bell. Mother A took the car, said “like this, watch here”, and moved the car against the bell three times. Alena first observed the actions and then turned first right then left to look around before walking away. In conclusion, mother A corrected Alena’s unfaithful imitation with another demonstration of the action which, again, was followed by a pause initiated by Alena.

For the next 28 s an interaction about Alena’s shoes unfolded which she finally brought to her mother. After handing the shoes over, Alena immediately took the car and tapped it against the side of the bell making it ring. Mother A said “good job” and then stopped Alena when she started tapping with force. In response, Alena moved the car across the board for 10 s and then continued playing with the car on the floor before turning to another game. In conclusion, after a pause Alena again imitated the mother’s action, this time with more fidelity than the first time but still not faithfully. Her mother still seemed to be pleased with Alena’s imitation as she did not correct Alena again and they both turned to play something else.

During the remaining time of the free play, similar interactions to those described unfolded. Alena also returned to play with the doll handle and the spheres. After Alena explored something on her own and her mother merely commented, she usually turned to explore something else. However, Alena paused for a few seconds after her mother guided her attention onto several new aspects of the object that Alena was currently exploring.

In summary, mother A frequently used ostensive and referential signals. Mother A taught Alena the action that she had observed in the video and Alena imitated as well as varied that action. Mother A also corrected and guided Alena's imitation by teaching her the action again. Before imitating or turning to something new, Alena took a pause for a few seconds during which she seemed to look at nothing in particular or briefly did a different, simple action and Alena's mother granted her that temporal space.

5.2.2.2 Ben. The next dyad was composed of a boy, Ben, with his mother B. Mother B was also generally in close contact with Ben: she frequently called him to show him something or to restrict him as he played raucously. She reacted fast to any utterances or moves of Ben, and she permanently used infant directed speech with him. Ben and mother B played with every toy for approximately 5 min, starting with the board.

At the start of the free play phase, mother B said immediately "uuuuh, look at this, ooooy," while looking first at the board and then at Ben, after which Ben moved to the board and started touching the bell. Ben explored the board for about 50 s while mother B commented on what Ben was doing. For example, when Ben touched the bell, his mother said "bell", or when Ben took the car, his mother said "car". After Ben said "nee-nah", his mother also said "nee-nah". When Ben moved the car across the rippled side of the board, his mother said "oh dear, that's bumpy".

After about 50 s, mother B turned to the experimenter and asked if she was supposed to show him "the thing with the bell". The experimenter responded that they could play as they wished. During this moment, Ben was touching the bell and said “bell”. Immediately after that mother B took the car and said “watch this, I will show you how to make the bell ring, look”. She then slowly moved the car against the bell once while making a car sound (“brrr”) and then pushed the car against the bell two more times. Only after the demonstrations did mother B look at Bens face and mimicked a laughing sound; Ben was looking at the board and touching the bell. After his mother placed the car on the board, he took it, moved it raucously, and pushed it off the other side of the board. Mother B commented “boom” and told him that he had to pick it up again. In the following 10 s after Ben had picked up the car, he moved the car again raucously across the board. Then mother B interrupted him by taking the car softly and saying “shall we drive with the car to the bell again, watch this”. She moved the car softly against the bell again multiple times commenting “buk” when the car touched the bell while alternating her gaze between Ben and the board. Mother B then partly handed the car to Ben when he reached for it and said “Ben also with the bell-“, and she partly still moved the car against the bell commenting “beep” before finally letting go of the car. Ben raucously moved the car for 5 s and then mother B touched the car when it was on the tracks and said “look, you can also drive it in here”. Ben pushed the car off the board and the interaction turned in a different direction when Ben tried to climb onto the board. After 50 s mother B had placed Ben on the chair with the board in front of him and picked up the car. She said “watch this. The car has beautiful flowers. [pointing at the flower on the side of the car], the car goes here like this [moving the car slowly across the tracks twice], or the car goes here [moving the car across the rippled side against the bell] ooohhh puk [puk was said in synchrony with the car touching the bell, she did that twice], do you want to try again?” and mother B put the car onto the tracks. During this teaching demonstration, mother B only gazed at Ben after every time that the car touched the bell. Ben took the car, moved it raucously, and the car fell off the board. Mother B commented “boom” and a short interaction about the car on the floor developed. About 7 s after the car had fallen down, mother B said “the car has to drive against the bell for a change” and pointed at the bell.

Within the next 2 min the interaction continued in the same manner. Mother B continued to teach Ben the action and she pointed out visual features of the car while Ben continued to move the car raucously every time he held it so that his mother warned him the toy would break, and Ben tried to climb onto the board again. Mother B took the board away after Ben had halfway climbed onto it and directed Ben towards the box.

In summary, mother B frequently used ostensive and referential signals as well as action demonstrations. She increased her gaze at Ben in the course of the 5 min interaction with repeated teaching. However, eye gaze was still not often used but rather at the end of each demonstration (while it appeared only after two to three demonstrations in the beginning). Eye contact between mother B and Ben very rarely happened and Ben generally gazed at his mother's face very few times. Over time, mother B varied her action demonstrations including moving the car across the board against the bell on the rippled side (first action), pushing the car across the board (i.e., giving it a push and letting go; second action), changing the angle of the movement from the long side to the short side of the board (only in the last 2 min), and moving the car through the air against the bell (only in the last 2 min). Mother B stopped teaching when she also took the toy out of Bens reach because she was afraid that he would break it (i.e., she had repeatedly said “it’s going to break if you do it like that”).

5.2.3 Four-year-old

5.2.3.1 Charlie. The third dyad was composed of a boy, Charlie, with his mother C. The interaction between Charlie and his mother was very friendly, and varied between both exploring the toys separately and both doing one little game together while Charlie was sitting on his mother's lap. Mother C used child directed speech for most of the time with Charlie.

Charlie and his mother started exploring the box for approximately 4 min. At the start of the exploration both were walking to and then standing at opposite sides of the box. Charlie briefly touched the spheres and then turned to the doll handle saying "huuuh". Mother C touched the spheres shortly after Charlie and then repeated Charlie's "huuuh" using the same melody and continued to say "I have got the rest of it here, wait, wait wait". Charlie, who had lifted the handle high, put it back to the side of the box and his mother started pulling her handle. Then mother C put her handle back and Charlie pulled his handle again. Mother C let go of it and continued to walk around the box while Charlie squatted to look closely at the handle and where it went into the box. Mother C went back to her handle and both explored the toy separately for a while. Charlie tried different movements with the doll while his mother explored the handle at the same time as the spheres, the smaller straps, and the rippled side of the box.

After about 45 s of individual exploration, both turned towards the spheres. They moved the spheres around for a moment before Charlie asked what the blue strap was for. His mother answered that she did not know. Charlie then entered his entire arm into one of the holes on the sides of the box. His mother asked where he was going with a small laughter. Charlie then moved a little bit further around the box and stopped at the handle that his mother had previously played with. After

Charlie sat down and touched the handle, his mother sat beside the other handle that Charlie had previously played with. They further continued in this manner for 2 min: Charlie explored one feature at a time and his mother occasionally commented on or asked what he was doing. Otherwise, mother C mostly sat down and observed Charlie during this time, or explored the box individually.

After approximately 4 min of play with the box, mother C asked “Did you already look at the other one yet? What this is?” while briefly pointing at the board. Charlie immediately moved towards the board and answered “yes”. Mother C asked “What is it?” and Charlie answered “This is such a thingy”. Mother C asked “What kind of thingy is it?” Charlie grabbed the car and moved it briefly across all three sides of the board. When he arrived at the tracks again, his mother tapped the bell with her finger twice and asked “What does this thing do?” Charlie also tapped the bell with his finger and said “ding dang dong” to which his mother responded “and how?” accompanied with another tap against the bell. Charlie grabbed the car and moved it across all three sides of the board again. When he arrived at the tracks, he looked up at his mother’s face and they shared the first eye contact since their turn to the board. They both laughed shortly and mother C said that it was okay for him to play loudly. Both looked at the board again and Charlie continued to move the car across different sides of the board. After about 7 s, mother C took the car from Charlie, said “wait, when you, one time here with power“, and she pushed the car against the bell which produced a clear ringing sound. Charlie took the car and imitated the action faithfully. Mother C reacted with a short and quiet laughter, and a gaze shift to Charlie that he did not return. He imitated the action a second time. Mother C immediately then took the car and pushed it against the bell from the other direction followed by another gaze shift to Charlie.

Following this, Charlie moved around one side of the table that held the board, looked to one side and asked a question about other objects in the room (i.e., temporal space). His mother did not respond but pushed the car against the bell again from the original direction. Charlie then pushed the car with force against the bell. His mother caught the car before it fell, said “careful” and put it back onto the board. Charlie pointed at the tracks and asked “What are those? Train tracks?” Mother C hummed affirmatively, pointed at the rippled side and asked “And what are those?” In this moment, Charlie pushed the car against the bell again with force. He asked “was that loud?” which is mother confirmed humming. Charlie then moved the car across the board fast and also hit the bell three times. He asked “Was that wild?” His mother said “that was wild, Charlie” and he repeated it again (i.e., variation). Both looked at the experimenter briefly. Charlie then imitated the car-push again. The interaction continued like that for another 20 s before mother C asked “Charlie, does it drive over there, too?” while pointing at the box with the car. Charlie took the car and started playing with it on the box.

In summary, mother C used some ostensive and referential signals. She used guiding and directing before she also demonstrated the action that she had observed in the video, and she demonstrated 2 versions of the action. Charlie immediately imitated the action that his mother had demonstrated and he varied the action particularly in speed and force.

5.3 Discussion

In the present study, 19-month-olds and 4-year-olds played freely with their parent for 10 min with two toys. Parents were previously introduced to the toys and it was measured whether they would teach their child an action to perform on one of the toys, and whether this teaching would involve ostensive and referential communication together with action demonstrations, as described by the theory of natural pedagogy. For this thesis, three example dyads were chosen and their interactions were described in detail.

The analysis revealed the recurrence of certain behaviour patterns across all dyads: exploration behaviour (joint and individually), pedagogical action demonstrations, guiding and directing behaviour, imitation and variation of the actions, as well as temporal space. Because of the frequency of these behaviours across participants, they should be explored further in future research. Of particular interest to the topic of this thesis are the relationship between pedagogical action demonstrations on the one side and guiding and directing behaviour on the other side, as well as the importance of temporal space and action variation.

The analysis also showed qualitative differences between dyads including 19-month-olds and dyads including 4-year-olds with, for instance, longer periods of guiding and directing for older children and faster appearing teaching for younger children. This difference could further be examined quantitatively in a following study; for instance, a subsequent study could measure the attempts of guiding and directing before parents teach the target action, and the amount of guiding and directing after parents teach and before children imitate in both age groups. This comparison was not possible in the present study because parents might have been differentially strong motivated for their child to learn the actions and thus, any possible statistical difference could not with certainty be attributed to actual differences in teaching and learning behaviour. This quantitative analysis would be particularly important considering the possibility of age specificity of the theory of natural pedagogy. If subsequent studies show that pedagogical action demonstrations are more frequently performed by parents for infants than for older children, and teaching is substituted with a guiding and directing behaviour for older children, then teaching according to the theory of natural pedagogy could be considered as a catalyst in the early development of social learning rather than as being the mechanism of social learning in humans across the life span. However, further studies within the present thesis focus on the effect of teaching on children's and adults' behaviour rather than on the prevalence and the exact structure of pedagogical knowledge demonstrations in parents.

The finding that children frequently claimed temporal space and their parents granted that space is of particular interest to study design. Studies on social learning often include a delay between action demonstration and test phase, and the influence of the length of the delay has also been investigated (e.g., Király et al., 2013). The implementation of a delay should not be required according to any of the discussed theories of social learning, an experiment could be reduced in time without a delay which would potentially make it more comfortable for young participants, and yet research commonly includes a delay. I am not aware of a study that has explicitly tested whether the use of any delay between action demonstration and test phase has an advantage for the research method, but Study 2 suggests that children might potentially benefit from a short pause between learning and showing what they have learned and that they potentially claim this pause if it is not automatically given to them. Excluding a short delay between action demonstration and test phase could possibly lead to false negative results on the imitation and emulation measure.

Additionally, there might be a connection between the temporal space and variation behaviour observed in this study and the finding that infants often both imitate and emulate taught actions, with emulation often performed first (Király et al., 2013). This finding adds to the argument made throughout this thesis that imitation behaviour should not be investigated in isolation when studying social learning but that other behaviours such as emulation also reflect social learning.

To summarize, parents taught their child actions as described by the theory of natural pedagogy, and children then imitated. The social learning interactions also included elements of joint and individual exploration, guiding and directing of the child's actions by their parent, temporal space, and variation of the action. The exact nature of these elements depended on the age of the child. The subsequent studies investigated the factors tool-use (Studies 3 through 5) following from Study 1, and children's normative learning following from Study 1 and the present study.

Chapter 6: Do Children and Adults Prefer to Learn about Tool-Use? (Study 3)

Study 3 investigated a possible preference in children and adults to imitate tool actions over non-tool actions including using their hand. As such, Study 3 is a follow-up to Study 1, which showed that 18-month-olds (a) were more likely to imitate unusual actions that involve using a tool than unusual actions without tools such as using the forehead to push a button, (b) that infants were more likely to imitate than to emulate tool actions, (c) infants were more likely to emulate than to imitate non-tool actions, and (d) infants emulated non-tool actions more often than tool actions. Although Study 1 indicated that children might prefer to learn tool actions, it did not measure a preference for tool-use. Children in Study 1 were only shown one action for each toy, that is either a tool action or a non-tool action but not both actions so they could choose the action they preferred. Also, Study 1 compared unusual tool actions to unusual non-tool actions, and children were more likely to copy tool actions than unusual non-tool actions but no comparison was made to the more common action using the hand. Indeed, most children innovated the hand action in Study 1 which was not demonstrated for them, as shown in the high rates of emulation across the study.

To investigate a tool-use preference, participants were presented with different ways to operate a toy and it was measured which type of action participants imitated first. For three different toys, 3- to 5-year-olds observed pairs of the three types of actions: common hand action, unusual tool action, unusual non-tool action. Each type of action elicited the same salient effect on the toy. The actions were presented on video and the demonstrations included ostensive and referential communication.

The theory of natural pedagogy and the normative account did not predict a results pattern with differences in imitation behaviour between the types of actions because the way the actions were presented were identical for all types of action, that is the actions were taught and performed confidently to convey the intentionality of the action. According to IMAIL and the naïve theory of rational action, participants were expected to imitate the hand action more often than the other actions because the hand action is the most rational action to perform and it is most likely to elicit motor resonance.

Additionally, according to the naïve theory of rational action and IMAIL, children were predicted to use their hand instead of copying the tool or non-tool actions because the intention to elicit the effect would activate an existing (default) motor association to use the hand action, or because using their hand is the most rational action to activate the effect (i.e., similar to participants in the study by Király, et al., 2013, who used their hand in all cases). Alternatively, one could hypothesize that participants would be more likely to imitate the tool actions than the non-tool actions, if presented with these two options, because at this age children might have similar action-effect associations from previous tool actions. Thus, the formation of new action-effect associations for the demonstrated tool actions might be facilitated. Also, the tool actions could be viewed as more rational than the non-tool actions because the demonstrated tool actions were little costly to perform for 3- to 5-year-olds (in contrast, in Study 1 tool actions were considered costly to perform because 18-month-olds have very different motor capabilities compared to 3- to 5-year-olds).

In any case, if children showed a preference to imitate a certain type of action, this could be an indicator that the action itself might influence social learning (above social cues such as ostensive and referential communication). Additionally, adults were tested in the same procedure to assess whether people in general have a preference to use tools or to see whether children in particular are prone to use tools.

6.1 Method

6.1.1 Participants

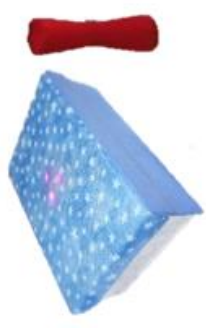
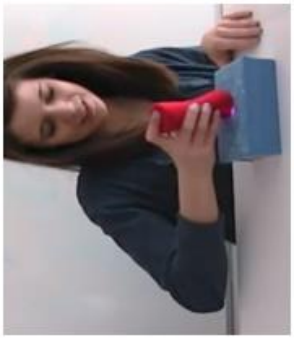
Forty-eight children (28 girls, 20 boys, M_{age} = 49.7 months, SD_{age} = 8.0 months, age range: 36–71 months) and 48 adults (31 women, 17 men, M_{age} = 20.5 years, SD_{age} = 1.3 years, age range: 18–24 years) participated in the study. Children came from mixed socioeconomic backgrounds in East Kent and were recruited via the Kent Child Development Unit database. Adults were University of Kent undergraduate students and were recruited through the Research Participation Scheme and social media. An additional two children were excluded from the data analysis due to fussiness (n = 1) or technical error (n = 1). All children received a small gift for their participation in the study. All adults received University credits.

6.1.2 Materials

The study included three target objects and three tools. Each target object featured a salient effect, such as making a noise. For the action demonstrations, two videos were presented on an iPad each. Table 5 includes more detailed information on the stimuli and the demonstrated actions.

Table 5

Stimuli Used in Study 3 with Descriptions of their Salient Target Effects and Still Images of the Demonstrated Actions as Presented in the Videos

Stimulus	Salient target effect	Tool action	Non-tool action	Hand action
Turtle & hammer 	Turtle squeaked when yellow button was pressed			
Lightbox & hourglass 	Box lit up when centre spot was pressed			
Dog & fork 	Dog wiggled back after tail was pulled			

6.1.3 Design and procedure

The study followed a within participants design with three conditions (action: hand vs. non-tool vs. tool). The study consisted of three trials on which one toy and one tool were used each. For each trial, participants observed two types of action being presented on separate iPads. Altogether, each participant was presented with all three types of action. The trials and actions were organised so that each type of action was presented twice in different combinations: hand – non-tool, hand – tool, and non-tool – tool. Every participant observed all three combinations. The order of toys, the order of combinations, and within each combination the order of actions (i.e., hand – tool vs. tool – hand) was counterbalanced between participants.

The experiment lasted between 5 and 10 min. For the child participants, the experiment was preceded by a short warm-up to familiarize the children with the laboratory environment. The adult participants were first informed that this study was designed to test children and thus contains toys and very simple tasks. All participants were instructed to watch the videos carefully as they would demonstrate how to operate certain toys. They were then shown two videos of these toys. The videos included three demonstrations of each type of action and each video included only one type of action. Irrespective of which actions were demonstrated in the videos, every toy was presented together with its tool (i.e., the tools were present even if they were not used in the videos). Afterwards, the experimenter brought out the toys and instructed participants that these were the same toys from the videos and that they could now play with them. This procedure was identical for all three trials.

6.1.4 Coding and reliability

All sessions were video recorded and coded by a single observer. It was coded which of the two demonstrated actions participants performed first after receiving the toys. In cases where participants first performed a different action from one of the demonstrated actions, for example participants used their hand before imitating the tool action on tool/non-tool trials, coding also included the different action, that is in the example the hand action.

Being successful with the action (i.e., eliciting the effect) was not necessary for the coding of an action because some effects were difficult for children to elicit. Similarly, for the turtle and the dog, the non-tool actions were coded if the child used a part of her arm other than her hand because use of the elbow in a faithful copy of the action from the video was particularly difficult for younger children. A second independent observer coded a sample of 10% of all sessions for reliability. There was complete agreement between coders (100%).

6.2 Results

Study 3 investigated whether children and adults show a preference to imitate tool actions over non-tool actions. Three types of action were demonstrated for participants: a common hand action, an unusual tool action, and an unusual non-tool action. In three trials, each two types of action were demonstrated for participants and it was measured, which action participants imitated first and if participants performed an alternative action before imitating one of the demonstrated actions. The actions were demonstrated in the combinations hand – tool, hand – non-tool, and tool – non-tool. Each participant observed every combination of actions once, and therefore, every participant observed every type of action on two trials. Participants were children between 3 and 5 years old, and young adults. Table 6 depicts the numbers of participants who imitated the hand action, the tool action, and the non-tool action as well as the average number of trials that imitation of the target actions was observed. On 9 trials (3% of total trials), participants did not imitate either of the two demonstrated actions, and only performed a different action (4 adults on the tool – non-tool trials, 2 children and 1 adult on the hand – non-tool trials) or performed no action at all (1 child on a tool – hand trial, 1 child on a hand – non-tool trial).

Table 6

Numbers of Participants who Imitated the Target Actions and Mean Number of Trials with Imitation of the Target Actions (out of Maximum 2 Trials)

	Children		
	Hand action	Tool action	Non-tool action
0 trials	6	3	35
1 trial	29	18	13
2 trials	13	27	0
M_{trials}	1.15	1.50	0.27
SD_{trials}	0.62	0.62	0.45
	Adults		
	Hand action	Tool action	Non-tool action
0 trials	0	6	45
1 trial	16	29	2
2 trials	32	13	1
M_{trials}	1.67	1.15	0.08
SD_{trials}	0.48	0.62	0.35

6.2.1 Children

To test whether children imitated the target actions by chance a binomial test was calculated. Children did not imitate by chance on the tool – non-tool trials, $p <$

.001, with 42 children who imitated the tool action and 6 children who imitated the non-tool action; nor on the hand – non-tool trials, $p < .001$, with 38 children who imitated the hand action and 7 children who imitated the non-tool action; and children tended to not imitate by chance on the hand – tool trials, $p = .079$, with 17 children who imitated the hand action and 30 children who imitated the tool action.

To investigate if children preferred to imitate one type of action the Friedman test was used. Indeed, children imitated the demonstrated actions to a different degree, $\chi^2(2, n = 45) = 41.50$, $p < .001$. Wilcoxon Signed-ranks tests were then calculated to investigate which action children were most likely to imitate. Children imitated the hand action significantly more often than the non-tool action, $Z = 4.92$, $p < .001$, and they imitated the tool action significantly more often than the non-tool action, $Z = 5.17$, $p < .001$, but they were equally likely to imitate the tool and hand actions, $Z = 1.64$, $p = .101$. See Table 6 for the mean numbers of trials with imitation of the target actions.

Children first performed an undemonstrated action before imitating one of the two demonstrated actions on 11 trials. On 3 trials participants used their hand to elicit the toy's effect before performing either the tool or the non-tool action, and on 8 trials participants innovated a tool action to elicit the toy's effect before performing either the hand or the non-tool action. No child performed a non-tool action first after the hand and the tool action were demonstrated. An exact McNemar test revealed no significant difference between the number of children who innovated the hand action on tool – non-tool trials and the number of children who innovated the tool action on hand – non-tool trials, $p = .125$, with 2 children who innovated both the hand and the tool action, 1 child who innovated the hand action only, 6 children who innovated the tool action only, and 39 children who imitated the demonstrated target actions without innovating any action.

After including the actions that participants performed first on all three trials, irrespective of whether it was an imitated or innovated action, the analysis showed that out of 48 children, 7 children used the tool first on all three trials, 1 child used his hand first on all three trials, and null children used a non-tool action first on all three trials. A Wilcoxon Signed-ranks test revealed that children tended to perform the tool action (M_{trials} = 1.68, SD_{trials} = 0.81) as first action more often than the hand action (M_{trials} = 1.27, SD_{trials} = 0.65), Z = 1.83, p = .067.

6.2.2 Adults

To test whether adults imitated the target actions by chance a binomial test was calculated. Adults did not imitate by chance on the tool – non-tool trials, $p < .001$, with 41 adults who imitated the tool action and 3 adults who imitated the non-tool action; nor on the hand – non-tool trials, $p < .001$, with 46 adults who imitated the hand action and 1 adult who imitated the non-tool action; nor on the hand – tool trials, $p = .006$, with 34 adults who imitated the hand action and 14 adults who imitated the tool action.

To investigate if adults preferred to imitate one type of action the Friedman test was used. Indeed, adults imitated the demonstrated actions to a different degree, $\chi^2(2, n = 48) = 63.86$, $p < .001$. Wilcoxon Signed-ranks tests were then calculated to investigate which action adults were most likely to imitate. Adults imitated the hand action significantly more often than the non-tool action, Z = 6.16, $p < .001$, they imitated the tool action significantly more often than the non-tool action, Z = 5.28, $p < .001$, and they imitated the hand action significantly more often than the tool action, $Z = 3.21$, $p = .001$. See Table 6 for the mean numbers of trials with imitation of the target actions.

Adults first performed another action before imitating one of the two demonstrated actions on 15 trials. On 11 trials participants used their hand to elicit the toy's effect before performing either the tool or the non-tool action, and on 4 trials participants used the tool to elicit the toy's effect before performing either the hand or the non-tool action. Similarly to the children, no adult performed a non-tool action first after the hand and the tool action were demonstrated. An exact McNemar test revealed a statistical trend for a difference between the number of adults who innovated the hand action on tool – non-tool trials and the number of adults who innovated the tool action on hand – non-tool trials, $p = .065$, with 2 adults who innovated both the hand and the tool action, 9 adults who innovated the hand action only, 2 adults who innovated the tool action only, and 35 adults who imitated the demonstrated target actions without innovating any action.

After including the actions that participants performed first on all three trials, irrespective of whether it was an imitated or innovated action, the analysis showed that out of 48 adults, 1 adult used the tool first on all three trials, 9 adults used their hand first on all three trials, and null adults used a non-tool action first on all three trials. A Wilcoxon Signed-ranks test revealed that adults performed the hand action ($M_{\text{trials}} = 1.90$, $SD_{\text{trials}} = 0.69$) as first action more often than the tool action ($M_{\text{trials}} = 1.23$, $SD_{\text{trials}} = 0.69$), $Z = 3.36$, $p = .001$.

6.2.3 Comparison of age groups

To investigate the development of an imitation preference for certain types of action, the numbers of trials on which children imitated and performed the hand action, the tool action, and the non-tool actions were compared to those of the adults. An ANOVA showed that children were significantly more likely than adults to imitate the tool action first, $F(1, 94) = 7.87$, $p = .006$, and to perform the tool action first, $F(1, 94) = 8.13$, $p = .005$, adults were more likely than children to imitate the hand action first, $F(1, 94) = 21.36$, $p < .001$, and to perform the hand action first, $F(1, 94) = 24.02$, $p < .001$, and children were more likely than adults to imitate the non-tool action first, $F(1, 94) = 5.24$, $p = .024$.

The different results between children and adults indicated a developmental shift in imitation behaviour of tool and hand actions. To investigate if this shift occurs between the age of 3 to 5 years, a median split was applied post hoc for the group of children to form the younger group of children up to the age of 48 months ($n = 25$) and the older group of children above the age of 49 months ($n = 23$). The two groups did not differ on how many trials they imitated nor performed any of the target actions (for imitation of tool actions: $F(1, 46) = 0.05$, $p = .818$, for performing the tool actions first: $F(1, 46) = 0.01$, $p = .907$, for imitation of hand actions: $F(1, 46) = 0.09$, $p = .766$, for performing the hand actions first: $F(1, 46) = 0.01$, $p = .931$, for imitation of non-tool actions: $F(1, 46) = 0.24$, $p = .625$).

6.3 Discussion

Study 3 investigated whether children and adults have a preference to imitate some types of action over others. Participants were presented with three different ways to operate a toy: by using a tool, using their hand, or performing an unusual non-tool action similar to those often used in imitation research.

Three- to 5-year-olds were more likely to imitate the tool and the hand actions than the non-tool actions, and they tended to perform the tool actions more often than the hand actions but they were equally likely to imitate the unusual tool and the common hand actions. Adults were most likely to imitate and perform the hand actions, second most likely to imitate the tool actions, and least likely to imitate the non-tool actions. In comparison, children were more likely than adults to imitate and perform the tool actions, adults were more likely than children to imitate and perform the hand actions, and children were more likely than adults to imitate the non-tool actions. No differences were found between younger and older children.

The results from the adult group but not from the child group confirmed the hypotheses based on the naïve theory of rational action and IMAIL, which predicted highest imitation rates for the hand actions because using the hand is the most rational action to perform and it is most likely to elicit motor resonance. Additionally, participants were expected to use their hand instead of copying the tool or non-tool action because, according to the naïve theory of rational action, previous research has shown that all children emulated unusual actions using their hand (thus performing the most efficient action) but only some children also imitated the actions (Gergely et al., 2002; Király, et al., 2013), and because, according to IMAIL, the intention to elicit the effect would activate an existing (default) motor association to use the hand action (Paulus, Hunnius, et al., 2011a). These predictions were confirmed in the adult group but not in the child group.

An alternative hypothesis based on the naïve theory of rational action and IMAIL predicted that participants would be more likely to imitate the tool actions than the non-tool actions if presented with these two options. The tool actions could be viewed as more rational than the non-tool actions, and the tool actions could be viewed as similarly efficient as using the hand, and thus, participants would imitate the tool actions instead of innovating the hand action in those cases. Similarly, participants might have observed or even performed similar tool actions before, and if so, the tool actions in this study would have activated previous action-effect associations leading to the facilitated formation of new action-effect associations (if necessary) for tool actions over non-tool actions. This, in turn, would lead to more imitation of the tool actions than the non-tool actions, and this would also cause the newly acquired action-effect associations to be activated when the child intends to elicit the effect, which in turn would cause imitation of the tool actions instead of previous action-effect associations leading to emulation. Indeed, participants in both age groups were more likely to imitate the tool actions than the non-tool actions, and children were equally likely to imitate the tool actions and the hand actions, which could reflect that both the tool actions and using the hand were viewed as similarly efficient and action-effect associations of both kinds got activated equally often. However, adults clearly preferred using their hand over imitating the tool actions, which showed that different explanations are needed to interpret the results from children and adults.

According to the theory of natural pedagogy and the normative account no difference in imitation behaviour depending on the type of action was hypothesized, and the pattern of results from both age groups contradicted this expectation. All actions were presented using ostensive and referential communication, which should have increased imitation behaviour in general, and the theory of natural pedagogy does not make a prediction for when different actions are taught to elicit the same effect. Similarly, the actions in the videos were performed confidently which, according to the normative account, should lead to a normative interpretation of the action, and the normative account does also not make a prediction for when different actions are demonstrated to elicit the same effect.

The differences between children and adults indicated a developmental change in copying tool-use throughout the life-span. Study 1 showed that 18-month-olds were more likely to imitate tool actions than unusual non-tool actions, and were more likely to imitate than to emulate tool actions. In the present study, 3- to 5-year-olds as well as adults were also more likely to imitate the tool actions than the non-tool actions when presented with these two options. However, children were equally likely to imitate the tool and the hand actions but they tended to perform the tool actions more often than the hand actions, and adults, in contrast, were more likely to imitate and perform the hand actions than the tool actions.

One might hypothesize that children prioritize learning about tool actions at a very young age and continue to prefer to use tool actions throughout childhood, potentially for the reason of cultural growth. Tools are important cultural objects and it was even hypothesized that some forms of social learning developed in evolution through tool-use (Gergely & Csibra, 2006). Adults, as well established individuals in their culture, might instead focus on other aspects of the learning situation, such as problem-solving or effect eliciting with the simplest solution being use of the hand in the least effort or the most common solution, as predicted by the naïve theory of rational action and IMAIL. However, this discourse is only speculation arising from the present study but exceeds the current findings by far. Further research is needed to explore this hypothesis.

Nonetheless, after being presented with a choice of actions, both children and adults were least likely to imitate the unusual non-tool actions. Additionally, no child and no adult innovated such an, or a similar, unusual non-tool action. This confirmed that the non-tool actions were indeed unusual actions. The non-tool actions used in the present study were very similar to the ones in Study 1 and other common imitation studies, with one non-tool action in this study being the frequently used head-touch.

In conclusion, the type of action used in a social learning study is of critical importance as it influences the results. For example, a number of over-imitation studies involve tool-use (e.g., Horner & Whiten, 2005; Keupp et al., 2015); over-imitation research might in some cases be biased due to the actions used in testing.

Additionally, results might be influenced by a developmental shift. Although this study did not find a difference within the age group of 3- to 5-year-olds, there was a difference between children and adults: adults did not show a preference to use tools. Study 1 suggested that the preference for tool actions is already present in 18-month-olds and the present study suggested that the preference for tool actions continues to exist in childhood but not in adulthood. This finding is further explored in Study 4.

To summarize, the current study further explored social learning of different types of actions across the life-span. Three to 5 years old children tended to use a tool to elicit an effect on a toy more often than to use their hand, they were equally likely to imitate tool and hand actions but more likely to imitate tool and hand actions than non-tool actions. In contrast, adults were more likely to use their hand than to use a tool or perform a non-tool action. These results could not be explained by the theory of natural pedagogy or the normative account, and the results could only partially be explained by the naïve theory of rational action and IMAIL.

Chapter 7: Do Children and Adults Prefer to Use a Tool Over Using their Hand Independently of Social Learning? (Study 4)

This study further investigated tool-use in children and adults. Study 1 first explored social learning of tool and non-tool actions in 18-month-olds between subjects; infants were more likely to imitate tool actions than non-tool actions, and they were more likely to emulate non-tool actions than tool actions (i.e., they used their hand instead of copying the demonstrated action). Study 3 then investigated an imitation preference of tool actions, non-tool actions, and hand actions in 3- to 5-year-olds and adults; children tended to perform the tool actions more often than the hand actions but they were equally likely to imitate tool and hand actions, and adults were most likely to imitate and perform the hand actions. One question that remains is whether adults and children would show a preference for tool-use in the absence of social learning.

The present study explored tool-use independently of social learning; children and adults were given the task to move small objects using tools or their hand. The task explanation did not involve a demonstration of the methods. Therefore, this study did not measure social learning and, thus, social learning theories did not apply. Instead, it explored whether children and adults preferred to use a tool or their hand when given the choice to perform a simple task without any explicit social learning components. In Experiment 1, adults used one tool with very low frequency; therefore, Experiment 2 was conducted in which one tool was substituted and children were recruited in addition to adult participants.

7.1 Experiment 1: Method

7.1.1 Participants

For Experiment 1, 123 adults (70 women, 51 men, 2 unknown gender, M_{age} = 22.4 years, SD_{age} = 6.6 years, age range: 17–58 years) participated in the study. Participants were of 26 different nationalities, including UK (64%), USA, Spain, Ghana, China, and others. All participants were fluent in English and 73% of participants reported that English was their first language. Participants had obtained varied educational degrees ranging from no degree to Ph.D. with most participants (70%) having obtained A-level or comparable as highest degree, and 59% of participants were currently enrolled as undergraduate students. The majority of participants (82%) was most skilful with their right hand, 2% of participants were most skilful with their left hand, 15% of participants changed hands between tasks, and 1% of participants were ambidextrous. Participants were recruited on University of Kent campus during Welcome Week. No participants were excluded from the data analysis. All participants received a small gift for their participation in the study.

7.1.2 Materials

The study included two pitchers as containers, eight small plastic balls, a kitchen spoon, and a slinky toy. The balls contained a small metal bell which made them stick onto magnets that were glued onto the kitchen spoon and onto one end of the slinky toy.

7.1.3 Design and procedure

The experiment consisted of one task only. All eight balls had to be moved from one container to the other and then back using one hand, the slinky toy, or the kitchen spoon. Participants were instructed to only take one ball at a time and they were made aware of the magnets on the tools. Participants were free to choose the method they wanted and to switch between methods at any time.

Participants were assigned to one of two experimental conditions or to the baseline condition. In the baseline condition, 15 participants were instructed to first move all balls from one container to the other for practise using one assigned method only; they were then instructed to move all balls back to the first container as fast as possible using the same method. Participants in the baseline condition used all three methods in random order. In contrast, 108 participants in the experimental conditions were first instructed to simply move all balls into the other container. After they had moved all balls from container one to container two, half of the participants were instructed to move the balls back to the first container as fast as possible, and this was emphasized by the experimenter showing a stopwatch and encouraging the participant to go fast (time pressure condition). The other half of participants moved the balls back to the first container at their own speed again (untimed condition).

7.1.4 Coding and reliability

All sessions were video recorded and coded by a single observer (baseline condition) or two observers (experimental conditions). Coding included the method that participants used to move each ball for the experimental conditions and the time that participants took to move all balls from one container to the other on the timed trials for the baseline condition. For the analysis, proportion scores were calculated for each method in the experimental conditions because some participants sometimes moved two balls at a time even though they were told not to (i.e., moving 2 balls at once was counted as moving 1 ball). There was very good agreement between coders (97% agreement).

7.2 Results of Experiment 1

In the baseline condition, participants needed on average 12.2 s to move all 8 balls as fast as possible on second trial using their hand (*SD* = 2.8 s), 34.8 s using the kitchen spoon (*SD* = 7.5 s), and 46.8 s using the slinky toy (*SD* = 11.5 s). The differences between methods were significant, $\chi^2(2, N = 15) = 25.20$, $p < .001$. Participants moved the balls faster with the hand than with the kitchen spoon, $t(14) = 11.10$, $p < .001$, or with the slinky toy, $t(14) = 12.94$, $p < .001$, and they moved the balls faster with the kitchen spoon than with the slinky toy, $t(14) = 3.62$, $p = .003$. There was no significant difference between men and women (hand: $F(1, 13) = 0.02$, $p = .882$, $\eta_p^2 = .002$, kitchen spoon: $F(1, 13) = 0.22$, $p = .647$, $\eta_p^2 = .02$, slinky toy: $F(1, 13) = 1.34$, $p = .268$, $\eta_p^2 = .09$).

To investigate whether participants' gender had an influence on their choice of method, and to test if participants chose the methods depending on whether they were supposed to move the balls as fast as possible or at their leisure on Trial 2, a MANOVA was calculated. The analysis revealed no significant interaction between gender and condition, $F(4, 99) = 0.78$, $p = .541$, Wilk's $\Lambda = .97$, $\eta_p^2 = .03$, no main effect of gender, $F(4, 99) = 0.64$, $p = .636$, Wilk's $\Lambda = .98$, $\eta_p^2 = .03$, but a significant main effect of condition, $F(4, 99) = 5.04$, $p = .001$, Wilk's $\Lambda = .83$, $\eta_p^2 = .17$. No differences were found between conditions for Trial 1 (hand: $F(1, 102) = 0.03$, $p = .868$, $\eta_p^2 = .000$, kitchen spoon: $F(1, 102) = 0.03$, $p = .866$, $\eta_p^2 = .000$, slinky toy: $F(1, 102) = 0.00$, $p = .985$, $\eta_p^2 = .000$) but on Trial 2, participants in the time pressure condition used their hand more often than participants in the untimed condition, $F(1, 102) = 17.90$, $p < .001$, $\eta_p^2 = .15$, and in turn, participants in the untimed condition used the kitchen spoon, $F(1, 102) = 13.78$, $p < .001$, $\eta_p^2 = .12$, and the slinky toy, $F(1, 102) = 5.19$, $p = .025$, $\eta_p^2 = .05$, more often than participants in the time pressure condition. Table 7 depicts the mean proportion scores for balls moved by each method for all participants on Trial 1 and separately for participants in the time pressure and the untimed conditions on Trial 2.

Table 7

Descriptive Statistics for the Proportion of Balls that were Moved by Hand, the Kitchen Spoon, and the Slinky Toy across Trials 1 and 2

	Trial 1[a]		Trial 2			
			Time pressure[b]		Untimed[b]	
Method	M	SD	M	SD	M	SD
Hand	.57	.43	.998	.02	.79	.38
Kitchen spoon	.34	.40	.002	.02	.16	.33
Slinky toy	.08	.20	.00	.00	.05	.16

Note. Depicted are the mean proportion and standard deviation of balls per trial that were moved by the methods hand, kitchen spoon, and slinky toy. [a]The number of participants was $n = 108$, data was collapsed across conditions for Trial 1. [b]The number of participants in each condition was $n = 54$.

Next, it was tested whether participants chose the methods at a rate equivalent to chance separately for Trial 1, which followed the same procedure for participants in both time pressure and untimed conditions, and for Trial 2, which differed between conditions. On Trial 1, participants performed differently from chance, $\chi^2(2, N = 108) = 48.71$, $p < .001$. Paired-samples *t*-tests revealed that participants used their hand more often than the kitchen spoon, $t(107) = 2.92$, $p = .004$, and more often than the slinky toy, $t(107) = 5.81$, $p < .001$, and they used the kitchen spoon more often than the slinky toy, $t(107) = 9.41$, $p < .001$. Participants even tended to use their hand more often than the two tools together, $t(107) = 1.72$, $p = .089$ ($M_{tools} = .43$, $SD_{tools} = .43$).

On Trial 2, participants also performed differently from expected by chance in the time pressure condition, $\chi^2(2, N = 54) = 107.35$, $p < .001$, and in the untimed condition, $\chi^2(2, N = 54) = 53.93$, $p < .001$. Paired-samples *t*-tests revealed that participants in the time pressure condition used their hand more often than the kitchen spoon, $t(53) = 215.00$, $p < .001$, and more often than the slinky toy, $t(53) = 431.00$, $p < .001$, and participants used the kitchen spoon and the slinky toy equally often, $t(53) = 1.00$, $p = .322$. Participants in the untimed condition also used their hand more often than the kitchen spoon, $t(53) = 6.69$, $p < .001$, and more often than the slinky toy, $t(53) = 11.48$, $p < .001$, and they used the kitchen spoon more often than the slinky toy, $t(53) = 2.28$, $p = .026$; they also used their hand more often than the two tools together, $t(53) = 5.66$, $p < .001$ ($M_{tools} = .21$, $SD_{tools} = .38$).

To explore whether participants changed methods between trials, paired-samples *t*-tests were calculated separately for participants in the time pressure and the untimed conditions. In both conditions, participants used their hand more often on the second trial than on the first trial (time pressure: $t(53) = 7.35$, $p < .001$, untimed: $t(53) = 3.90$, $p < .001$), and they used the kitchen spoon less often on second trial than on first trial (time pressure: $t(53) = 6.16$, $p < .001$, untimed: $t(53) = 3.44$, $p = .001$). Participants in the time pressure condition also used the slinky toy less often on the second trial than on the first trial, $t(53) = 3.49$, $p = .001$, and participants in the untimed condition used the slinky toy equally often on Trials 1 and 2, $t(53) = 1.58$, $p = .120$.

Furthermore, I explored whether participants could be categorized as tool-users or hand-users. In total, 39% of participants only used their hand on both trials of the experiment across both conditions and 6% of participants only used the tools to move all balls (each 1% of participants only used the cooking tongs or only used the kitchen spoon, respectively). A binomial test revealed that more participants were strict hand-users than strict tool-users, $p < .001$. Of all participants, 24% used the tools or their hand equally often (i.e., 50% of balls moved by hand and 50% of balls moved by tools), 66% of participants used their hand more often than the tools (i.e., 50.1% or more of balls moved by hand), and 10% of participants used the tools more often than their hand (i.e., 50.1% or more of balls moved by tools; see also Table 9 in Section 7.5), $\chi^2(2, N = 108) = 54.17$, p < .001.

Those participants, who used a tool at least once during the experiment, did so on average for 44% of balls ($SD = .26$) with the kitchen spoon being used for 35% of balls ($SD = .26$) and the slinky toy being used for 9% of balls ($SD = .16$). Participants who used a tool at least once in both time pressure and untimed conditions also used their hand more often on second trial than on first trial (untimed: $t(32) = 4.29$, $p < .001$, time pressure: $t(32) = 12.33$, $p < .001$). Participants used the tools (untimed: $M = .72$, $SD = .35$, time pressure: $M = .68$, $SD = .32$) more often than their hand (untimed: $M = .28$, $SD = .35$, time pressure: $M = .32$, $SD = .32$) on Trial 1 (untimed: $t(32) = 3.63$, $p = .001$, time pressure: $t(32) = 3.32$, $p < .005$) but they used their hand (untimed: $M = .66$, $SD = .44$, time pressure: $M = .996$, $SD = .02$) more often than the tools (untimed: $M = .34$, $SD = .44$, time pressure: $M = .004$, $SD = .02$) on Trial 2 (untimed: $t(32) = 2.09$, $p < .05$, time pressure: $t(32) = 131.00$, $p < .001$).

7.3 Discussion of Experiment 1

Experiment 1 of Study 4 investigated whether adults prefer to use a tool or their hand to perform a simple task. Similar to the results found in Study 3 on social learning of tool-use and hand actions, adult participants in this study used their hand more often than the tools. Particularly, they used their hand nearly all of the time when put under time pressure. Although it was not asked, some participants in both conditions commented after completing the experiment that they chose to use their hand because they felt it was the most efficient method. Indeed, the baseline condition showed that using the hand was the fastest method to complete the task. Future research could further investigate whether adults would use their hand still more often than a tool under time pressure when it is faster to use a tool than hand, thus exploring whether adults indeed choose the method based on efficiency.

Nevertheless, participants used the tools more often on first trial than on second trial, showing that adults at least tried out using a tool, and in fact, those participants who did try out a tool at least once, at first used the tools much more often than their hand. However, even those participants, and when not under time pressure, switched to using their hand more often than the tools after they had moved half of the balls. Also, only very few participants used the tools for all balls, about a tenth of participants used the tools more often than their hand, and about a quarter of all participants used the tools for half of the balls and their hand for the other half of the balls. In comparison, two-thirds of participants were mostly hand-users with about one-third of participants being strictly only hand-users.

Because the slinky toy was used so few times (overall and in comparison with the kitchen spoon), and because the tool actions were very similar for the kitchen spoon and the slinky toy (i.e., the part with the magnet needed to be moved close to a ball, the ball stuck to the tool, and then the tool with the attached ball was moved), in Experiment 2 of Study 4 the slinky toy was substituted by cooking tongs that required a different movement (i.e., a grasping action mediated by a tool that is more similar to the hand action than the action required by the kitchen spoon). Furthermore, for Experiment 2 children were recruited besides adults, and participants were recruited from the general public instead of from a University campus.

7.4 Experiment 2: Method

7.4.1 Participants

For Experiment 2, altogether 91 children and adults (41 female, 47 male, 3 unknown gender, M_{age} = 16.5 years, SD_{age} = 14.7 years, age range: 3–61 years) participated in the study. Because of the large age range in this sample and because of differences found between children and adults in Study 3, participants were post hoc divided into two groups: children (*n* = 58, 28 girls, 29 boys, 1 unknown gender, M_{age} = 8.7 years, SD_{age} = 2.8 years, age range: 3–14 years) and adults (*n* = 23, 12 women, 9 men, 2 unknown gender, M_{age} = 38.4 years, SD_{age} = 12.3 years, age range: 18–61 years).

Participants were of 13 different nationalities, including German (76%), Turkish, Afghan, Croatian, Bengal, Colombian, Indian, and others. All participants were fluent in German or English. Adult participants had obtained varied educational degrees ranging from a secondary school level certificate (or equivalent) to Ph.D., with each nearly one third of adult participants having obtained a secondary school level certificate or equivalent (32%), A-levels or equivalent (28%), or a Master's degree or equivalent (24%) as highest degree. School-aged participants were attending school in years 1 to 8 with most children in year 3 (22%) or year 6 (20%). All but one pre-school participant attended Kindergarten. The majority of participants (81%) answered they were most skilful with their right hand, 6% of participants were most skilful with their left hand, and 13% of participants changed hands between tasks. Participants were recruited in a large shopping mall in Munich at a one-day research information desk. No participants were excluded from the data analysis. All participants received a small gift for their participation in the study.

7.4.2 Materials

The study included two bowls as containers, 17 small plastic balls, cooking tongs, and a kitchen spoon. The balls contained a small metal bell which made them stick onto the magnets that were glued onto the kitchen spoon.

7.4.3 Design and procedure

Design and procedure of this experiment were the same as of Experiment 1 with two changes: participants moved 17 balls in each trial instead of 8 balls, and the slinky toy, which was rarely chosen as method in Experiment 1, was substituted by cooking tongs. With the latter change, the tools provided two qualitatively different ways to move a ball (i.e., by making a ball stick onto the magnet on the kitchen spoon or by grasping the ball with the tongs). Participants were randomly assigned to the conditions baseline (n = 10), time pressure (n = 41) and untimed (n = 40), which followed the same procedure as in Experiment 1.

7.4.4 Coding and reliability

All sessions were video recorded and coded by a single observer. Coding followed the same principles as in Experiment 1.

7.5 Results of Experiment 2

In the baseline condition, participants needed on average 14.2 s to move all 17 balls as fast as possible on second trial using their hand (SD = 3.8 s), 22.0 s using the cooking tongs (SD = 5.8 s), and 40.5 s using the kitchen spoon (SD = 12.1 s). The differences between methods were significant, $\chi^2(2, N = 10) = 20.00, p < .001$. Participants moved the balls faster with the hand than with the cooking tongs, $t(9) = 6.74, p < .001$, or with the kitchen spoon, $t(9) = 6.55, p < .001$, and they moved the balls faster with the cooking tongs than with the kitchen spoon, $t(9) = 5.23, p = .001$.

To investigate whether participants' gender, age, and the condition had an influence on their choice of method, a MANOVA was calculated. The analysis revealed no significant interactions between gender, age group, and condition, $F(4, 67) = 1.42, p = .238$, Wilk's $\Lambda = .92$, $\eta_p^2 = .08$, nor between gender and age group, $F(4, 67) = 0.69, p = .601$, Wilk's $\Lambda = .96$, $\eta_p^2 = .04$, nor between gender and condition, $F(4, 67) = 0.67, p = .613$, Wilk's $\Lambda = .96$, $\eta_p^2 = .04$, nor between age group and condition, $F(4, 67) = 1.08$, $p = .373$, Wilk's $\Lambda = .94$, $\eta_p^2 = .06$. The analysis also revealed no significant main effect of gender, $F(4, 67) = 0.84$, $p = .505$, Wilk's $\Lambda = .95$, $\eta_p^2 = .05$, but a statistical trend for the main effect of age group, $F(4, 67) = 2.11$, $p = .090$, Wilk's $\Lambda = .89$, $\eta_p^2 = .11$, and a significant main effect of condition, $F(4, 67) = 4.50$, $p = .003$, Wilk's $\Lambda = .79$, $\eta_p^2 = .21$.

Participants in the time pressure condition were more likely to use their hand on both trials than participants in the untimed condition (Trial 1: $F(1, 70) = 4.83$, $p = .031$, $\eta_p^2 = .07$, Trial 2: $F(1, 70) = 14.76$, $p < .001$, $\eta_p^2 = .17$), and participants in the untimed condition were more likely than participants in the time pressure condition to use the cooking tongs, $F(1, 70) = 6.07$, $p = .016$, $\eta_p^2 = .08$, and to use the kitchen spoon on Trial 2, $F(1, 70) = 7.16$, $p = .009$, $\eta_p^2 = .09$, but not on Trial 1 (cooking tongs: $F(1, 70) = 2.85$, $p = .096$, $\eta_p^2 = .04$, kitchen spoon: $F(1, 70) = 1.70$, $p = .197$, $\eta_p^2 = .02$). No differences were found between the age groups for Trial 1 (hand: $F(1, 70) = 0.22$, $p = .639$, $\eta_p^2 = .003$, cooking tongs: $F(1, 70) = 0.04$, $p = .853$, $\eta_p^2 = .000$, kitchen spoon: $F(1, 70) = 0.26$, $p = .614$, $\eta_p^2 = .004$), but on Trial 2, children used their hand more often than adults, $F(1, 70) = 5.39$, $p = .023$, $\eta_p^2 = .07$, adults tended to use the kitchen spoon more often than children, $F(1, 70) = 2.95$, $p = .090$, $\eta_p^2 = .04$, and both age groups were equally likely to use the cooking tongs, $F(1, 70) = 2.06$, $p = .156$, $\eta_p^2 = .03$. Table 8 depicts the mean proportion scores for balls moved by each method for all participants separately for Trials 1 and 2, as well as separately for participants in the time pressure and the untimed conditions.

Table 8

Descriptive Statistics for the Proportion of Balls that were Moved by Hand, the Cooking Tongs, and the Kitchen Spoon Separately for Trials and Conditions

	Trial 1				Trial 2			
	Time pressure[a]		Untimed[b]		Time pressure[a]		Untimed[b]	
Method	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Hand[c]	.76	.37	.53	.46	.90	.30	.51	.47
Cooking tongs	.13	.25	.28	.39	.10	.30	.36	.43
Kitchen spoon[d]	.11	.24	.19	.32	.00	.00	.13	.29

Note. Depicted are the mean proportion and standard deviation of balls per trial and condition that were moved by the methods hand, cooking tongs, and kitchen spoon by all participants. [a]The number of participants in the time pressure condition was $n = 41$. [b]The number of participants in the untimed condition was $n = 40$. [c]The use of the hand across conditions on Trial 2 varied between children, $M = .81$, $SD = .39$, and adults, $M = .45$, $SD = .45$. [d]The use of the kitchen spoon across conditions on Trial 2 varied between children, $M = .02$, $SD = .13$, and adults, $M = .18$, $SD = .32$.

On both trials, participants in the time pressure condition used their hand more often than they used either tool (Trial 1: cooking tongs $t(40) = 6.85$, $p < .001$, kitchen spoon $t(40) = 7.26$, $p < .001$, Trial 2: cooking tongs $t(40) = 8.58$, $p < .001$, kitchen spoon $t(40) = 19.24$, $p < .001$), and they even used their hand more often than both tools combined (Trial 1: $t(40) = 4.44$, $p < .001$, $M_{tools} = .24$, $SD_{tools} = .37$, Trial 2: $t(40) = 8.58$, $p < .001$, $M_{tools} = .10$, $SD_{tools} = .30$). On Trial 1, they were equally likely to use the cooking tongs and the kitchen spoon, $t(40) = 0.48$, $p = .636$, and on Trial 2, they used the cooking tongs more often than the kitchen spoon, $t(40) = 2.08$, $p = .044$.

Participants in the untimed condition tended to use their hand more often than the cooking tongs on Trial 1, $t(39) = 1.97$, $p = .056$, but they were equally likely to use their hand and the cooking tongs on Trial 2, $t(39) = 1.15$, $p = .256$. Participants used their hand more often than the kitchen spoon on both trials (Trial 1: $t(39) = 3.14$, $p = .003$, Trial 2: $t(39) = 3.69$, $p = .001$), and they used the cooking tongs more often than the kitchen spoon on Trial 2, $t(39) = 2.49$, $p = .017$, but not on Trial 1, $t(39) = 1.07$, $p = .290$.

On Trial 2, children were more likely to use their hand than either of the tools (cooking tongs: $t(57) = 6.60$, $p < .001$, kitchen spoon: $t(57) = 13.44$, $p < .001$, $M_{hand} = .81$, $SD_{hand} = .39$, $M_{tongs} = .17$, $SD_{tongs} = .37$, $M_{spoon} = .02$, $SD_{spoon} = .13$) and they used the cooking tongs more often than the kitchen spoon, $t(57) = 2.79$, $p = .007$. Adults, on the other hand, were equally likely to use their hand and the cooking tongs on Trial 2, $t(22) = 0.43$, $p = .668$, adults tended to use their hand more often than the kitchen spoon, $t(22) = 1.96$, $p = .063$, and they were equally likely to use the cooking tongs and the kitchen spoon, $t(22) = 1.61$, $p = .121$ ($M_{hand} = .45$, $SD_{hand} = .45$, $M_{tongs} = .38$, $SD_{tongs} = .41$, $M_{spoon} = .18$, $SD_{spoon} = .32$).

To explore whether participants changed the methods between trials, paired-samples *t*-tests were calculated separately for participants in the time pressure and the untimed conditions. Participants in the time pressure condition used their hand more often on Trial 2 than on Trial 1, $t(40) = 2.70$, $p = .010$, and they used the kitchen spoon less often on Trial 2 than on Trial 1, $t(40) = 3.00$, $p = .005$. They chose the cooking tongs equally often on Trials 1 and 2, $t(40) = 0.86$, $p = .396$. Participants in the untimed condition did not change how often they chose any method between trials (hand: $t(39) = 0.31$, $p = .762$, cooking tongs: $t(39) = 1.44$, $p = .158$, kitchen spoon: $t(39) = 1.58$, $p = .122$).

Children also used their hand more often on Trial 2 than on Trial 1, $t(57) = 3.01$, $p = .004$, they used the kitchen spoon less often on Trial 2 than on Trial 1, $t(57) = 3.16$, $p = .003$, and they chose the cooking tongs equally often on Trials 1 and 2, $t(57) = 0.68$, $p = .499$. Adults tended to use the cooking tongs more often on Trial 2 than on Trial 1, $t(22) = 1.95$, $p = .064$, and they chose to use their hand, $t(22) =$

1.09, p = .288, and the kitchen spoon equally often on Trials 1 and 2, $t(22) = 1.02$, p = .321.

In total, 52% of participants only used their hand for all balls on both trials and 15% of participants only used the tools to move all balls; 6% of participants only used the cooking tongs and 4% of participants only used the kitchen spoon. Of all participants, 4% used the tools or their hand equally often, 68% of participants used their hand more often than the tools, and 28% of participants used the tools more often than their hand. Those participants, who used a tool at least once during the experiment, did so on average for 67% of the balls (*SD* = .31) with the kitchen spoon being used for 22% of the balls (*SD* = .27) und the cooking tongs being used for 45% of the balls (*SD* = .35).

Table 9 depicts the proportion of participants in Experiments 1 and 2 who were categorized as hand-users and tool-users, separately for adults and children in Experiment 2. Fisher`s-exact tests revealed that, in Experiment 2, significantly more children than adults were strict hand-users, p = .006, and that children and adults were equally likely to be strict tool-users, p = .733. Similarly, more children than adults were mostly hand-users, p = .007, but more adults than children were mostly tool-users, p = .005.

A binomial test revealed that more children were strict hand-users than strict tool-users, $p < .001$, and more children were mostly hand-users than mostly tool-users or used both hand and tools equally often, $\chi^2(2, N = 58) = 53.21$, $p < .001$. In contrast, adults were equally likely to be strict hand-users as they were to be strict tool-users, p = .754, and adults were equally likely to be mostly hand-users as they were to be mostly tool-users, p = .832, but they were less likely to use both hand and tools equally often, $\chi^2(2, N = 23) = 8.96$, $p < .05$.

Table 9

Proportion of Participants in Experiments 1 and 2 who were Categorized as Hand-Users and Tool-Users

	Experiment 1	Experiment 2	
	Adults[a]	Adults[b]	Children[c]
Strict hand-users	39%	26%	62%
Strict tool-users	6%	17%	14%
Equal hand/tool-users	24%	4%	3%
Mostly hand-users	66%	44%	78%
Mostly tool-users	10%	52%	19%

Note. Participants were categorized as strict method-users if they used the same method to move all balls across Trials 1 and 2, and participants were categorized as mostly method-users if they used one method to move more than half of all balls across Trials 1 and 2. [a]The number of participants in Experiment 1 was n = 123. [b]The number of adults participants in Experiment 2 was n = 23. [c]The number of child participants in Experiment 2 was n = 58.

7.6 Discussion of Experiment 2

Experiment 2 of Study 4 further investigated whether adults and children preferred to use tools or their hand to perform a simple task. As expected and similar to participants in Experiment 1, participants in this experiment used their hand nearly all of the time when put under time pressure, while using the hand was again the fastest method. However, participants without time pressure were equally likely to use their hand as they were to use the cooking tongs. Furthermore, children in this experiment were much more likely to use their hand than either of the tools, and they used their hand more often than adults did, but adults were equally likely to use their hand and the cooking tongs. Children in this experiment also increased the use of their hand from Trial 1 to Trial 2, and they were more likely to be strict hand-users or mostly hand-users than to be strict tool-users or mostly tool-users, similar to the adult participants in Experiment 1. In contrast, the adults in Experiment 2 tended to increase the use of the cooking tongs from Trial 1 to Trial 2, and they chose to use their hand equally often on Trials 1 and 2, as well as they were equally likely to be strict hand-users or mostly hand-users as they were to be strict tool-users or mostly tool-users.

In contrast to Experiment 1, participants in the untimed condition did not change how often they chose any method between trials, and they chose the tools for about half of the balls. While those participants, who used a tool at least once during the experiment, did so for about two-thirds of the balls with frequent use of both tools.

Again, only few participants used the tools for all balls and less than a third of participants used the tools more often than their hand. In comparison, two-thirds of participants were mostly hand-users with about half of participants being strictly only hand-users. However, many more children than adults were strict hand-users while children and adults were equally likely to be strict tool-users, and more children than adults were mostly hand-users but more adults than children were mostly tool-users.

7.7 General Discussion of Study 4

Study 4 further investigated whether adults and children preferred to use tools or their hand to perform a simple task. The present study explored tool-use independently of social learning. In both experiments of Study 4, children and adults were given the task to move small objects using tools or their hand. As the task explanation did not involve a demonstration of the methods, this study did not measure social learning. Instead, this study explored whether children and adults preferred to use a tool or their hand when given the choice to perform a simple task.

In Study 1, social learning of tool and non-tool actions was investigated in 18-month-olds. Infants imitated tool actions more often than non-tool actions, and they emulated non-tool actions more often than tool actions. In Study 3, 3- to 5-year-olds' and adults' preference to imitate tool actions, non-tool actions, and hand actions was investigated. Children tended to perform tool actions more often than hand actions but they were equally likely to imitate tool and hand actions. Adults were most likely to imitate and perform hand actions.

In Experiment 1 of Study 4, adults used their hand more often than the tools to perform the task, similar to the adults in Study 3 who were most likely to imitate and perform hand actions. In particular, when adults were put under time pressure, they used nearly only their hand. However, many adults tried out using the tools on Trial 1 and many then switched to using their hand on Trial 2.

While Studies 1 and 3 suggested that children are potentially very interested to perform (less efficient) tool actions, Experiment 1 of Study 4 and the adult results of Study 3 suggested that this interest in tools declines with age. However, the results of Experiment 1 might be biased because using the hand was in this study very clearly the most (and much more) efficient action compared to using the offered tools. Not systematically measured comments from participants in Experiment 1 also suggested that adults might pay more attention to efficiency when solving the task than to factors like fun or experimenting with the offered methods.

When trying to draw parallels between the results of Experiment 1 and social learning theories, one could argue that the findings are most likely to support the naïve theory of rational (i.e., using the hand as most rational action) or IMAIL (i.e., using the hand as the most common action which is therefore most likely to elicit the associated motor resonance when the person forms the intention to perform an action). No parallels can be drawn to the theory of natural pedagogy nor the normative account because all three methods were introduced to participants in the same way: ostensive and referential communication was used to describe all three methods, none of the methods was demonstrated, and no method was highlighted as being more conventional or normative than the others.

Importantly, the results from Experiment 2 of Study 4 were different in some aspects in comparison to the results from Experiment 1. Similar to participants in Experiment 1, participants in Experiment 2 also used their hand nearly all of the time when put under time pressure and using the hand was again the fastest method. However, participants without time pressure in Experiment 2 were equally likely to use their hand as they were to use the tools on both trials.

Furthermore, an important difference between children and adults was observed: Children in this experiment were much more likely to use their hand than either of the tools, and they used their hand more often than adults did, but adults were equally likely to use their hand and the cooking tongs. This finding is in contrast to the findings from Experiment 1 of Study 4 and Study 3. Children in Experiment 2 were more likely to be hand-users than to be tool-users, similar to the adult participants in Experiment 1. In contrast, the adults in Experiment 2 were equally likely to be hand-users as they were to be tool-users, similar to the child participants in Study 3.

What could have caused this difference in performing tool and hand actions? The difference between Experiments 1 and 2 was that in Experiment 2 a very different tool was used. One possible explanation is that children are not per se more interested in tools (i.e., more interested to copy and perform tool actions) than adults are but that the type of tool has an important influence on performance. The cooking tongs in Experiment 2 required a very similar grasping action to that of the hand action, which might have made it more interesting to the adult participants than the kitchen spoon. Additionally, the cooking tongs were a very safe method because very few balls fell once grabbed with the tongs while the kitchen spoon and the slinky toy were quite unsafe to use, that is multiple times the balls fell back into the container because the participant had moved the spoon or slinky toy too quickly for the magnets to keep the contact to the ball. For (younger) children, however, the cooking tongs were more difficult to use than for adults because they required a relatively large grip to hold the balls with them and particularly the younger children had too small hands to grab the tongs comfortably. Indeed, 8 of 10 participants in the baseline condition were children and therefore, the difference in efficiency between the cooking tongs and using the hand might in fact be much smaller for adults than for children. The perceived efficiency of the cooking tongs for adults might in turn have increased the use of the tongs, while the perceived inefficiency, and the difficulty to use the tongs, for children might have decreased use of the tongs and increased use of the hand.

One other difference between Study 4 and Studies 1 and 3, besides the difference of demonstrating versus explaining only, is that the tools in Study 4 were common everyday objects while the tools in Studies 1 and 3 were toys. Adults in Study 3 might have refrained from using the tools more often because they were toys while adults in Study 4 might have felt more comfortable using the tools because they were common objects. This explanation may also explain the different findings between Experiments 1 and 2 of Study 4: In Experiment 1, a common but modified object (i.e., the kitchen spoon) and a toy were used while in Experiment 2, a common object without any modification (i.e., the cooking tongs) and the same common but modified object (i.e., the kitchen spoon) were used. Participants in Experiment 1 hardly used the slinky toy at all but participants in Experiment 2 frequently used the cooking tongs.

Neither of these two explanations can be accepted based on Study 4 alone and further research is needed to investigate adults' and children's imitation and performance of tool and hand actions. However, Study 4 adds to the argument made throughout this thesis that children's and adults' performance of certain actions are influenced by the objects involved. Study 5 further investigated on what basis a person identifies an object as a tool.

Chapter 8: How do Adults and Children Identify an Object as Tool? (Study 5)

This study was a rudimentary investigation into how an object gets defined as a tool based on properties such as its size. Studies 1, 3, and 4 in this thesis investigated if children and adults treated objects differently depending on their classification as a tool: Study 1 showed that infants were more likely to imitate actions that involved the use of one object on another object (i.e., tool-use) than to imitate actions that involved the use of their own body on an object (i.e., non-tool actions); Study 3 showed that young children would use an object on another object (i.e., innovate a tool action on a toy) even though they were just shown two other options how to play with the toy by using their hand or another part of their body; Study 4 showed that children and adults liked to try out and use some tools but not others. One question that arose from this research is: How does one identify an object as tool?

The term *tool* can refer to a variety of things. The Merriam-Webster online dictionary refers to tool as “a handheld device that aids in accomplishing a task” (definition 1) or “something (as an instrument or apparatus) used in performing an operation or necessary in the practice of a vocation or profession” (definition 2), the online Oxford Dictionaries refer to a tool as “a device or implement, especially one held in the hand, used to carry out a particular function” (definition 1), and the online Cambridge Dictionary refers to a tool as “a piece of equipment that you use with your hands to make or repair something” (definition 1) or “something that helps you to do a particular activity” (definition 2). These definitions are all very broad and do not provide a clear guide on how to identify an object as a tool. Anecdotal evidence even suggests that some people may refer to parts of their own body as a tool, for instance, the arm can be referred to as a tool to push open a door if both hands are occupied.

Study 5 rudimentary investigated how an object is identified as a tool based on the factors size, movement, and effect. Participants were presented with multiple videos that showed two differently sized objects, one of which (or both) moved to touch the other object, and upon touch, one of the objects (or none) lit up. Participants were then asked which of the two objects they would call a tool. The task did not involve using the objects in any way, the videos did not show a person (but only a person's hands), and no further responses, but the answer to the question which object the tool was and, if provided, an explanation for the answer, were recorded. Therefore, this study did not measure (an outcome of) social learning and, thus, social learning theories did not apply. Instead, this study explored one of the bases for studies on tool-use, such as studies on the innovation of tools (e.g., Beck, Apperly, Chappell, Guthrie, & Cutting, 2011), namely how a tool is identified as such.

Participants were expected to identify one of the objects as a tool based on the following characteristics of the objects: the small/large object is the tool, the object that is moved/not moved is the tool, the object that exhibits/does not exhibit an effect is the tool. These characteristics were further combined to investigate which participants prioritized over the others. Some of these combinations made the decision more distinct while others forced participants to choose one defining characteristic over another. For example, a person who would usually call the smaller of two objects the tool or who would usually call the object that moves towards another object the tool, might find it easy and straightforward to identify one of the two objects as tool if, in the video, the small object was moved towards the large object. In contrast, this person might find it more difficult to identify one of the objects as a tool if, in the video, the large object moved towards the small object or both objects moved towards each other. Similarly, a person who would usually identify an object that is moved and causes an effect on another object as tool, might find it easy and straightforward to identify one of the two objects as tool if, in the video, the large object was moved towards the small object and either the small object or none illuminated. In contrast, this person might find it more difficult to identify one of the objects as a tool if, in the video, the large object was moved towards the small object and the large object itself illuminated, or if both objects were moved towards each other and none illuminated.

8.1 Method

8.1.1 Participants

Altogether, 110 children and adults (58 female, 45 male, 7 unknown gender, M_{age} = 25.4 years, SD_{age} = 16.8 years, age range: 5–63 years) participated in the study. Because of the large age range in this sample, participants were post hoc divided into two groups based on whether they were still attending school or had completed their basic school education: children (n = 52, 24 girls, 26 boys, 2 unknown gender, M_{age} = 9.9 years, SD_{age} = 2.5 years, age range: 5–17 years) and adults (n = 58, 34 women, 19 men, 5 unknown gender, M_{age} = 39.4 years, SD_{age} = 10.9 years, age range: 17–63 years).

Participants were of 19 different nationalities, including German (68%), Turkish (11%), Albanian, Afghani, Greek, Ethiopian, Danish, and others. All participants spoke German or English. Adult participants had obtained varied educational degrees ranging from no degree to Ph.D., with most participants having obtained a secondary school level certificate or equivalent as highest degree without further job training (*Hauptschulabschluss*: 17%, *Realschulabschluss*: 24%, A-levels or equivalent: 17%), or a University degree as highest degree (Bachelor: 2%, Master: 9%, Diploma or equivalent: 14%, Ph.D. or equivalent: 7%). School-aged participants were attending school in years 1 to 10 with most children in year 2 (16%), year 3 (18%), or year 6 (20%). The majority of participants (85%) answered they were most skilful with their right hand, 8% of participants were most skilful with their left hand, 6% of participants changed hands between tasks, and 1% of participants was ambidextrous. Participants were recruited in two large shopping malls in Munich, Germany at research information desks. No participants were excluded from the data analysis. All participants received a small gift for their participation in the study.

8.1.2 Materials

The study included videos of each two objects. In the beginning, one small object was located on the left side of the frame and one large object was located on the right side of the frame. The objects were identical except for their size. In each video, the two objects were of the same colour. Altogether, objects in six different colours were seen in the videos. Two example still images from the videos are depicted in Figure 3.

In the videos, two hands reached for the objects and moved one of the objects, or both, towards the other object until they touched. Upon touch, one of the objects illuminated (or nothing happened). The videos ended with a still image of the last frame, that is both objects were located on the left side of the frame if the large object had moved towards the small object, they were located on the right side of the frame if the small object had moved towards the large object, or the objects were located in the middle of the frame if both objects had moved towards each other, and one (or none) of the two objects was illuminated, like the examples in Figure 3.

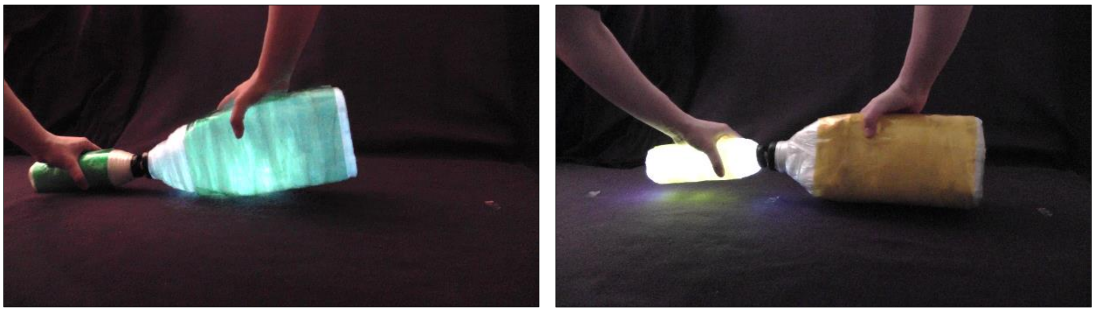


Figure 3. Still images from two of the videos used in Study 5. Left image: the large object on the right had been moved towards the small object on the left and illuminated upon touch. Right image: both objects had been moved towards each other and the small object on the left illuminated upon touch.

8.1.3 Design and procedure

The study followed a 3 (movement: small object moving vs. large object moving vs. both objects moving) x 3 (effect: small object illuminating vs. large object illuminating vs. no-effect) design. Every participant was shown 6 videos of each differently coloured objects. Every video showed one small and one large object. It was counterbalanced which of the two objects, or both, moved towards the other object, and which object (or none) illuminated upon touch. In every video, the large object was located on the right side of the frame and the small object was located on the left side of the frame.

The videos were sorted into 10 playlists. Three playlists showed videos of every possible combination of movement and effect with illumination in random order (i.e., full combinations), 4 playlists showed videos of 4 of the 6 possible combinations of movement and effect with illumination in random order whereby 2 combinations were repeated (i.e., repeated combinations), and 3 playlists showed videos of the combination of all three movements with no effect in random order (i.e., no-effect combinations).

At the beginning of the experiment, participants were instructed to carefully watch the following videos and that they would be asked a question to every video. They were then shown the videos on a laptop. While the still frame at the end of the video was still visible to the participants, the experimenter asked them which of the two objects they would call a tool if they had to decide that one of the objects (and only one of them) would be called so. Participants were informed that there is no correct or mistaken answer, and that we were interested in what they defined as the tool. After participants had made their choice, the procedure was repeated for the other 5 videos. Participants could not change their previous answers in the course of the experiment. If participants made remarks on why they chose a certain object, the experimenter noted the comment on the answer sheet, and left the remark uncommented or said that this was an interesting explanation.

8.1.4 Coding and reliability

The experimenter noted for each video which object (small or large) the participant chose to call a tool. The experimenter also noted remarks from the participant that explained his choice, if any were made.

8.2 Results

Children and adults were shown 6 videos of each two differently sized objects and were asked to identify one of the objects as a tool. In the videos, either the small, the large, or both objects moved towards the other. Additionally, either the small, the large, or none of the objects illuminated upon touch with the other object. A total of 72 participants (41 children and 31 adults) were shown all combinations of movement crossed with an effect; 23 participants (4 children and 19 adults) were shown 4 out of 6 possible combinations of movement crossed with an effect and two combinations were repeated to investigate whether participants would change their criteria to identify the tool within the experiment; 15 participants (7 children and 8 adults) were shown the combinations of movement crossed with no effect and each of these combinations was shown twice. Table 10 depicts the number of participants for each combination who selected the small and the large object as tool.

Table 10

Number of Participants Who Chose Each Object as the Tool

Moving object	Illuminated object	"Tool"	
		Small object	Large object
Small	Small	38	52
	Large	67	23
	No-effect	14	1
Large	Small	26	64
	Large	61	26
	No-effect	3	12
Both	Small	30	52
	Large	55	30
	No-effect	6	9

Even though some participants gave different answers on the same combination (e.g., they answered the small object was the tool on the first trial with the combination *small object moved and no effect* but they answered the large object was the tool on the second trial with this combination), the difference between trials was not significant for any combination (exact McNemar tests for small object moved/small object illuminated: $n = 5$, $p = 1.000$, small object moved/large object illuminated: $n = 5$, $p = 1.000$, small object moved/no-effect: $n = 15$, $p = .250$, large object moved/small object illuminated: $n = 5$, no change, large object moved/large object illuminated: $n = 5$, $p = 1.000$, large object moved/no-effect: $n = 15$, $p = 1.000$, both objects moved/small object illuminated: $n = 10$, $p = 1.000$, both objects moved/large object illuminated: $n = 13$, $p = .250$, both objects moved/no-effect: $n = 15$, $p = 1.000$).

To investigate whether participants chose the object as tool based on size or movement, the no-effect combinations were analysed. Binomial tests revealed that participants did not choose the object as tool by chance for the combinations small object moved/no-effect, $p = .001$, and large object moved/no-effect, $p = .035$, but the answers were not different from chance for the combination both objects moved/no-effect, $p = .607$. When the small object moved, more participants chose the small object than the large object as tool; when the large object moved, more participants chose the large object than the small object as tool; and participants were equally likely to choose either object as tool when both objects moved (see also Table 10).

These findings were confirmed for the combinations in which one object (or both) moved and the other object illuminated. Binomial tests revealed that more participants chose the moving object that did not itself illuminate as the tool than the still object that illuminated (small object moved/large object illuminated: $p < .001$, large object moved/small object illuminated: $p < .001$, both objects moved/small object illuminated: $p = .020$, both objects moved/large object illuminated: $p = .009$).

To investigate whether participants chose the object as tool based on movement or effect, the combinations in which the same (one) object moved and illuminated were investigated. Participants' answers were not different from chance for the combination small object moved/small object illuminated, $p = .170$, but participants were more likely to choose the small object as tool in the combination large object moved/large object illuminated, $p < .001$.

No differences between adults and children were found for most combinations but more adults than children tended to choose the large object as tool in the combination large object moved/small object illuminated, $U = 832.5$, $p = .064$, and all 8 adults but only 4 of 7 children chose the large object as tool in the combination large object moved/no-effect, $U = 16.0$, $p = .046$ (all other $p > .150$). Adults chose the large object significantly more often than the small object in both combinations (large object moved/small object illuminated: 36 of 45 participants, $p < .001$, large object moved/no-effect: 8 of 8 participants, $p = .008$) but children chose both objects equally often in both combinations (large object moved/small object illuminated: 28 of 45 participants chose the large object, $p = .135$, large object moved/no-effect: 4 of 7 participants chose the large object, $p = 1.000$).

8.3 Discussion

This study investigated on what basis an object was identified as a tool. Participants were shown videos of two objects and the analysis investigated whether participants called one of the objects a tool based on its size, based on movement towards the other object, or based on an effect that was elicited on one of the objects. Participants were expected to identify one of the objects as a tool based on the following characteristics of the objects: the small/large object is the tool, the object that is moved/still is the tool, the object that exhibits/does not exhibit an effect is the tool.

The most basic of the explored combinations were (a) those of both objects moving crossed with no effect because participants had to decide which object was the tool based on size alone. Participants were equally likely to choose either object as tool when both objects moved and none illuminated, indicating that size did not affect participants' decision in this combination. Further basic combinations were (b) those of one object moving crossed with no effect because participants had to decide which object was the tool based on (size or) movement. For those combinations, participants chose the object that was moved to be the tool, again irrespective of its size. More basic combinations were (c) those of both objects moving crossed with one object illuminating because participants had to decide which object was the tool based on (size or) effect. Most participants chose the large object as tool after the small object illuminated, and in turn, most participants chose the small object as tool after the large object illuminated, indicating that they thought the object that exhibited an effect was the target object and the object that did not exhibit an effect was the tool, which potentially elicited the effect in the target object.

These findings supported the earlier cited word definitions of a tool as "a handheld device […]" (Merriam-Webster online dictionary, definition 1), which hints that a tool is something that can be moved easily with the hands, and "something that helps you to do a particular activity" (online Cambridge Dictionary, definition 2), such as eliciting an effect in another object. Under these assumptions, results would be non-ambiguous for the combinations in which one object moved and the other object illuminated. This could be interpreted as the tool moving towards and eliciting an effect in a target object. Indeed, participants were most likely to choose as the tool the moving object that did not itself illuminate.

Most critical in this study were the combinations in which the same (one) object moved and illuminated because both explored explanations (i.e., the tool is the object that moves and the tool is the object that elicits an effect in the other object) were mutually exclusive. Interestingly, participants were equally likely to choose as the tool the small object and the large object after they observed the small object moving and illuminating, but participants were more likely to choose the small object as tool after they observed the large object moving and illuminating. It seems that participants considered size in the cases where the characteristics movement and effect were conflicting.

Adults seemed to soundly use these characteristics of objects to identify them as tools or target objects because multiple combinations resulted in the same pattern of results as mentioned above, and because those participants who observed the same combination twice in the course of the experiment did not significantly change their answer from first trial with this combination to second trial. Children, on the other hand, chose both objects equally often on one basic combination (i.e., large object moved/no-effect) and one seemingly non-ambiguous combination (i.e., large object moved/small object illuminated). Possible explanations include that children might not have developed sound rules to identify objects as tools yet, or that children might consider the sizes of the objects more than adults (i.e., tools are usually the smaller objects) which complicates identification of an object as tool when size is crossed with other characteristics such as movement or effect. Further research is needed to investigate this hypothesis.

The answer to the question “How do children identify objects as tools?” is important because the previous studies within this thesis showed that children were more likely to copy tool-use than unusual non-tool actions (Studies 1 and 3), children frequently innovated tool actions (Study 3), and children preferred to use some tools but not others when the tool-use was described but not demonstrated (Study 4). Future research could, for example, investigate whether children might just use any object as a tool (thus, turn any object into a tool), whether children can only under certain circumstances innovate the tool functionality (e.g., depending on the difficulty of the task), or whether children need to observe an object being used as a tool to identify it as such. Future research could also explore what characteristics of objects help children to identify them as tools, or whether tools could be sorted into different categories based on how they are used and the actions they require. The last study within this thesis investigated whether children not only imitated tool actions more often but also whether children interpreted tool actions as more normative than non-tool actions.

Chapter 9: Are Tool Actions "More Normative" than Non-Tool Actions? (Study 6)

Previous research has shown that 3- to 5-year-olds interpreted others' intentional actions as normative (Schmidt et al., 2010). To test children's normative interpretation, they were usually shown one action, and their reaction to another agent performing a different action was measured; if children protested against this other agent, it was inferred that children had interpreted the first action as normative and the action of the other agent as a mistake because it did not follow the norm of "you are supposed to do X" (i.e., the first action).

Previous research has also shown that children interpreted normative behaviour context-dependent; thus, the norm becomes "in context Y, you are supposed to do X". For example, children protested against an agent who had claimed to join the game but performed a different action and they did not protest against an agent who had claimed to play a different game (Rakoczy et al., 2008).

Because children might be less inclined to protest against an unfamiliar adult, a puppet is usually used as third-party that performs the mistake. To familiarize children to the puppet and the idea that mistakes can happen, a normative warm-up is used in which children practise to protest against the puppet when the puppet performs silly actions, such as holding a pencil up-side-down to draw a picture (Schmidt et al., 2010).

Besides the default normative interpretation of intentional actions, the normative account also proposes that actions are interpreted as conventional. In other words, children expect other people to also be familiar with and perform the normative actions.

Study 6 explored children's normative learning and different influences on normative behaviour. Firstly, the hypothesis that intentional actions are interpreted as normative was investigated (thus replicating the findings from previous studies). To this end, children were taught some actions, they imitated the actions, and then another person joined the game and either performed the same (no-mistake condition) or a different action (mistake condition). If children interpreted the actions as normative, they would protest against the other person only when she performed a different action but not when she performed the same action.

In contrast to previous studies, in Study 6 the agent performing the mistake was not a puppet but the participant's parent. Because a parent is a familiar person, the study did not include a normative warm-up; only a short "normal" warm-up was included to familiarize the child with the experimenter and the room.

Additionally, children's interpretation of the intentional action as conventional was investigated. In a between-subjects design, the parent was either observing the teaching of the action (observing condition), or the parent was otherwise occupied and did not observe the teaching (drawing condition). If children interpreted the action as conventional (in addition to the normative interpretation), children's behaviour would not differ between conditions because they would expect their parent to know the action irrespective of whether the parent watched the experimenter show the action to the child or not. Thus, participants would protest against their parent performing a different action in both observing and drawing conditions (but not if the parent performed the same action as the experimenter).

Similarly, the theory of natural pedagogy states that taught actions are interpreted by the learner as culturally shared; therefore, children's behaviour would not differ between the two conditions observing and drawing. However, if children interpreted the taught action as normative but not as conventional and culturally shared, they would protest less against their parent if she did not observe the teaching than if she did observe it, and they might themselves teach their parent the action if she did not observe the teaching.

It has been proposed that children show a gradation of normative interpretation (Schmidt et al., 2010). Because children seem to prefer learning about tools (Study 1), they show a preference to imitate tool-use (Study 3), and they like to use a tool when given the choice (Study 4), children might interpret tool actions more strongly normative than non-tool actions.

In the present study, children (a) were taught an action using their hand and then the parent used a tool instead of her hand to elicit the effect in one trial, and (b) children were taught an action using a tool and then the parent used her hand instead of the tool to elicit the effect in another trial. Children would show protest against their parent in both cases if they interpreted intentional actions as normative; but if there is a gradation of normative interpretation and tools are treated as special also in normative contexts, children would show more protest when their parent ignored the tool using her hand than when she used a tool instead of her hand.

Moreover, in this study it was explored how strictly children themselves followed the rules. If children are strict norm-followers (as they seem to expect others to be if they protest against them for performing a different action), they would imitate the action they were taught, and they would not show emulation of the action. What is more, if they were strict norm-followers, children would also only perform the taught action even after they observed their parent perform a different action with the same outcome. However, it has been argued that the normative interpretation children make after observing intentional actions falls into the category of conventional norms, and conventional norms are not as strict as, for example, moral norms which must not be violated under any circumstances (S. Keupp, personal communication, June 19, 2015). Therefore, the normative account would not be strictly falsified if children also emulated the taught action or they imitated the mistake action. Still, emulation and imitation of the mistake actions would call into question the prominence of the normative interpretation.

The naïve theory of rational action and IMAIL do not explain or allow for hypotheses regarding the protest behaviour or teaching behaviour of children. According to IMAIL, however, children were expected to imitate both the taught action and the mistake action, because both actions would elicit motor resonance in the child irrespective of tool-use and hand action, or observing and drawing conditions; also, both actions were demonstrated equally often by the experimenter and the parent, and the attention was drawn onto the toys for both demonstrations.

According to the naïve theory of rational action, children were expected to imitate the actions using their hand, whether those were taught or mistakes, because the hand actions were more rational than the tool actions. Children were expected to be less likely to imitate the tool-mistake actions because using a tool was less efficient in these cases than using their hand and the parent was not using pedagogical signals to activate a pedagogical stance that might override the rationality principle.

9.1 Method

9.1.1 Participants

Twenty 3.5- to 5.5-year-olds (8 girls, 12 boys, M_{age} = 54.3 months, SD_{age} = 8.0 months, age range: 42–65 months) together with their parent (16 mothers, 4 fathers) participated in the study. Participants were assigned to one of the conditions: parent-observing / mistake condition, parent-observing / no-mistake condition, parent-drawing / mistake condition, parent-drawing / no-mistake condition. Two participants did not fit into these conditions due to parental mistake or experimenter mistake: for one child, the experimenter mistakenly demonstrated the tool actions on both trials instead of hand on first and tool on second trial so that the parent then performed the no-mistake action on the first trial and the mistake action on second trial, and for another child, the parent accidentally imitated the experimenters action on first trial (i.e., no-mistake action) and the instructed mistake action on second trial. These two participants needed not be excluded from the data analysis because the procedure was otherwise followed. The number of participants, their gender, mean age, and the parents' gender in each condition are depicted in Table 11. Children came from mixed socioeconomic backgrounds in East Kent and were recruited via the Kent Child Development Unit database. An additional seven children were excluded from the data analysis due to fussiness or inactivity (*n* = 2), experimental error (*n* = 3), or technical malfunction (*n* = 2). All children received a small gift for their participation in the study.

Table 11

Number, Gender, and Mean Age (in Months) of Participants in each Condition, as well as Gender of Participating Parent

Condition		Parent	
		Observing	Drawing
Mistake	N_{girls} / N_{boys}	2 / 4	3 / 4
	M_{age} (SD)	56.2 (6.5)	51.4 (9.8)
	Parents	6 mothers	7 mothers
No-mistake	N_{girls} / N_{boys}	1 / 1	2 / 1
	M_{age} (SD)	63.5 (0.7)	52.7 (6.7)
	Parents	1 mother, 1 father	2 mothers, 1 father
No-mistake & mistake	N_{girls} / N_{boys}	0 / 1	0 / 1
	Age	46	58
	Parents	1 father	1 father

9.1.2 Materials

The study included two target objects with one tool each (see Figure 4). The first stimulus set comprised the green Lamaze "Pupsqueak" dog with a small toy hammer. The actions were slowly pressing the dog's nose with the hand or with the hammer until the dog made a barking noise. The second stimulus set comprised a cylindrical box and a silver wand. The box had a round button inside that made a noise and blinked when pressed. The actions were pressing the button inside the box with the hand or with the wand until the sound was audible.

9.1.3 Design and procedure

The study followed a 2 (mistake: mistake vs. no-mistake) x 2 (parent: observing vs. drawing) between-subjects x 2 (action: tool vs. hand) within-subjects

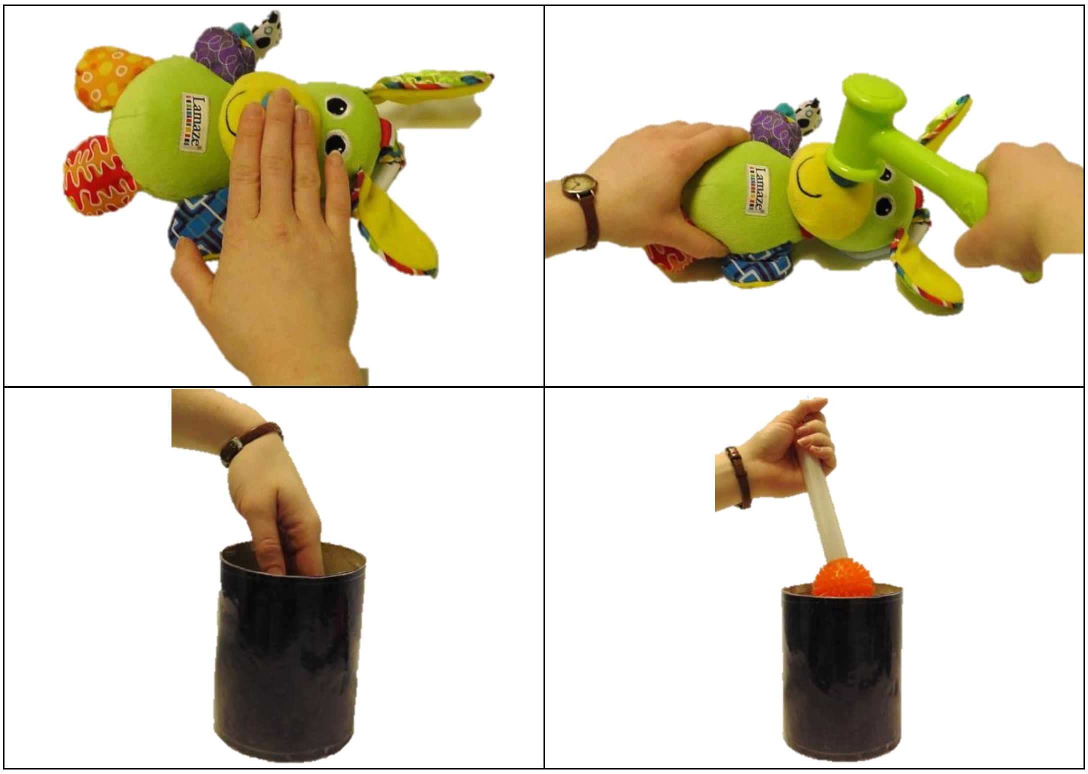


Figure 4. Pictures of the stimuli from Study 6 showing the hand actions (on the left) and the tool actions (on the right) on the dog (top) and the box (bottom).

design. The experiment consisted of a warm-up and two trials, and lasted between 10 and 15 min.

<u>9.1.3.1 Warm-up.</u> Before the experiment, the parent and child were met in a child-friendly room for a warm-up phase. While the child played freely, the parent was informed about the study and secretly trained for her part.

<u>9.1.3.2 Set-up.</u> After the warm-up, the parent was asked to sit at a small table next to the door of the experimental room. The parent was instructed to either draw a picture with the back turned to her child and the experimenter (parent drawing condition), or to sit there and observe the procedure (parent observing condition).

After the parent had taken her position, the child was asked to sit at a table approximately 2.5 m from the parent so that the child could clearly see what the parent was doing. The experimenter sat opposite the child at the other side of the table, and reminded the child of what the parent was doing, and that the parent could or could not see what they were going to do.

9.1.3.3 Demonstration and action phase 1. In the demonstration phase, the experimenter brought out one of the stimulus sets (i.e., the dog and the hammer on first trial, and the box and the wand on second trial), and demonstrated one type of action (i.e., hand or tool action) two times using ostensive and referential signals. Immediately after the demonstrations, the child received the toys to play with (i.e., action phase 1). If the child did not herself imitate the demonstrated action, the experimenter asked the child to produce the sound (e.g., "Can you make the dog bark?" or "Can you make it sound?") without telling the child how to produce the sound or which action to perform. The first action phase ended when the child imitated the action successfully three or more times, or the child undoubtedly indicated that she did not wish to continue playing with these toys.

9.1.3.4 Child teaching phase. The experimenter then asked the parent to come over and join the game, which started the child teaching phase. Parents were instructed to say that they would join the game. During the child teaching phase, children had the opportunity to spontaneously teach their parent the game, but they were not in any way encouraged to do so. The duration of the child teaching phase depended on whether the child spontaneously taught his parent, and ended when the parent performed her action for the first time.

9.1.3.5 Protest phase. Parents were instructed to perform either the same action as the experimenter (no-mistake condition) or the other type of action (mistake condition) two times without further talking to or looking at their child. Again, children had the opportunity to respond to their parent's behaviour. The protest phase started when the parent performed her action for the first time and its duration depended on whether the child spontaneously showed protest behaviour. Parents were then asked to sit at their table again and continue with their activity (i.e., drawing or observing). The protest phase ended when the parent turned away to return to her table.

9.1.3.6 Action phase 2. Following the protest phase, participants received the toys again for free play in action phase 2, which followed the same procedure as action phase 1.

9.1.3.7 Trial 2. The second trial included the box and the wand as stimuli, but otherwise followed the same procedure as the first trial: (1) the experimenter reminded the child of what their parent was doing and demonstrated one type of action two times using ostensive and referential signals, (2) the child played with the toys in action phase 1, (3) the experimenter called the parent and the parent joined the game in the child teaching phase, (4) the parent performed her action twice in the protest phase and then returned to her activity, and (5) the child again played with the toys in action phase 2.

The first trial always included the dog with the hammer and the second trial always included the box with the wand. For every child (but one), the experimenter demonstrated one tool action and one hand action across both trials, counterbalanced which type of action was demonstrated on the first trial with the dog and on the second trial with the box; one participant observed a tool demonstration on both trials following experimental error (i.e., this participant was not excluded from the analysis due to otherwise correct procedure).

9.1.3.8 Conditions. For 13 participants, the parent performed the different type of action than the experimenter on both trials. Specifically, the parent performed the tool action if the hand action was demonstrated by the experimenter and vice versa (mistake condition). For five participants, the parent performed the same action as the experimenter on both trials (no-mistake condition) to control that participants indeed only showed protest behaviour following deviant behaviour from their parent and not after the parent acted correctly. For two participants, the parent performed the no-mistake action on the first trial but performed the mistake action on the second trial (mixed no-mistake and mistake) due to the experimenter accidentally demonstrating tool actions on both trials for one child, and due to the parent accidentally copying the experimenter on the first trial but following the instruction to perform a different action on the second trial for the other child.

9.1.4 Coding and reliability

All sessions were video recorded and coded by a single observer. The child's play with the toys during the action phases was coded for imitation, variation of the imitated action, emulation (i.e., alternative action), gaze to the parent, and gaze to the experimenter. The child teaching phase was coded for all verbal and behavioural responses of the child after the experimenter asked the parent to join the game until the parent performed her action for the first time. The protest phase was coded for the child's gaze to the parent and gaze to the experimenter, as well as any verbal and behavioural responses of the child to their parent performing the same or a different action than the experimenter.

9.2 Results

9.2.1 Did children differentiate between mistake and no mistake?

To investigate the success of the experimental manipulation, protest rates were compared between participants in the mistake and the no-mistake conditions. Protest was observed in multiple cases after the parent performed a different action than the experimenter had previously taught the child (see below). In contrast, in the no-mistake condition, out of five children with two no-mistake trials and two additional children with one no-mistake trial each (i.e., altogether 12 no-mistake trials), only one child showed a hint of protest during the protest phase after their parent performed the same action that the experimenter had taught them (hand action, watching condition). This child performed a short finger point to and touched the tool briefly while whispering inaudibly at the same time as the parent performed the hand action for the first time. The child also grabbed the tool, lifted it, and quickly put it onto the table again right after her mother performed the hand action for the second time. Previously, the child had imitated the hand action multiple times and the child had also performed the tool action. She had innovated the tool action herself in action phase 1 but had always been unsuccessful in eliciting the sound effect with the tool and had even commented on that fact ("I can't do it with the hammer"); the child had generally played around with the tool, hammering the dog's nose and belly, and the table. The difference between the experimental mistake condition and the no-mistake control condition was significant with children showing more protest in the mistake condition than in the no-mistake condition, U = 18.50, p = .020.

9.2.2 Did children imitate the experimenter's actions and innovate the alternative actions?

The action phases 1 lasted on average 41.9 s (*SD* = 9.6 s, duration range: 15 - 75 s). The imitation level was at ceiling during action phase 1: all children imitated the actions that were demonstrated for them by the experimenter at least three times or on two instances, except for one child who imitated the action only on second trial with the tool action but not on first trial with the hand action. Nine children showed variation of imitation on Trial 1 (seven children on tool trials and two children on hand trials), and seven children did on Trial 2 (five children on tool trials and two children on hand trials).

On seven of 40 trials, children innovated the alternative action during action phase 1: on five trials children used the tool to elicit the sound when they were taught the hand action and on two trials children used their hand to elicit the sound when they were taught the tool action. On half of the trials children looked to their parent at least once during action phase 1.

9.2.3 Did children teach their parent?

The child teaching phases lasted on average 13.3 s (*SD* = 6.3 s, duration range: 7 - 60 s). Verbal teaching included statements such as "Mummy, look, this is how you do it", "use the hammer", and "go in there and then" (i.e., for the hand action on the box together with behavioural teaching) from the child to their parent. Behavioural teaching included actions of the child such as performing the hand or tool action while the parent watched (i.e., after the experimenter had said that it was the parent's turn now), or handing the tool to the parent.

Altogether, eight children showed no signs of teaching in the experiment, two children showed verbal and behavioural teaching on both trials, six children showed either verbal (n = 2) or behavioural (n = 4) teaching on one trial, and four children showed both forms of teaching on at least one trial. No differences were found between children in the mistake condition and children in the no-mistake condition, U = 31.00, p = .876, nor between the frequency of verbal teaching and behavioural teaching, Z = 1.41, p = .157. Nine children showed any form of teaching on Trial 1 and seven children showed any form of teaching on Trial 2. On nine trials children exhibited teaching behaviour of tool actions and on seven trials children exhibited teaching behaviour of the hand actions.

9.2.4 Did children protest against their parent performing a different action than the experimenter had taught them?

The protest phases lasted on average 12.9 s (SD = 3.2 s, duration range: 10 - 20 s). Altogether, 60% of children showed any form of protest behaviour across the experiment; 27% of children showed verbal protest and 60% of children showed behavioural protest. Verbal protest included statements such as “No, daddy, don’t do it like that”, “you do it with that”, or “with a hammer, silly mummy”. Behavioural protest included actions of the child such as covering the dog’s nose with his hand while holding out the hammer to his parent, or snatching the box from the parent and performing the hand action in a demonstrative manner.

More children tended to perform behavioural protest than verbal protest, exact McNemar p = .063, with six children showing no form of protest, no child showing only verbal protest, five children showing only behavioural protest, and four children showing both forms of protest.

On Trial 1, 19 of 20 children looked at their parent's face at some point during the protest phase, and 13 of 19 participants looked at the experimenter at some point during the protest phase (one child was not coded for eye gaze to the experimenter because his face was temporarily occluded, he did not look at the experimenter while his face was visible in the video), irrespective of the conditions mistake or no-mistake, U = 28.00, p = .605. On Trial 2, 17 of 20 children looked at their parent, and nine of 20 children looked at the experimenter at some point during the protest phase, again irrespective of the conditions mistake or no-mistake (gaze to parent: U = 27.50, p = .366, gaze to experimenter: U = 19.00, p = .125).

9.2.5 Did children imitate their parent's wrong action or stick to the action the experimenter had taught them?

The action phases 2 lasted on average 38.9 s (*SD* = 15.7 s, duration range: 10 - 75 s). On Trial 1, 75% of children again imitated the action that the experimenter had demonstrated for them; two of these children only imitated the action once or twice and the other children imitated the action at least three times or on two instances, and 25% of children showed variation of imitation. In the mistake condition, 54% of children also imitated the action that their parent had performed, and one of them showed variation of the parent's action. Children were equally likely to imitate the experimenter as to imitate their parent, exact McNemar p = .453. In the no-mistake condition, three of seven children innovated the alternative action. Forty percent of children looked at their parent during action phase 2 on Trial 1. No differences were found between children in the mistake condition and children in the no-mistake condition regarding imitation of the experimenter's action, U = 23.00, p = .232, or gaze to the parent, U = 21.00, p = .197.

On Trial 2, 80% of children again imitated the action that the experimenter had demonstrated for them; one of these children only imitated the action once or twice and the other children imitated the action at least three times or on two instances, and 40% of children showed variation of imitation. In the mistake condition, 47% of children also imitated the action that their parent had performed, and one of them showed variation of the parent's action. Children were equally likely to imitate the experimenter as to imitate their parent, exact McNemar $p = .388$. In the no-mistake condition, no child innovated the alternative action. Ninety percent of children looked at their parent during action phase 2 on Trial 2. No differences were found between children in the mistake condition and children in the no-mistake condition regarding imitation of the experimenter's action, $U = 25.00$, $p = .253$, or gaze to the parent, $U = 30.00$, $p = .535$.

9.2.6 Did children react differently to their parent depending on whether the parent had observed the teaching or not?

To investigate the conventionality hypothesis, differences were explored between children's teaching and protest behaviour depending on whether their parent observed the action demonstrations or was drawing. In the drawing condition, 64% of participants showed at least one form of teaching (verbal or behavioural) on at least one trial compared to 56% of children in the watching condition, $U = 36.50$, $p = .300$. Similarly, in the drawing condition 50% of children showed at least one form of protest (verbal or behavioural) on at least one trial compared to 71% of children in the watching condition, $U = 27.50$, $p = .951$. Also, no differences were found between conditions regarding imitation of the parent's action on either trial in action phase 2 (Trial 1: $U = 16.00$, $p = .409$, Trial 2: $U = 15.00$, $p = .082$).

9.2.7 Did children react differently to tool and hand actions?

To investigate if children showed a gradation of normative and conventional interpretation between tool and hand actions, differences were explored within subjects between children's teaching and protest behaviour depending on whether the demonstrated action was a tool or hand action. The same number of children showed the same degree of teaching behaviour (i.e. verbal and behavioural teaching) for tool and hand actions (exact McNemar p = 1.000, Z = 0.486, p = .627) with eight children not showing any teaching behaviour, four children teaching only the tool action, four children teaching only the hand action, and three children teaching both actions.

In contrast, significantly more children protested against their parent when the parent used her hand instead of the tool than when the parent used the tool instead of her hand, exact McNemar p = .039. Four children showed no protest behaviour at all, one child protested only after the parent did not perform the hand action, eight children protested after the parent did not perform the tool action, and no child protested in both cases.

No differences were found between the numbers of children who imitated the experimenter's action during action phase 2 depending on whether it was a hand or tool action, exact McNemar p = .125, with no child who would not imitate any of the actions, six children who imitated only the tool action, one child who imitated only the hand action, and eleven children who imitated both the hand and tool actions during action phase 2. In contrast, significantly more children imitated the parent's mistake action if it was the tool action than if it was the hand action, exact McNemar p = .031, with three children who did not imitate any of the parent's actions, six children who imitated only the parent's tool action, no child who imitated only the parent's hand action, and three children who imitated both types of actions.

9.3 Discussion

Study 6 investigated (a) children's normative learning in general, (b) whether children would protest against their parent after the parent performed a different action on a toy than they were previously taught by the experimenter without a normative warm-up, (c) whether children interpreted other's intentional actions as conventional in addition to the normative interpretation, (d) if children taught their parent the action that they had learned, (e) the influence of tool actions on children's normative and conventional interpretation of other's actions, and (f) how strictly children themselves followed the norm without making mistakes that is whether they did not perform a different action as they also expected others to do. To this end, without a normative warm-up, children were taught tool and hand actions; they imitated the actions; then their parent, who was either watching the procedure or was drawing, joined the game and either performed the same or a mistake action; and finally, children received the toys again for another opportunity to imitate the experimenter's and the parent's action.

If children (a) interpreted the actions as normative, they would protest against the other person only when she performed a different action but not when she performed the same action. Indeed, the results of Study 6 confirmed this hypothesis: several children showed protest but only after the parent performed a different action than the experimenter had previously taught the child. This results pattern also confirmed that, considering the methodology of normativity research, (b) the child's parent was a suitable third-party that performed the mistake action in substitution of a puppet, which is usually used in those studies, and a specific normative warm-up may be necessary if a puppet is used but not if the child's parent performs the mistake action.

No differences were found (c) between children in the drawing condition and children in the watching condition. This indicates that children indeed interpreted the actions as conventional in addition to the normative interpretation of the actions, expecting their parent to be familiar with the action irrespective of whether the parent watched their child being taught or the parent being otherwise occupied. However, the study had few participants and the difference between the conditions may have turned out insignificant due to low power while it still exists.

Interestingly (d), even though participants seemed to interpret the actions as conventional, they still showed teaching behaviour: 60% of children taught their parent the actions that they had learned from the experimenter. According to the theory of natural pedagogy, teaching is described as a clearly marked demonstration using a special type of communication that includes ostensive and referential signals (i.e., specifying the recipient and the item of teaching), and that primarily supports knowledge transmission from parent to child or, more generally, from expert to novice (Csibra & Gergely, 2006, 2011; Gergely & Csibra, 2013). Indeed, the behaviour of some children could be classified as teaching following the guidelines of the theory of natural pedagogy even though in this case it was from child to parent; children called their parent, made exclamations such as "look", described the action, pointed to the objects, and demonstrated the action. This finding indicates that the disposition in humans to teach, as described by the theory of natural pedagogy, might appear earlier in development than the theory itself proposes (i.e., it does not explicitly propose at what age teaching develops but it suggests that teaching is commonly done from parent to child).

As previous studies within this thesis have shown that children are very inclined to imitate tool actions, the present study (e) investigated if the use of a tool influenced children's normative and conventional interpretation of other's actions.

Children were equally likely to show teaching behaviour of tool and hand actions but children showed different rates of protest depending on the type of action: significantly more children protested against their parent when the parent used her hand instead of the tool than when the parent used the tool instead of her hand. In other words, children were more likely to punish omitting the use of a tool than innovating a tool action. What is more, significantly more children imitated the parent's mistake action if it was the tool action than if it was the hand action. Thus, children were more accepting of another person using a tool when she was supposed to use her hand than when she omitted using a tool, and they also frequently broke the rule of using their hand in favour of using a tool but they were less inclined to copy a wrong hand action.

Remarkably, one child in the no-mistake condition also showed some small protest after their parent had correctly used her hand: the child had previously innovated the tool action herself and, although not exactly "telling her parent off" for using her hand as other children had done, she had still pointed to and even lifted the tool briefly while her parent was present as if to draw attention to the tool that she seemed to find very interesting as she had spent a considerable amount of time using it (unsuccessfully) before. On the other hand, she did also not address the tool boldly as if she knew that she was supposed to use her hand and not the tool, and as if she did not dare to ask her parent about how to use the tool on the dog in front of the experimenter. This interpretation is very subjective and based on qualitative data from one child only. Future research could investigate this further, for instance by exploring if children would treat a present but unused tool differently when the experimenter was not present, or how children would react to their parent using a tool, after they had been taught a hand action, in the absence of the experimenter (i.e., would they also show protest against the mistake tool action in that case in comparison to a mistake hand action in the absence of the experimenter).

While imitation levels during action phase 1 were at ceiling, a similar finding to those in other studies (e.g., Keupp et al., 2013), children (f) were generally not very strict with themselves on not performing any other actions that would elicit the same effect. Similar to the participants in Study 2 (see Chapter 5), children in the present study varied the action that they had learned, for example by taking the box into one hand and putting it over their other hand to press the button with the opening pointing towards the floor instead of simply having the box on the table and entering it from top to bottom with one of their hands, or by holding the tool in a full grip and entering it into the box but also placing the tool inside the box, holding it in place, and then tapping onto it to push the button. Thus, even though children faithfully imitated the actions and protested against their parent for performing a different action, they also modified the normative actions.

Imitation levels during action phase 2 were again very high with 75-80% of children who again imitated the action they had learned from the experimenter but also half of children who imitated the mistake action that their parent had performed and 40% of children who innovated the alternative action on Trial 1 after their parent had performed the same action as the experimenter.

Additionally, 35% of children already innovated the alternative action during action phase 1 (i.e., they innovated the tool action after they were taught the hand action, and they innovated the hand action after they were taught the tool action). Four of these children were in the mistake condition: two children were taught the tool action, they innovated the hand action during action phase 1, one of them protested against their parent for also using her hand (in fact, they also did not protest on the other trial), and none of the two performed the hand action again during action phase 2; the other two children were taught the hand action, they innovated the tool action during action phase 1, none of them protested against their parent for also using the tool (but both protested on the other trial after they were taught the tool action and their parent used her hand), and both children performed the tool action again during action phase 2. Again, this is qualitative data and should be interpreted with caution, but future research could investigate this using a larger sample size. Possible research questions are, Are children who innovate alternative actions less likely to show protest behaviour?, or Do children protest against other persons for performing the wrong action but do they allow themselves to deviate from the norm?

Another qualitatively interesting finding was that of the children's gaze to their parent as well as to the experimenter. For example during the protest phase, the experimenter did usually not interact with the child but the parent (and the child) was the main actor; indeed, nearly all children gazed at their parent's face in addition to observing what the parent did with the toys but also about half of participants looked to the experimenter while their parent performed her actions, and there was no difference between mistake and no-mistake conditions regarding how many children looked at the experimenter. However, the qualitative analysis revealed that the looks differed in the manner: while several children in the mistake condition very quickly turned to the experimenter with wide open eyes and quickly turned back to their parent again (in fact, some of these children did not exhibit verbal or clear behavioural protest), children in the no-mistake condition often looked at the experimenter turning at normal speed and accompanied with a smile as if to confirm with the experimenter that their parent did well. Similarly, between 40-90% of children looked at their parent during action phase 2, again irrespective of mistake and no-mistake conditions, indicating that children potentially have a social motive. While the theory of natural pedagogy proposes that children have an epistemic motive rather than a social motive (Gergely et al., 2007; Király et al., 2013), the normative account does not make a clear distinction (to date) between these motives. Yet, research on the normative account focused on the acquisition of norms (e.g., from reliable versus unreliable models, Rakoczy et al., 2009) rather than on the social factors following norm acquisition, such as conventionality like in this study or questions like, Who should follow the norms and who is allowed to deviate from the norm (i.e., focusing on persons rather than context like in the study by Wyman et al., 2009).

Study 6 provided indications that children are not only interested in acquiring, following, and enforcing norms, but also in distributing their knowledge through teaching (e.g., in the teaching phase), diversifying and exploring their knowledge (e.g., through varying the actions and innovating alternative actions), and further engaging with others on their knowledge (e.g., through eye gaze to the experimenter and their parent also in action phase 2 when the parent had already returned to her place distant from the child and the experimenter). Future research could further investigate these aspects using qualitative and quantitative methods.

Chapter 10: General Discussion

In this thesis, I reviewed four recent social learning theories: The naïve theory of rational action, the theory of natural pedagogy, IMAIL, and the normative account of social learning. I focused on how the theories explain the acquisition of knowledge from others as reflected in imitation, emulation, action understanding or interpretation, and how the theories consider the social and situational circumstances of learning, which no theory fully explores.

The empirical research in this thesis focused on the hypothesis that social learning is strongly influenced by the social and situational circumstances of the learning situation and the developmental stage of the learner. In six studies, the influence of a shared history between model and learner, tool-use, social learning in natural settings, and the normative quality of social learning were investigated.

10.1 What is Missing in the Social Learning Theories?

Four social learning theories' accounts of imitation, emulation, action understanding or interpretation, and their systematic prediction of learning based on the social and situational circumstances were compared. I argue that an overarching account of social learning would provide explanations and predictions about social learning including several of the discussed facets. Importantly, it would systematically include the circumstances of learning, such as the model-learner interaction and the objects involved, to better account for social learning across contexts. Additionally (but not discussed further in this thesis), it might hypothesize about other factors in the different contexts in which the knowledge is applied, such as social motives or personal factors like temperament. Moreover, I argue that the four theories explain developmental shifts and peaks of social learning biases rather than the core mechanisms of learning. An overarching account of social learning would include these shifts in its explanations and predictions to fully account for the development of social learning.

Integrating multiple facets, in particular systematic explanations and predictions about social learning as a factor of the social and situational circumstances, will bring us closer to understanding social learning across contexts. It may also contribute to the understanding of the development of social learning, as children may be particularly receptive to some social and situational circumstances as a factor of development. For example, children might be most receptive to ostensive and referential communication up to 2.5 years of age (as proposed by the theory of natural pedagogy), and they might be more receptive to the intentionality of an actor between 3.5 to 6 years, and interpret intentional actions as normative (as proposed by the normative account). Alternatively, children might be similarly receptive to communicative information of this kind at any age, but social learning might be more influenced by one or the other at specific times in development. An argument of this kind might lead to the development of a new theory of social learning that integrates the theory of natural pedagogy and the normative account in some form not as explaining social learning per se but as explaining social and situational influences on learning at specific peaks in development.

In a next step, one could investigate similarities and differences of social learning during these developmental peaks; that is, which aspects of social learning remain and which aspects change during times in development at which social learning is particularly influenced by certain factors such as ostensive communication or the perception of an actor’s intentionality. The identified differences could then be integrated into an overarching theory of social learning as developmental peaks of those factors (possibly integrating the discussed theories). For example, an overarching theory of social learning could identify ostensive communication as an interpretation bias in social learning that is particularly dominant at the age of 9 months to 3.5 years, at which time it is substituted by a peak in the bias to act based on the perception of an actor’s intentionality. The identified similarities in social learning between different ages and contexts would contribute towards determining the underlying core mechanisms and processes of social learning. This is assuming that social learning has common underlying core mechanisms throughout development. Another possibility is that what is currently described as social learning more broadly, and imitation, emulation, et cetera in particular, in different age groups is disparate behaviour based on different mechanisms and processes that simply appear to look like the same behaviour, possibly with one behaviour enabling the development of the other behaviour.

Although some empirical and theoretical research is consistent with the hypothesis that social learning is (strongly) influenced by the social and situational circumstances of the learning situation and the developmental stage of the learner, many aspects have not been systematically investigated. While research on social learning strategies (see Section 3.5.3) has investigated the influence of context on social learning more broadly, it does not systematically differentiate between different forms of copying, such as copying actions and copying a model’s choice of object, which have been argued in this thesis and other research (including all four discussed theories) to be different behaviours based on different cognitive mechanisms. It is crucial to know which social, contextual, and developmental factors lead to differential learning of actions, outcomes, and other knowledge (e.g., norms, conventions, relational information). Only when those factors are recognised may the underlying cognitive mechanisms and processes of social learning per se be identified in a theoretical account.

Some factors may be revealed to function as additional influences that affect learning only under certain conditions or during specific developmental stages, while other factors may generally influence learning, independent of context or developmental stage. For example, is social learning generally based on a bias to interpret others' actions as normative, or is the normative interpretation bias a sign of a *normative developmental period* (e.g., usually between 3.5 to 6 years of age) that strongly influences social learning during that developmental stage? The former would mean that social learning is always strongly dependent on the interpretations of others' actions as normative, while the latter would mean that normativity is an influencing rather than a determining factor of social learning. Similarly, is the natural pedagogy interpretation bias the underlying mechanism for learning of taught knowledge, or is this bias predominant during a developmental stage (e.g., 12 - 30 months of age) and might otherwise influence but not determine social learning? If natural pedagogy is generally viewed as a determining factor of social learning for teaching contexts, then what is the underlying mechanism for learning information that is not taught?

10.2 What Does the Empirical Research in this Thesis Show?

In six studies, the hypothesis that social learning is (strongly) influenced by the social and situational circumstances of the learning situation and the developmental stage of the learner was investigated. The studies explored the influence of a shared history between model and learner, tool-use, social learning in natural settings, and the normative quality of social learning.

Study 1 investigated the argument that social learning is influenced by the social and situational circumstances of learning, in particular by ostensive and referential communication, a shared history between model and learner, and the objects and actions involved. In Study 1, 18-month-olds were more likely to imitate unusual actions following teaching than incidental observation under some conditions but not others, they were more likely to imitate a familiar model than a stranger model, they were more likely to imitate tool actions than non-tool actions, and participants frequently emulated the unusual actions. Critically, Study 1 included very few participants, in particular when considering the large number of tested variables and conditions. While previous research has found similar effects regarding learning from teaching versus incidental observation (e.g., Király et al., 2013) and learning from familiar models versus strangers (e.g., Shimpi et al., 2013), future research is necessary to confirm the findings of this study in a more straight forward research design that includes fewer independent variables and more participants.

In Study 2, 19-month-olds and 4-year-olds played freely with their parent for 10 min with two toys. Parents were previously introduced to the toys and it was measured whether they would teach their child as described by the theory of natural pedagogy. Parents frequently used ostensive and referential communication together with action demonstrations. Furthermore, four recurring behaviours were identified in the social learning interactions: exploration as joint action or individually, the parents guiding and directing their child before and after demonstrating any action, the element of temporal space usually directly following an action demonstration or following some imitation before the action was imitated again, and variation of the action by the parent and child. The exact nature of these behaviours depended on the age of the child. Study 2 was analysed qualitatively and narratives for three participants were presented in this thesis as examples of the analysis. The data could be analysed further, for instance with cross recurrence quantification analysis to investigate if the identified behaviours followed certain patterns in the interactions, possibly depending on the age of the child. Future research could also follow up on these behaviours and their meaning for social learning. For example, the concept of temporal space potentially translates into the methodology of a delay between teaching and action phases in empirical research which was used, for instance, in Study 1 but not in Study 6. The element of guiding and directing the child's attention and actions is often controlled (in the case of attention) or omitted (in the case of guiding actions) in empirical research. The element of variation is usually only indirectly described, if at all: under this category would fall low or high fidelity imitation but also potentially emulation; if emulation was seen as a variation of the action instead of as a separate action with the same goal, theoretical accounts would have to reconsider their proposals and definitions. Within this thesis, social learning situations and interactions between a parent and their child were also further explored under more controlled conditions in Study 6 on normative learning.

Study 3 further investigated the argument that children prefer to learn about tool actions, and explored this argument across the life-span. Across 3 trials, participants were presented with three different ways to operate a toy: by using a tool, using their hand, or performing an unusual non-tool action similar to those often used in imitation research. On each trial, participants were shown two types of action and their subsequent imitation behaviour as well as the first action they performed were measured. Three- to 5-year-olds tended to use a tool to elicit an effect on a toy more often than to use their hand, they were equally likely to imitate tool and hand actions when presented with these two options, but they were more likely to imitate unusual tool and common hand actions than unusual non-tool actions. Adults, on the other hand, were most likely to imitate and perform the hand actions, second most likely to imitate the tool actions, and least likely to imitate the non-tool actions. In comparison, children imitated and performed the tool actions more often than adults, adults imitated and performed the hand actions more often than children, and children imitated the non-tool actions more often than adults. No differences were found between younger children and older children. Future research could further investigate the development of social learning about tool and non-tool actions. Because Study 1 found that 18-month-olds were more likely to imitate tool actions than to emulate tool actions, but they were more likely to emulate than to imitate non-tool actions, it would be particularly interesting to include 18-month-olds in Study 3 and investigate whether 18-month-olds are also equally likely to imitate tool and hand actions, or whether children grow from "promiscuous tool-imitators" in infancy to equal tool- and hand-imitators in childhood to "promiscuous hand-imitators" in adulthood. However, Study 4 found some conflicting results regarding tool-use in adulthood.

Study 4 further investigated a preference for tool actions over hand actions independently of imitation learning in adults and 3.5 to 5.5 years old children. In two experiments, children and adults were instructed to move small objects using tools or their hand. The task explanation did not involve a demonstration of the methods. Study 4 showed that children's and adults' choice of actions depended on the tools involved. Children (in Experiment 2) were much more likely to use their hand than either of the tools, they used their hand more often than adults did, and they were more likely to be hand-users than to be tool-users, similar to the adult participants in Experiment 1. Adults used their hand more often than the tools to perform the task in Experiment 1. In particular, participants of both age groups in both experiments used nearly only their hand when they were put under time pressure. This result might, however, be biased because using the hand was by far the most efficient action compared to using the tools, and younger children might have found it particularly difficult to use the tools. Further research could investigate whether adults indeed pay more attention to efficiency when solving the task, for example, by changing the task so that using one tool would be most efficient, second most efficient would be using the hand, and least efficient would be using another tool. However, the adult participants in Experiment 2, and participants of both age groups without time pressure in Experiment 2 were equally likely to use their hand as they were to use the tools on both trials. Also, many adults in Experiment 1 tried out using the tools on Trial 1. The adults in Experiment 2 were equally likely to be hand-users as they were to be tool-users, similar to the child participants in Study 3. One possible explanation for the differences in tool-use behaviour between Experiments 1 and 2 of Study 4, but also between Studies 3 and 4, is that children are not more interested in copying and performing tool actions than adults are, but that the type of tool influences tool-use performance in both age groups. For example, the cooking tongs in Experiment 2 were frequently used by participants and the slinky toy was very rarely used. (A) The grasping action with the cooking tongs was very similar to that of the hand action–maybe adults prefer grasping actions over other types of actions. In this case, social learning might be more influenced by the mechanics of the learned action than the objects involved, as I argued previously in this thesis. (B) Participants were usually successful in moving the balls using the cooking tongs, whereas the kitchen spoon and the slinky toy were more difficult to use with balls dropping down if they were moved too quickly. The cooking tongs were more difficult to use for younger children than for adults due to the large grip needed to handle them–maybe adults like to use tools too but prefer safe methods and will thus not use a tool that is perceived as unsafe and children prefer to use tools that are not very difficult to use. (C) The frequently used cooking tongs were a common household object while the less frequently used kitchen spoon was common but modified for the study and the rarely used slinky was a toy similar to the stimuli in the other studies in this thesis–maybe adults prefer to use "adult objects", and children do not make a difference between toys and adult objects but using the slinky toy and the kitchen spoon were too difficult for children. All these questions should be further investigated empirically before making strong claims on a preference for tool or hand actions in children and adults. Moreover, this study included participants from a large age range with most children being older than the children in Studies 1 through 3; future research should aim to replicate this study with a more defined age range, preferably comparing different age groups in childhood.

Study 5 investigated on what basis an object was identified as a tool. Children and adults were shown videos of two objects that were (a) differently sized, (b) either one of the objects or both moved, and (c) either one of the objects or none illuminated upon touch with the other object. Participants were asked which of the two objects they would call a tool. The results indicated that size alone did not affect participants' decision on which object they would call a tool. In contrast, participants chose the object that was moved to be the tool (irrespective of its size), and participants chose the object that did not itself exhibit an effect but that seemingly elicited an effect in the other object as the tool. When movement of the objects and illumination were combined so that participants had to decide which object they thought was the tool based on only one of them and against the other, participants had different responses based on size: participants were more likely to choose the (still) small object as tool after they observed the large object moving and illuminating, but they were equally likely to choose as the tool the small object and the large object after they observed the small object moving and illuminating. Differences between adults and children were found for two combinations that included movement of the large object. While all adults chose the large object as tool (seemingly based on its movement irrespective of size), and most adults chose the large object as tool based on its movement and the illumination of the small object, children chose both the small and the large objects as tool equally often in these two combinations. Two explanations for this finding were discussed: children might not have developed sound rules to identify objects as tools yet, or children might consider the sizes of the objects more than adults with the result that children were at chance to call the small and large object the tool; that is, some children possibly favoured size and thus called the small object the tool, while others possibly favoured movement and thus called the large object the tool leading to an unclear result. This study was only an initial investigation into the question of how an object is identified as a tool and future research could explore many more affordances of objects as the basis for tool identification. Importantly, this study again included participants of a large age range and future research should try to replicate this study using a more defined age range.

One related and very interesting question is: Do children (and at what age do they) identify a still object as tool or do they need to observe the object be used as a tool before they identify it as such? This question is relevant to social learning research because the availability of other objects that could potentially be used as tools in situations with the opportunity for social learning might influence children's readiness to imitate the model. Study 3 has shown that 3- to 5-year-olds innovate tool actions without prior demonstration of the object as tool, and they sometimes do so before imitating an action that they were taught. Study 6 also showed that 3.5- to 5.5-year-olds are capable of innovating tool actions. However, none of the studies within this thesis was designed to specifically test whether the availability of a tool influences children's readiness to imitate in particular and their social learning more broadly.

Study 6 investigated different aspects of children's normative learning of tool and hand actions. The results indicated that 3.5- to 5.5-year-olds interpreted both types of actions as normative and also as conventional (although the results on conventionality should be replicated before drawing final conclusions because of the small sample size in this study). The present study further revealed that children taught their parent the actions that they had learned from the experimenter using ostensive and referential communication. Study 6 also contributed that children were less likely to enforce norms when hand actions were involved and more likely to enforce norms when tool actions were involved. Children were also more likely to imitate mistake tool actions than mistake hand actions. Children in Study 6 showed an array of actions from faithful imitation of the demonstrated action, through variation of this action, to innovation of alternative actions, and the imitation of mistake actions. Again, this study had a very small sample size considering the number of variables and further participants should be recruited for this study.

In summary, Studies 1 through 6 showed that social learning in infants is influenced by the communication between model and learner, and a shared history between model and learner; children's and adults' social learning varies depending on whether a tool is involved or not; children and adults learn differently; and children and adults show a number of behaviours that are associated with social learning, such as imitation, emulation, teaching, and protest.

10.3 How do the Theories Explain the Empirical Findings in this Thesis?

10.3.1 How does the naïve theory of rational action account for the empirical findings in this thesis?

The naïve theory of rational action (e.g., Csibra & Gergely, 2007) focuses on the learner's action understanding and his prediction of others' actions. The theory concentrates on the learner's understanding of the efficiency of others' actions based on the action, the goal, and the situational constraints. Under this account, learners selectively imitate the model's rational actions and they emulate the model's less efficient actions, or they emulate due to a change in the situational constraints. The theory does not consider the interaction between the learner and the model, or other social circumstances that might influence learning.

The naïve theory of rational action has not primarily been tested by the studies in the present thesis, but as the theory aims to explain social learning and the studies broached the issue of social learning, some hypotheses regarding participants' behaviour were still postulated. According to the naïve theory of rational action, it was hypothesized that children in the present studies would generally, and irrespective of the circumstances, be more likely to use their hand to elicit the target effects following the action demonstrations than to copy any unusual actions. Specifically, in Study 1 infants were predicted to be more likely to emulate both tool and non-tool actions than to imitate either type of action irrespective of condition, in Study 3 both children and adults were predicted to be more likely to imitate the hand actions than any other type of action, and in Study 6 children were predicted to imitate the hand actions in both action phases and to innovate the hand action on tool trials. Even though no actions were demonstrated in Study 4, one could deduce from the naïve theory of rational action that both children and adults would be more likely to use their hand than either of the tools. These hypotheses were formulated on the basis that using the hand was the most efficient and rational means to elicit the effect on the toys.

These hypotheses were only partially confirmed by the findings in this thesis. Study 1 showed that the vast majority of infants showed emulation behaviour and infants overall performed more emulation than imitation indicating that emulation learning is a very important aspect of social learning. In contrast to imitation, participants' emulation behaviour did not differ as a factor of shared history nor communication, as was predicted by the naïve theory of rational action. However, an analysis revealed a differential pattern for imitation and emulation regarding tool and non-tool actions. More infants in Study 1 emulated than imitated on non-tool trials, which confirms the prediction made according to the naïve theory of rational action. However, infants were more likely to imitate than emulate tool actions, which speaks against the prediction made according to the naïve theory of rational action. Although the tool actions do not seem very costly (and might thus be considered as more or less rational), they were much more difficult to perform for young children than simply using their hand. Thus, both tool and non-tool actions were inefficient and should have been emulated rather than imitated. The naïve theory of rational action cannot explain this differential finding depending on the objects and actions participants learned about.

Similarly, the results from Study 3 are also only partly accounted for by the naïve theory of rational action. The naïve theory of rational action successfully explains the results from the adult participant group, but not from the child group. As predicted, adults showed most imitation and performance of the hand action, which was the most rational action to perform. Contrary to the prediction from the naïve theory of rational action, children were equally likely to imitate the tool and the hand actions. Similar to Study 1, the tool actions were more difficult to perform for young children than simply using their hand and therefore tool actions can be considered less efficient than using the hand. Indeed, children in Study 6 who had also observed tool and hand actions on the same toy and eliciting the same effect (i.e., in action phase 2 in the mistake conditions) were more likely to imitate tool actions than hand actions, which cannot be accounted for by the naïve theory of rational action. In conclusion, tool actions seem to make a special case for social learning which cannot be explained by the naïve theory of rational action.

Király and colleagues (2013) argued that the naïve theory of rational action and the theory of natural pedagogy interact in social learning. The authors proposed that children learn from others in steps: children foremost learn about the outcome or goal of an action from the model (leading to emulation of unusual actions) and, only under certain circumstances, do children also learn the action itself as a means to the goal in a second step (leading to imitation). Király and colleagues (2013) reported that 100 % of children in their study emulated and they did so before they imitated the unusual head-touch action which was a non-tool action. In Study 1 in the present thesis however, participants emulated on average on only half of all trials and the differential findings regarding learning tool and non-tool actions are also in contrast to the proposal by Király and colleagues (2013): Infants' pattern of imitating and emulating non-tool actions is in agreement with the learning-in-steps argument but infants' pattern of imitating and emulating tool actions contradicts this. Participants either both imitated and emulated non-tool actions (i.e., they followed both steps and learned the outcome as well as the action), or they only emulated non-tool actions (i.e., they followed only the first step and learned only the outcome); no participant imitated without emulating the non-tool actions. However, infants showed more imitation than emulation on tool trials, which corresponds to following the second step and omitting the first step, which should not happen according to the argument of learning from others in steps. As a consequence, the proposal that the naïve theory of rational action and the theory of natural pedagogy combine to an account of social learning in steps with the principle of rational action being the primary mechanism of social learning and the pedagogical interpretation bias as a secondary mechanism is flawed. Instead, the data from Study 1 suggests that in some cases the pedagogical interpretation bias may also override the principle of rational action.

The findings from both age groups in Study 3 that participants imitated the tool actions more often than the non-tool actions are slightly more difficult to account for. This finding contradicts the naïve theory of rational action under a strict interpretation of theory, because participants were expected to perform the most rational action, which is using the hand, and thus participants were expected to emulate the tool and non-tool actions instead of imitating either of them. However, both actions were demonstrated using ostensive and referential communication. Under the assumption made above that the pedagogical interpretation bias may indeed override the principle of rational action to some degree, one could argue that participants imitated the more efficient of the taught actions. This argument is based on the hypothesis that natural pedagogy facilitates imitation and that learners choose the more efficient action, as proposed by the principle of rational action, when presented with different actions to elicit the same effect. In this case, the naïve theory of rational action and the theory of natural pedagogy would interact with each other in the form that the pedagogical interpretation bias, which facilitates imitation, is prioritized.

Indeed, the findings that children in Study 3 were equally likely to imitate the tool and the hand actions would also be accounted for if one assumes that the naïve theory of rational action and the theory of natural pedagogy combine to explain social learning, but in this case the principle of rational action competes with the pedagogical interpretation bias leading to equal amounts of imitating an unusual action and performing the most efficient action. Importantly, this explanation is not supported by the finding that participants rarely imitated and frequently emulated non-tool actions.

Altogether, the naïve theory of rational action accounts well for some but not all results in Studies 1 and 3. In particular, the different results from children and adults in Study 3 call for different explanations that cannot be derived directly from the naïve theory of rational action. The differences between children and adults indicate a developmental change in copying tool-use throughout the life-span.

One could argue that the findings of Study 4 are somewhat related to the naïve theory of rational action (i.e., using the hand as most rational action). Indeed, adults in Experiment 1 of Study 4 used their hand more often than the tools to perform the task, similar to the adults in Study 3 who were most likely to imitate and perform hand actions. In particular, when adults were put under time pressure, they often used their hand, and some participants even commented after the experiment that they had used their hand because they thought it was more efficient than using the tools. However, adults without time pressure in Experiment 2 were equally likely to use their hand as they were to use the tools. Experiment 2 included a tool that was still less efficient than using the hand considering the time that was required to perform the task, but it might have seemed similarly safe to use. Specifically, in Experiment 1 both tools were relatively unsafe to use, that is the task was more difficult to perform with them because balls frequently fell back into the container.

On the contrary, balls rarely fell back into the container with the tongs in Experiment 2 and thus, the tools in Experiment 2 may have been perceived as safe to use. This perception of difficulty may in turn have changed participants' perception of rationality. Follow-up studies could, for instance, investigate adults' and children's tendency to use tools or their hand when it is equally efficient or more efficient to use a tool than the hand to explore if participants prioritize tool-use, hand-use, or efficiency. This would help us understand the relation between a preference to use tools and a bias to favour rational actions, as proposed by the naïve theory of rational action.

In summary, the naïve theory of rational action accounts well for most emulation findings but not for the differential patterns of imitation and emulation regarding the copying of tool and non-tool actions. Different approaches were discussed of how the naïve theory of rational action could interact with the theory of natural pedagogy to explain some of these findings. However, none of these approaches satisfactorily explains the broader results from the present studies, particularly the finding that the learning of tool actions seems to produce different behavioural patterns depending on the age of the learner. Future research is required to pinpoint the exact nature of social learning of tool compared to non-tool actions across development.

10.3.2 How does the theory of natural pedagogy account for the empirical findings in this thesis?

The theory of natural pedagogy (e.g., Csibra & Gergely, 2006) proposes that humans are predisposed to teach and to learn from teaching. The model uses ostensive and referential communication together with action demonstrations and the learner interprets the model's action as relevant, culturally shared, and generalizable. Pedagogical action demonstrations facilitate imitation behaviour and the learner also generalizes the information. The theory of natural pedagogy does not account for emulation behaviour, except in cases when the pedagogical interpretation bias is overruled by the principle of rational action (e.g., when the learner has prior knowledge about a more efficient means to the goal). The theory does not further address an influence of the social and situational circumstances on learning. It is applicable only to those social learning situations in which the model teaches the learner.

The theory of natural pedagogy was tested in several of the empirical studies within this thesis. Study 1 directly compared social learning from teaching with social learning from non-pedagogical action demonstrations. As expected by and confirming the theory, infants in the teaching condition were more likely to show imitation behaviour than infants in the incidental observation condition. However, this effect of teaching was masked or eliminated when investigating the imitation of tool actions in comparison with the imitation of non-tool actions, and the order in which these different types of actions were presented, which cannot be explained by the theory of natural pedagogy. This indicates that the effect of teaching on learning is subject to further influences such as the order in which new information is presented and the use of certain objects.

The effect of tool-use on social learning from teaching was further explored in Studies 3 and 6. In those studies, teaching was not compared to incidental observation but all participants were taught novel actions. Instead, Study 3 explored whether children and adults learned differently from teaching depending on the action that was taught. The theory of natural pedagogy itself predicted no difference in imitation behaviour depending on the type of action, but the results from both age groups contradicted this expectation. A differential behaviour pattern can only be explained when assuming that the naïve theory of rational action overrides the pedagogy assumptions in cases when a learner is taught two actions with the same goal (for a discussion on how the naïve theory of rational action explains the results of Study 3 see Section 10.3.1).

Following a lean interpretation of the theory of natural pedagogy, however, one might hypothesize that learning about tools is favoured over acquiring non-tool actions. Tools are important cultural objects and it was argued that in evolution, humans became especially receptive to teaching through tool-use (Gergely & Csibra, 2006). Indeed, children in Study 3 were more likely to imitate tool actions than unusual non-tool actions and they tended to use a tool to elicit an effect on a toy more often than to use their hand, but they were equally likely to imitate tool and hand actions when presented with these two options. Additionally, adults were more likely to imitate and perform hand actions than either tool or unusual non-tool actions. The findings in the child participant group could be explained if one assumes that natural pedagogy also favours learning about tools and the pedagogy interpretation bias can be overridden by the naïve principle of rational action half of the time. The findings in the adult participant group could be explained if one assumes that adults, as well established individuals in their culture, focus on other aspects of the learning situation. For instance, adults may focus on problem-solving including how to elicit an effect most efficiently. In the present studies, the simplest means to elicit an effect was to use the hand as it required the least effort. The focus on efficiency is also predicted by the naïve theory of rational action, and thus the naïve principle of rational action may override the pedagogy interpretation bias more often in adults than in children. However, this is highly speculative and based on a lean interpretation of the theory of natural pedagogy instead of actual statements from the theory. Furthermore, the theories do not specify any developmental changes to the interaction between the naïve principle of rational action and the pedagogy interpretation bias (i.e., except for an influence on how well a learner is able to detect efficiency based on his prior knowledge of the world and the development of the promiscuity of the pedagogy interpretation bias; both exceptions are stated separately for one theory, respectively, not for the interaction of the theories).

The hypothesis that children favour learning about tools, but not the hypothesis that the pedagogy interpretation bias is overridden by the naïve principle of rational action half of the time, is further supported by findings in Study 6. In the first action phase, imitation of tool and hand actions following teaching from the experimenter was at ceiling but in the second action phase following the parent's non-pedagogical action demonstration, children were more likely to imitate mistake tool actions than mistake hand actions. Because parents were not teaching their children in this study however, children rather seemed to favour learning about tools independently of natural pedagogy.

Nevertheless, Study 6 indirectly supports the claim made by the theory of natural pedagogy that taught actions are interpreted as culturally shared because no difference in behaviour was found between children in the observing and the drawing conditions. According to the theory of natural pedagogy, learners expect other members of their culture to also be familiar with the actions that they are taught by the model. In Study 6, children reacted no differently whether their parent was observing how the child was taught by the experimenter or whether their parent was busy doing something else and could therefore not observe the teaching. However, this theoretical support is uncertain, because the theory of natural pedagogy does not state how this expectation of culturally shared information is represented in a learner's behaviour. Study 6 was designed to test the normative account of social learning and these parallels to the theory of natural pedagogy were drawn post-hoc.

A further critical finding in Study 1 requires a lean interpretation of the theory of natural pedagogy. In Study 1, 18-month-olds were more likely to imitate a familiar model than a stranger model. This finding is supported by the theory of natural pedagogy when assuming that the learner takes a pedagogical stance with the model and remains in this stance at least for a couple of minutes even when the model does not continue to communicate pedagogically with the learner. In some discrepancy with this hypothesis is the argument made by the theory of natural pedagogy that learners by default unconditionally trust the teacher and children first have to learn when not to trust a communicative other (Csibra & Gergely, 2006; Gergely et al., 2007, Gergely & Csibra, 2013), although the authors do not specify at what age children stop trusting teachers unconditionally (see Section 4.3 for a thorough discussion of this argument).

Furthermore, the results from Study 2 suggest that the way parents teach changes with the development of their children. Future research could investigate whether teaching in parents changes from pedagogical action demonstrations in infancy to a pedagogical action description in childhood. Parents of 4-year-olds in Study 2 frequently guided and directed their children so that they could figure the action out individually with the help of the parent. In this behaviour, parents still made use of ostensive and referential communication but demonstrated fewer actions (or demonstrated later when the child had not discovered the action based on the guiding). Future research could also investigate children's differential learning depending on whether actions are demonstrated or verbally described that is, if knowledge from teaching that only includes action descriptions instead of action demonstrations also leads to increased performance of the target action and to generalisation, as well as the expectation that this knowledge is culturally shared. A development of the theory of natural pedagogy across the life-span is currently not proposed.

In summary, the theory of natural pedagogy accounts well for some of the imitation findings in this thesis. In particular, the theory explains the preference to imitate tool actions, when the assumption that natural pedagogy evolved from tool-use in human evolution is accepted, and an interaction of the theory of natural pedagogy with the naïve theory of rational action is assumed. However, the theory of natural pedagogy does not currently account for some of the differential imitation and emulation findings in this thesis, most importantly the finding that learners seem to acquire different information from social learning depending on their age.

10.3.3 How does IMAIL account for the empirical findings in this thesis?

IMAIL (e.g., Paulus, 2014a) proposes as the basis of social learning the acquisition of bidirectional action-effect associations through motor resonance. IMAIL predicts selective imitation and emulation based on the learner's motor capabilities, a salient action effect, and competing action-effect associations. IMAIL is only applied to cases when the model's action elicits a salient effect (i.e., learners may only acquire actions in connection with a salient effect), and only those actions that the learner has, in principle, performed before (i.e., which are part of the learner's motor repertoire). IMAIL does not offer explanations on action understanding, and the social circumstances of the learning situation are not systematically discussed.

IMAIL has not primarily been tested by the studies in the present thesis, but as the theory aims to explain social learning and the studies broached the issue of social learning, some hypotheses regarding participants' behaviour were still postulated. According to IMAIL, it was hypothesized that participants in the present studies would generally, and irrespective of the circumstances, be most likely to imitate the actions that they were shown. IMAIL predicts that an action will be imitated as long as (a) the action elicits a salient effect, (b) the action is part of the learner's motor repertoire, and (c) the action is repeatedly observed by the learner so that the learner may form a bidirectional action-effect association for the demonstrated action and its effect. In all studies within this thesis, the experimenter (or parent) demonstrated an action that elicited either a visual or auditory effect (a), at least some participants in each study imitated the actions which indicates that all actions should have been within the participants' motor repertoire (b), and all actions were demonstrated two to three times (c).

By this assumption, IMAIL accounts for the finding of imitation behaviour in the studies in the present thesis but not for the identified patterns of differential imitation, for example that tool actions were imitated more frequently than non-tool actions in Studies 1 and 3. Participants in Study 1 were expected to imitate all demonstrated actions irrespective of condition, which was not supported by the findings. IMAIL may however account for the emulation behaviour in Study 1: the target actions involved pressing a certain spot on a toy or pulling on one end of a toy which is usually done using the hand. When infants intended to elicit the effect during an action phase, the motor code for the prepotent response for button-pressing or pulling on objects might have been activated, inducing an automatic emulation response.

Employing a lean interpretation of IMAIL, one might also account for participants' increased imitation of tool actions over non-tool actions (see Studies 1 and 3). The tool actions were arguably more usual actions than the non-tool actions (but not more usual than the hand actions) and therefore participants might have more readily formed action-effect associations for tool actions than for the unusual non-tool actions. Thus, IMAIL successfully explains the findings from both age groups in Study 3 that participants imitated the tool actions more often than the non-tool actions, if presented with these two options, because the tool actions were more likely to elicit motor resonance than the non-tool actions.

However, this explanation does not cover the different findings for children and adults in Study 3. While a difference in learning behaviour between adults and children could be explained by assuming that adults and children have different degrees of experience with different types of actions and therefore, differing established action-effect associations, I would suppose that the hand actions would be most likely to elicit motor resonance in both age groups. Consequently, IMAIL successfully explains the results from the adult group (i.e., most imitation of the hand action), but not from the child group (i.e., equal imitation of hand and tool actions). Similarly, children in Study 6 were more likely to imitate the tool actions than the hand actions and children were even more likely to innovate the tool action than the hand action; a finding which is not accounted for by IMAIL. One could however argue that the findings of Study 4 (i.e., a preference to use the hand) are to some degree related to IMAIL because using the hand is the most common action and therefore, it is most likely to activate the associated motor code when the participant intends to perform the task.

Most critically, IMAIL does not account for differential imitation patterns in Study 1 between the conditions familiar teacher versus stranger, and teaching versus incidental observation. However, Paulus (2014b) proposed a strong connection between perceptual encoding of the observed action and the learner’s attention to features of the situation such as familiarity with the model or novelty of the object.

In this way, the differential imitation patterns in Study 1 may be explained by IMAIL with the argument that children paid less attention to the model in the conditions with less imitation compared to the conditions with more imitation.

In summary, IMAIL accounts well for some of the more general findings in this thesis (i.e., participants imitated and emulated) but not for the more subtle findings with differential patterns of behaviour depending on social and situational factors such as the communication between model and learner, or the involvement of a tool.

10.3.4 How does the normative account explain the empirical findings in this thesis?

The normative account of social learning (e.g., Schmidt et al., 2010) emphasizes action interpretation and protest. It argues for a predisposition to interpret others' intentional actions as conventional and normative. As a result, learners are predicted to (over-)imitate, to expect others to perform the same actions, and to show protest to a third person performing a mistake. Presently, normativity does not systematically explain emulation learning. Although normativity predicts sensitivity to the social contexts in which the learning and the subsequent application of knowledge take place, ideas on how the social and situational circumstances shape learning are not discussed more broadly.

The normative account of social learning has only been directly tested in Study 6 of this thesis, but as the theory aims to explain social learning and the other studies also broached the issue of social learning, some hypotheses regarding participants' behaviour were still postulated for the other studies as well.

The results of Study 6 confirmed the main argument of the normative account, namely that children interpret others' intentional actions as normative and that they protest against a third party acting differently in the same context. Furthermore, Study 6 suggests that children interpret others' intentional actions as culturally shared.

According to a strong interpretation of the normative account, children are promiscuous normativists (Keupp et al., 2013; Schmidt et al., 2010). This claim may be supported by the finding that children in Study 6 readily taught their parents the new actions (and rules) that they had learned in the game, which could be interpreted as an indication that children are not only eager to learn new rules, but also to enforce new rules and to share new rules with others.

Not accounted for by the normative account is the finding that children in Study 6 were more likely to imitate parents' mistake tool actions than parents' mistake hand actions. This difference in imitation behaviour, which indicates a preference for tool actions, cannot be explained by the account.

Furthermore, the normative account does not explain children's permissiveness with their own actions: in Study 6 children frequently innovated the tool action, and in Study 1 children frequently emulated the demonstrated unusual actions by using their hand to elicit the toys' effect. Similarly, children in Study 2 eagerly varied the actions they had learned from their parents in the course of the interaction, which equates to a kind of sampling of faithful and unfaithful imitation. According to the normative account's argument regarding over-imitation, I would expect more faithful imitation of others' intentional actions, especially as children expect others to faithfully perform the normative action. However, some children in Study 6 even imitated their parent's action, which they had just moments before protested against.

A prediction of participants' behaviour in Study 3 was more difficult to derive from the normative account. Every participant observed one person on video intentionally performing two different actions on a toy that each elicited the same effect. Consequently, participants could be expected to learn that one ought to elicit the effect of the toy at least twice by performing each action, possibly in the same order as the actions were presented on video. The current data coding does not allow us to test this claim. Instead, one could predict that both demonstrated actions should be imitated first in each half of the trials, because each of the two actions was presented first on half of the trials. Indeed, children imitated tool and hand actions each half of the time when presented with these two options. However, children showed a different pattern of behaviour for the other combinations of actions, and adults clearly preferred to use their hand. The latter findings are not accounted for by the normative account.

To summarize, most findings from Study 6 are well accounted for by the normative account. Qualitative results of Study 6 further indicated that children potentially have a strong social motive in normative learning besides an epistemic motive. Children seemed to have an interest in acquiring, following, and enforcing norms, as well as in distributing their knowledge through teaching. However, participants also showed a strong motive to diversify and explore their knowledge further throughout the studies in this thesis, which is not accounted for by the normative account.

10.4 Conclusions for Empirical and Theoretical Research on Social Learning

In the present thesis, three lines of research were followed: (1) Is social learning influenced by the social and situational circumstances? (2) What does social learning look like across development? And (3) which behaviours are associated with social learning? Each of these questions was touched upon by both the theoretical research and the empirical research within this thesis. The previous sections present a discussion on how the theories of social learning and the empirical research in this thesis contribute to the answers to those questions.

In brief, the empirical research within the present thesis shows that social learning is influenced by communication from the model to the learner, a shared history between model and learner, and by the type of object and action that participants learned about. In particular, tool actions were identified as taking a distinct position in imitation learning, emulation learning, and action interpretation (1). The empirical research also showed that social learning varies as a factor of development. In the present studies, participants of different age groups frequently showed different behavioural patterns following social learning (2). Social learning was argued to have multiple behavioural facets: imitation, emulation, and action understanding or interpretation. These facets were confirmed to be relatively independent facets of social learning in the analysis of the present research. The theoretical analysis additionally identified protest and generalization as facets of social learning. The analysis of the empirical research within this thesis from the perspective of the social learning theories furthermore identified the learners' assumption that actions they learn about are culturally shared (3).

As the present thesis presents an initial analysis and study design based on a certain definition of imitation with some research based on few participants, future research could (a) broaden the analysis to include further theories and learning facets such as copying a model's choice of object or location, and (b) aim to answer the reviewed three questions individually with a more focused strategy of analysis and a stronger empirical approach tailored to the respective question.

The most fundamental results from this thesis are that (a) children show a preference to learn about tools and tool actions, (b) social learning develops so that (c) the existing social learning theories account for different findings of social learning research depending on the age of the learner. A complete social learning theory would allow for differential predictions of multiple facets of social learning based on the social and situational circumstances.

In conclusion, it is crucial to know which social, contextual, and developmental factors lead to differential learning of actions, outcomes, and other knowledge (e.g., norms, conventions, relational information). Only when those factors are recognised may the underlying cognitive mechanisms and processes of social learning *per se* be identified in a theoretical account. The studies within this thesis demonstrated that all reviewed social learning theories succeed in explaining some but not all of the results. In essence, the discussed social learning theories explain developmental shifts and peaks, and an overarching account of social learning would provide explanations and predictions of social learning including imitation, emulation, and action understanding or interpretation, and it would make differential predictions as a factor of the social and situational circumstances of learning.

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