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EARLY UNDERSTANDING OF CUES OF POSSESSION

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CONTENTS

Abstract – Comprensione precoce degli indizi di possesso

Il concetto di proprietà identifica la relazione esistente tra più individui nei confronti di un determinato bene. Tale relazione si esplica nella capacità di stabilire e mantenere il controllo su un bene e nella possibilità di escludere gli altri dall'uso di quel bene. La proprietà di un oggetto può essere inferita a partire da una serie di indizi spazio-temporali che legano un soggetto ad un oggetto, come ad esempio il contatto fisico, la prossimità e il controllo. La precoce capacità di identificare tali indizi e di rispettare il possesso altrui permette ai bambini di evitare i conflitti e costruire stabili relazioni tra pari.

Attraverso due lavori sperimentali condotti su infanti di 6 e 9 mesi sono stati indagate (a) l'abilità di identificare gli indizi percettivi di possesso (b) la capacità di riconoscere quando il possesso viene violato (c) la capacità di rispettare il possesso altrui. Un elemento chiave di questa ricerca è stato quello di indagare la comprensione delle relazioni di possesso attraverso l'uso due diversi approcci sperimentali: un paradigma di preferenza visiva dove il bambino doveva osservare delle interazioni soggetto-oggetto (Studio 1), e un paradigma interattivo dove il bambino veniva direttamente coinvolto nell'interazione soggetto-oggetto (Studio 2).

Lo Studio 1 analizza le abilità socio-cognitive del bambino attraverso il suo comportamento visivo. Nello specifico, il paradigma sperimentale prevedeva che agli infanti venissero mostrate delle animazioni video in cui delle figure geometriche dotate di movimento auto-prodotto compivano azioni finalizzate al raggiungimento di oggetti inanimati e/o interagivano tra loro. I risultati ottenuti suggeriscono una comprensione precoce degli indizi di possesso, della violazione del possesso e delle regole sociali alla base della nozione di proprietà.

Lo Studio 2 indaga la comprensione delle relazioni di possesso attraverso un paradigma interattivo. Nello specifico, le mie domande riguardavano come e quando la capacità di rispettare il possesso altrui emergesse durante la prima infanzia e se il processo di acquisizione di un oggetto da parte del bambino (ovvero l'atto di impossessarsi di un oggetto) fosse influenzato dal possesso altrui. Lo scopo principale dello studio era quello di analizzare il comportamento del bambino durante un compito di scelta tra due oggetti. A seconda della condizione, uno dei due oggetti poteva essere in contatto fisico o prossimità con la mano dello sperimentatore. I risultati mostrano come i meccanismi alla base del rispetto del possesso altrui emergano relativamente presto durante l'infanzia. Tuttavia, il processo di acquisizione sembra essere influenzato dalla compresenza di diversi meccanismi che dirigono la preferenza dell'infante verso uno dei due oggetti. Si ipotizza che la competizione tra tali meccanismi conduca a esiti differenti in funzione delle abilità socio-cognitive e motorie del bambino e del contesto in cui l'interazione soggetto-oggetto si verifica.

Nonostante il crescente interesse nei confronti della comprensione del concetto di proprietà e dei diritti ad esso associati durante l'infanzia, pochissimi lavori sperimentali hanno investigato la comprensione delle relazioni di possesso nei bambini al di sotto dell'anno di vita e la capacità di rispettare il possesso altrui. I risultati di questa ricerca sembrano suggerire l'insorgenza relativamente precoce di tali abilità, supportando l'idea secondo cui alcuni meccanismi di ragionamento sociale siano già presenti nell'architettura cognitiva degli individui e probabilmente affondino le loro radici nella nostra storia evolutiva.

Abstract – Early understanding of cues of possession

The concept of ownership refers to a particular relationship between several individuals and an object. The relationship consists of the power of an individual to establish and maintain control over an object and the possibility to exclude others from that object. At a basic level, objects' ownership is expressed and recognized by others through a set of spatial-temporal cues such as subject-object physical proximity or contact, actual control, and first possession. The ability to identify these cues and respect others' possession early in life enables children to avoid conflict and build stable relationships with peers.

The aim of this research is to examine the cognitive bases of sense of ownership and to explore how the understanding of the social norms concerning ownership evolve during the first year of life.

In two experimental studies, I examined (a) infants' ability to identify physical cues of possession, (b) infants' ability to recognize violation of possession, and (c) infants' ability to respect others' possession. A key goal of this research was to examine ownership cognition adopting two different methodological approaches: a classical visual paradigm where the infant was observing a subject-object interaction (Study1), and an interactive paradigm where the infant was directly involved in a subject-object interaction (Study 2).

In Study 1, I focused my investigation on ownership understanding analyzing infants' social-cognitive abilities from a third-person perspective. Specifically, I presented 6 and 9-month-old infants with a set of non-verbal video animations representing object-oriented goal scenarios and interactions between two animated agents. Results from these experiments suggest that, as third-party observers, infants seem to recognize

others' possession by showing interest when possession is violated and, possibly, the social rules concerning ownership.

In Study 2, I focused on ownership cognition by analyzing infants' behavior from a first-person perspective. Specifically, my questions concerned how and when the abilities to respect others' possession emerge during development and how the acquisition process (i.e., the act of taking possession of an object) could be affected by others' possession. The aim of this study was to analyze infants' behavior in a choice task involving two objects. Depending on the condition, one of the two objects could be either in physical contact or in proximity with the experimenter's hand. Results suggest that the mechanisms that elicit respect of possession emerge quite early during development. Nevertheless, the acquisition process seems to be affected by the co-occurrence of different mechanisms that drive the infant's preference toward one of the objects. I hypothesize that the competition between these mechanisms leads to different outcomes depending on the infant's socio-cognitive skills and motor abilities and on the context where the subject-object interaction occurs.

Despite the growing interest in the development of the notion of ownership and property rights, only very few experimental studies have investigated the understanding of possessive relationship in preverbal infants, and their ability to respect others' possession. Results of the research presented here suggest a very early emergence of these abilities, supporting the idea that some of the mechanisms responsible for dealing with ownership recognition are rooted in our evolutionary history and probably shared with other animal species.

PART 1 – THEORETICAL BACKGROUND

CHAPTER 1

The notions of ownership and possession

The concepts of ownership and possession refer to a particular relationship between several individuals and an entity. The relationship consists of the power of an individual to establish and maintain control over an object; the ability to control entails the possibility to exclude others from that object (Merrill, 1998; Snare, 1972). Ownership differs from possession because it does not need physical contact or actual control of the objects; essentially it is an invisible, abstract characteristic of objects, in the sense that one can be an owner of a thing without being in actual control of that thing. The two concepts are indeed conceptually different: ownership refers to the legal right to control a thing and exists thanks to a body of normatively stipulated conventions, while possession refers to the practical ability to control a thing. Regardless of this, ownership and possession may commonly coincide in people's appraisal. For example, in humans, like in other animal species, everyday attributions of ownership are primarily based on the ability to perceive and identify cues of physical possession such as contact, proximity, and actual control (Friedman, 2008; Merrill, 2015).

From a developmental perspective, possessive relationships play a crucial role in social interactions from infancy. Nevertheless, the age of emergence of a mature understanding of the normative nature of ownership is difficult to define. The body of studies on children reveals the existence of a relatively long period of overlap between the two concepts where the comprehension of possession and experience of possessive relationships are propaedeutic to the development of the abstract concept of ownership and property rights (Blake & Harris, 2011; Friedman & Neary, 2008).

Scholars from various disciplines have been interested in the nature of possessive behaviors, and philosophical theories on ownership have been discussed since the classical antiquity (see Rudmin, 1991 for a review). Ownership has been studied in a variety of populations, including infants and children (e.g., Fasig, 2000; Furby, 1980; Rochat, 2010), elderly individuals (e.g., Cram & Paton, 1993; Kamptner, 1991), and animals (e.g., Kummer & Cords, 1991; Sigg & Falett, 1985). Socio-anthropological studies have been conducted within different ethnic groups and across different socio-economic levels (Patricia Kanngiesser, Rossano, & Tomasello, 2015; Rudmin, 1988, 1996). Several legal, economical and psychological theories have been developed around this topic and the complex and multifaceted nature of the phenomenon has been widely investigated both through speculative and experimental research (Belk, 1988; Demsetz, 1967; Merrill, 1998; Pierce, Kostova, & Dirks, 2003; Reb & Connolly, 2007; Rose, 1985; Van Dyne & Pierce, 2004). Recently, the neural and cognitive bases of the sense of ownership have been analyzed through neuroimaging techniques (Kim & Johnson, 2014; Krigolson, Hassall, Balcom, & Turk, 2013; Turk, van Bussel, Waiter, & Macrae, 2011) and motor-behavioral analysis (Constable, Kritikos, & Bayliss, 2011; Constable, Kritikos, Lipp, & Bayliss, 2014).

Ownership reasoning affects our thinking and behavior towards multiple varied aspects of everyday life. A common understanding and respect of ownership regulates much of our behavior towards both objects and other individuals. During infancy and early childhood, the ability to understand first possessive relationships and later ownership rights is essential to navigate and act effectively on the physical and social environment. Ownership and possession are involved in many daily life activities like giving and taking, buying and selling, borrowing, begging, stealing, and so on. Regarding *what* can be owned, ownership can be applied to a wide variety of entities: objects (Dittmar, 1989; Prelinger, 1959), lands (Rudmin & Berry, 1987; Verkuyten, Sierksma, & Thijs, 2015; Zebian & Rochat, 2012), work (Holmes, 1967; Pierce, Kostova, & Dirks, 2001), new creations (Kanngiesser, Gjersoe, & Hood, 2010; Levene, Starmans, & Friedman, 2015), symbols (Dittmar, 1991), ideas (Goodenough & Decker, 2009; Olson & Shaw, 2011; Shaw, Li, & Olson, 2012), living entities such as animals and other people (L. Ellis, 1985; Prelinger, 1959; Rudmin & Berry, 1987), and body parts (Vondervoort & Friedman, 2015).

The concept of ownership involves different rights and duties, and an entire branch of law, property law, is concerned with ownership and possession. Snare (1972) suggested the existence of three main rights associated with ownership. An owner has the right of possession and use, the right to exclude others from possession, and the right to transfer possession to another individual. Non-owners must recognize and respect these rights, and when a transfer of ownership occurs, the previous owner relinquishes his rights by becoming a non-owner, while the rights associated with ownership are transferred to the new owner. In every known human society, respecting others' property is a fundamental norm of common life. Human societies that have a formal legal system protect possession and ownership as a matter of law. Societies that do not have a formal legal system protect possession through a set of informal norms and common practices. Ownership violations are prosecuted through a set of penalties that can vary depending on cultural differences. However, individuals who violate the norm are typically disapproved, mistrusted and punished with retaliation by the whole community. The body of behavioral and anthropological evidence identifies respect for possession as a universal social norm, with low variation in space and time, and scarcely dependent on cultural constraints (Merrill, 2015).

Although ownership is a social notion, some theoretical and empirical works have examined ownership at the individual level by analyzing the dyadic relationship between a single individual and an object. These studies highlight the psychological effect of self-ownership on both object- and self- perception and evaluation (Belk, 1988a; Cunningham, Turk, Macdonald, & Neil Macrae, 2008; Cunningham, Vergunst, Macrae, & Turk, 2013). Other studies have addressed the issue considering the social nature of ownership relationship. These works examine people's reasoning and behavior toward others-ownership, considering patterns of collective behavior and their compliance with different rights and duties associated with the institution of property (e.g., Friedman, 2008; Kalish & Anderson, 2011). Within this context, some of them suggest that many of our behaviors and psychological tendencies concerning ownership are evolutionary adaptations to social life (Ellis, 1985).

Possession is important in social interactions from infancy, and the concept of ownership has been suggested as one of the earliest forms of abstract thinking (Fasig, 2000; Furby, 1980; D. F. Hay, 2006). Compelling evidence of the early importance of ownership are, for example, the attachment children express towards some objects (Winnicott, 1971) and the large amount of conflicts about possession during childhood (Hay, Hurst, Waters, & Chadwick, 2011; Ross, Conant, & Vickar, 2011; Ross, 2013). During development, it is likely for sensory-motor experience associated with objects possession to play an important role in ownership cognition. However, separating the concept of abstract ownership from that of physical possession has resulted in a gap in the description of the early developmental steps that lead to a conceptual understanding of this relationship (however, see Blake & Harris, 2011 and Rochat, 2011 for speculative models). According to Furby (1980) the the early notion of possessiveness arise from the combination of two hard-wired components of human behavior that describe the triadic relationship between an infant, an object and another individual. One component is represented by infants' exploratory behavior (*effectance motivation*) and is the child's drive to possess, control and have an effect on the external environment. The other component is the limit caregivers impose on the infant's drive to possess, in order to avoid dangerous consequences. The resultant effect of these contrasting components is that infants gradually learn to distinguish those objects that they can touch and grab (mine) from those that are off limits (not-mine).

By contrast, Rochat suggests that a minimal sense of possession is present in humans from birth. The notion of ownership hence develops from the point in time when infants extend their sense of self (including the sense of agency) to objects. Between 3 and 6 months of age, property consists in use and possession: infants use objects, but they do not seem to experience any form of entitlement over them. Later, by the end of the first year of life, they start to include objects in their interactions with other individuals, and gradually their sense of exclusive and pre-conceptual possession becomes a sense of alienable and conceptual possession. With a different approach, Blake and Harris propose a developmental model where children include ownership as an attribute of their object representations. They suggest that an early understanding of ownership concepts begins with a simple visual association between a subject and an object, and develops later combining and integrating the visual source with verbal information (Blake & Harris, 2011). The importance of a visual source of information to make inferences about objects ownership emerges also from a study by Blake and colleagues (Blake, Ganea, & Harris, 2012). Results from this study show that when the visual and verbal information about objects ownership are contradictory, children until 5 years of age tend to favor the visual cues over the verbal information in their ownership attributions.

The majority of empirical evidence of ownership attribution skills in young children relies on explicit judgments such as the use of possessive pronouns or the ability to identify objects belonging to oneself and to others (*ownership understanding index*: Fasig, 2000; Brownell, Iesue, Nichols, & Svetlova, 2013). The ownership understanding index measures the children's ability to remember associations and past experiences between a subject (self or other) and an object; this ability requires the development of an *extended historical self*. Indeed, as stated by Fasig (2000): "recognition of the owned object and association of the object with the self requires knowledge of the self in conjunction with the object in the past". According to Gelman and colleagues (Gelman, Noles, & Stilwell, 2014), the status of ownership, although an invisible feature, improves attentive processing and memory of objects both in adults and in children. They suggest that the ability of tracking owned objects derives from an early emergent and spontaneous disposition to track people, their actions, and inanimate but socially relevant items. A more detailed description of studies concerning the concepts of self- and others-ownership and their development will be presented later.

The notion of affordance

The interaction of an individual with an object may be described in terms of *affordance*. Gibson (1977) defines affordances as properties in the environment that are relevant for an organism's goals. Nevertheless, affordances cannot be defined in terms of physical properties of the environment only. They represent practical opportunities offered by the environment to an organism that is able to perceive and use them. Thus, affordance implies the coupling of perceiving and acting. Affordances may therefore be thought of in terms of a mutual relationship between the environment and the organism.

Recent literature on micro-affordance (a term proposed by Ellis & Tucker, 2000 which refers to a specific kind of interaction with objects, such as reaching and grasping) highlights the existence of brain networks representing objects in terms of actions that can be performed with them (for a review see Thill, Caligiore, Borghi, Ziemke, & Baldassarre, 2013). For example, behavioral and neuroimaging studies show that observing objects (or pictures of objects) activates specific motor acts corresponding to reaching and grasping behaviors typically performed with them (Grèzes & Decety, 2002; Tucker & Ellis, 2001).

The perception of the affordance of an object could depend on its spatial location. In a study by Costantini and colleagues (Costantini, Ambrosini, Tieri, Sinigaglia, & Committeri, 2010), authors show that the perception of affordance suggests a motor act only when the object is presented within the participants' reaching space. At the same time, peripersonal space can be extended when individuals are provided with tools useful to reaching objects (Berti & Frassinetti, 2000; Farnè & Làdavas, 2000; Iriki, Tanaka, & Iwamura, 1996; Maravita, Spence, Kennett, & Driver, 2002). Reaching space remapping occurs both during active tool-use and through the observation of tool actions performed by others (Costantini, Committeri, & Sinigaglia, 2011). Despite the growing knowledge about the mechanisms defining the functional relationship between a singular individual and an object, little is known about the behavioral and neural mechanisms encoding the social dynamics of our interactions with objects. Recent literature shows how the social context in which the action occurs could affect the planning and execution of movements towards (or with) objects (for a review see Becchio, Sartori, & Castiello, 2010). For example, the kinematics of reaching to grasp an object can be influenced by the presence of another person and it is modulated by the strength of the affiliative relationship between the two people (Gianelli, Scorolli, & Borghi, 2013). Moreover, kinematics could change depending on the final goal of the performed action (i.e. social intention/non social intention) (Ferri, Campione, Dalla Volta, Gianelli, & Gentilucci, 2011; Sartori, Becchio, Bulgheroni, & Castiello, 2009; Claudia Scorolli, Miatton, Wheaton, & Borghi, 2014).

Empirical studies on ownership: self-ownership

Speculations about the existence of a strong link between ownership and the self have been made in the realms of philosophy, psychology, anthropology and economics (Belk, 1988; Brown, Pierce, & Crossley, 2013; Pierce, Kostova, & Dirks, 2001). Self-ownership association is commonly expressed by the psychological attachment we feel towards our property (objects or other entities that we consider to belong to us) and by the sense of power and control we experience towards owned entities. This association is bidirectional: on the one hand ownership may be considered an extension of the self (Belk, 1988a), on the other hand, owned things contribute to self-construction and definition (Dewey, 1922). Furby (1991) suggests that the feeling of 'mine' emerges in close connection with the feeling of 'me' during infancy and derives from the innate propensity of infants to control objects and to be *effectant* on the environment. Similarly, Rochat (2011) affirms that by 2 months of age, infants begin to explore the self as agent through control over the objects, incorporating the objects into the self.

Owned objects acquire a special cognitive and affective meaning. Several studies on human and non-human primates show the existence of preference biases towards owned objects, even when ownership is a transient event (Beggan, 1992; Belk, 1988; S. Brosnan, Jones, & Lambeth, 2007; Kahneman, Knetsch, & Thaler, 1991; Knetsch & Sinden, 1984; Lakshminaryanan, Chen, & Santos, 2008). These effects are enhanced when participants can touch or manipulate the owned objects (physical possession) (Peck & Shu, 2009; Reb & Connolly, 2007). In a study by Peck and colleagues authors found that merely imagining to touch an object (haptic imagery) resulted in an increase in perceived ownership and positive valuation of that object (Peck, Barger, & Webb, 2012).

People also show enhanced awareness towards owned objects, like attentional biases and increased memory performance (Cunningham, Brady-Van den Bos, & Turk, 2011; Cunningham et al., 2008, 2013). Recent neuroimaging studies suggest that the cognitive system favors the processing and representation of self-owned things recruiting in part the same brain regions involved in self-processing (Cunningham et al., 2011; Kim & Johnson, 2014).

In developmental research**,** explicit measures of ownership understanding from a first-person perspective are primarily based on the use and comprehension of possessive pronouns (D. F. Hay, 2006; Saylor, Ganea, & Vázquez, 2011). Saylor and colleagues, for example, show that already at 12 months of age infants are able to understand the meaning of "my" when they have to determine to which of several things a person was referring. Nevertheless, it is between 15 and 18 months of age that they start to use personal pronouns to express their own possession (Hay, 2006).

Implicit assessments of ownership comprehension are gathered from behavioral observation of children during peer interactions (D. F. Hay et al., 2011; D. F. Hay, Nash, & Pedersen, 1983; Hildy Ross et al., 2011) or, in experimental settings, when children are directly involved in live interactions concerning ownership (Patricia Kanngiesser & Hood, 2014; Federico Rossano, Rakoczy, & Tomasello, 2011; Vaish, Missana, & Tomasello, 2011). With regard to experimental studies, research has mainly focused on children's reaction to violations of their/others' ownership (i.e., stealing, alteration, destruction), finding that an emotional reaction occurs earlier related to self-ownership violation than to the violation of others-ownership. Due to the complexity of these tasks, these abilities have been investigated mainly in children and not in infants.

Empirical studies on ownership: others-ownership

With respect to others-ownership, experience and judgment of physical possession facilitates the respect of property rights. There is evidence describing this ability as a basic cognitive mechanism, grounded in our sensory-motor system and rooted in our evolutionary history (Stake, 2004; Tummolini & Castelfranchi, 2011; Tummolini, Scorolli, & Borghi, 2013). Experimental studies and behavioral observations on animals show that in several species, individuals are able to identify and respect others-ownership when it is signaled by physical contact or proximity; an individual can indeed maintain its possession regardless of which other individuals are present (Kummer & Cords, 1991; Russ, Comins, Smith, & Hauser, 2010; Sigg & Falett, 1985). It has been suggested that the general rule that enables individuals to retain their property is the rule of prior possession: the first individual to be in physical possession of a resource is the one that retains ownership; the late-comer is the one that respects the first-possessor's ownership (Kummer, 1991; Maynard Smith & Parker, 1976). This strategy allows animals to allocate resources minimizing the costs of a fight. A more detailed description of studies conducted on animals will be presented later.

The prior possession rule, also known as the first-possessor heuristic, is a powerful construct for the human species as well. In the absence of further information, people tend to attribute the ownership of an object to the first possessor they have seen it with; evidence of this behavior can be found very early during development (Friedman & Neary, 2008; Friedman, Neary, Defeyter, & Malcolm, 2011; Friedman, Van de Vondervoort, Defeyter, & Neary, 2013). Behaviors and judgments arising from an intuitive use of the prior possession rule are evidence of the important role played by spatiotemporal cues of possession in ownership attribution, both in young children and later in adult life (Blake & Harris, 2011).

Recently, researchers have investigated how other people's property is represented from a social affordance perspective, specifically how awareness of others-ownership affects our judgments and our motor behavior during object-interaction. Results from these studies demonstrate that: (a) perceptual cues such as physical proximity and object interaction play an important role in ownership attribution; (b) others-ownership awareness influences the kinematic patterns associated with hand–object interactions; (c) our motor behavior changes depending on the final goal of the action (i.e., giving vs getting an object) and the object location (self- vs other-peripersonal space) (Constable et al., 2011, 2014; Scorolli, Borghi, & Tummolini, 2015; Scorolli et al., 2014).

To my knowledge, this methodological approach has not yet been adopted in order to investigate ownership cognition from a developmental perspective. As mentioned earlier, it has been argued that an early understanding of others-ownership is primarily based on the visual association between individuals and objects (Friedman, 2008; Friedman & Neary, 2008). However, no recent studies have investigated how this perceptual information is processed and translated into motor behaviors associated with object-interaction. The only observational study to address this question in infants has been conducted by Hay and colleagues on dyads of 6-month-olds (D. F. Hay et al., 1983). The authors find that, when two infants touch the same toy, in the majority of cases the original holder (the first who touched the toy) is the one that retains possession, while the other infant withdraws their hand. They conclude that already at this age infants might be sensitive to others' possession and that their interaction with objects is affected by the presence of another infant.

In developmental research, studies on children's others-ownership understanding have mainly focused on the notions of rights associated with the use and transfer of owned objects. The most commonly used technique is based on explicit measures of ownership comprehension from a third party perspective (i.e., children are presented with verbal stories or vignettes representing object ownership interactions between characters, and later they are asked to attribute ownership to one of the characters, or to judge their behavior). Other authors have exploited non-verbal measures of ownership awareness, like spontaneous protests against property rights violation or they infer ownership awareness through implicit measure of social evaluation (Hamlin & Wynn, 2011; Vaish, Carpenter, & Tomasello, 2009). Results from these studies show differences in the ages at which children exhibit some degree of ownership understanding and this seems to depend on the methodology used. In verbal studies, for example, the age of evaluation of ownership rights transgressions is higher than in studies exploiting implicit measures. Thus, the lack of evidence of ownership awareness in younger children may indeed be due to their incapacity to communicate or react on norm violations. At the same time, it is possible that children lack the motivation to intervene when they are not directly involved in the ownership relationship. One of the open questions is whether prior to the emergence of productive language abilities and prior to the explicit mastery of the concepts of property rights, infants have an implicit and intuitive knowledge about ownership.

Origins of ownership rights

Some researchers ascribe the origins of ownership rights exclusively to the realm of human inventions (Bentham,1914; Kalish & Anderson, 2011; Rakoczy & Schmidt, 2013). Others recognize a continuum with our evolutionary past, suggesting that the sense of ownership, and precursors of ownership rights, can be found in the behavior of many other animal species (Brosnan, 2011; Ellis, 1985; Gintis, 2007; Krier, 2009; Stake, 2004). In this section, I will focus on the second hypothesis, presenting evidence that suggests the importance of biological evolution behind the emergence of private property rights.

The economist Harold Demsetz argued that, in human societies, a system of property rights is more likely to emerge when the benefits that derive from that economic system outweigh the costs imposed on all individuals involved (Demsetz, 1967). For example, when the costs of overhunting caused by fur trade outweighed the benefits in some tribes of American Indians, they decided to turn from a shared use of the land to a system of property rights where each family owned a piece of land for their exclusive use. The reasoning that resulting from a particular environmental pressure the ratio between costs and benefits leads human groups to adopt a specific socio-economic strategy strongly resembles the socio-ecological explanation of some behavioural adaptations in non-human animals. Indeed, in several species, ecological conditions and species-specific needs have led to evolutionary adaptations such as having an exclusive territory or hoarding food in cache sites. In these species, individuals or groups exhibit behaviours with the goal to define and defend their property. At the same time, they recognize and respect property of others. As previously said, it has been suggested that the general rule that enables individuals to retain their property is the rule of prior possession. According to the rule, "the resource falls to the individual who had it first, and the late-comer respects the owner's control over it" (Kummer, 1991). This rule has been formalized as part of an evolutionary stable strategy (ESS) that prevents individuals to continuously fight over resources, minimizing the costs associated with fights (Maynard Smith and Parker, 1976; see also Stake, 2004). Observational studies show that as soon as property has been settled, individuals are more likely to retain it without actual fighting, and they are more likely to win a fight against an intruder (Davies, 1978; Krebs, 1982; Nelson, 1984). For example, Davies (1978) observed that speckled wood butterflies (*Pararge aegeria*) exploit a first-in-time rule for the possession of sunspot: the first individual to touch the sunspot is the one that fights harder to maintain possession and usually wins the contest with the intruder.

The rule of prior possession can be applied to territories, harems and food- or non-food-objects. Experiments and behavioural observations on non-human primates show that, in general, the event of taking an object possessed by another individual is extremely rare (Gintis, 2007) and that individuals are able to identify and respect others-ownership when it is signalled by contact or proximity. However, it should be noted that this rule takes different forms depending on the species, the identity of the involved parties, and the attributes of the owned object. In some primates, visual cues like physical contact and proximity are not the only ones used to determine possession and property; olfactory and auditory signals can play a role as well. Basing on her research on white-faced capuchin monkeys (*Cebus capucinus*), Gros-Louis (2004) assumed that food-associated calls may function to signal food possession, regulating inter-individual spacing and reducing the likelihood of aggressions.

In experimental studies, a typical measure of respect for possession is the probability of a dominant individual refraining from taking an object from a subordinate. In hamadryad baboons (*Papio hamadryas*), for example, it has been noted that proximity can be sufficient to draw respect for possession; however, between dyads of monkeys, the likelihood of maintaining possession depended also on the gender of the involved parties and on their relative hierarchical distance (Sigg & Falett, 1985). In another study involving long-tailed macaques (*Macaca fascicularis*), researchers observed that proximity or physical contact with an object were not sufficient for others to respect possession; in this species, individuals respected ownership when the owner was also able to carry the object. In case of attempted taking by a dominant individual, the probability to retain possession increased when the subordinate owner screamed, attracting support from other group members. Authors proposed third-party intervention as evidence of the existence of possession-related norms in this species (Kummer & Cords, 1991). In a different experimental setting, Russ and colleagues (2010) studied how free-ranging rhesus monkeys (*Macaca mulatta*) reacted to different cues of possession expressed by a human competitor. When monkeys had to choose between two food options, they avoided to take the resource that was in proximity or physical contact with the experimenter, even when the connection was made through a rope attached to the food. The attentional state of the human competitor was also a strong cue inhibiting food acquisition.

In some species, the behavioural repertoire concerning possession and object interaction can be context dependent. For example, individuals can adopt a flexible behaviour depending on their proximate motivations and on inter-individual relationship. An example of a particular context in which rules of possession are subverted is social play that involves objects. Major evidence of this behaviour has been found in primates, canids and birds (Bekoff & Byers, 1998). Social object play is presumed to have immediate and long-term effects on social skills and species-specific abilities like environmental exploration, predation, and tool use abilities (Burghardt, 2005).

Interestingly, it has been observed that, during play, respect for possession disappears and the roles of owner and non-owner are repeatedly reversed. Moreover, in this context the competition for an object does not lead to serious aggressive escalations, although this aspect could vary from one species to another.

Another example of behavioural flexibility is represented by tolerance toward transfer of possession in circumstances that involve food or tools (Pruetz & Lindshield, 2012; Stevens & Gilby, 2004). Expression of tolerance depends on the species, and it is strongly affected by kinship relationship; nevertheless, there are many evidences of this behaviour even between unrelated subjects. In primates, examples of tolerated transfers of food from the hands, or even the mouth, of one individual to another have been observed both in apes and in monkeys (Brown et al., 2004; Feistner & McGrew, 1989; Kasper et al, 2008). Tolerance, however, seems to be higher toward infants and young individuals and, in some cases, only certain kinds of food are shared that are highly nutritious or difficult to obtain (Rapaport, 2006; Silk, 1979).

This body of evidence seems to support the idea that a sense of ownership and the origin of ownership rights are rooted in our evolutionary history and have a pre-cultural basis. Stake (2004; see also Litwinski, 1942) affirms that humans are equipped with a *property instinct* and that some fundamental principles of property are ingrained in human behaviour by the virtue of evolution. According to this theory, the mechanisms dealing with ownership recognition are hard-wired in the human brain and humans are adapted to respecting others' possession.

Another source of evidence that supports the existence of a property instinct is provided by research on human infants' behaviour. As previously said, the majority of experimental studies dealing with ownership cognition have been conducted on children and not on infants. Nevertheless, some indirect sources of evidence seem to suggest that, from a very young age, infants are equipped with the ability to recognize physical cues of possession and build a representation of possessive relationship in complex social contexts. A detailed description of these studies will be presented in the next chapter.

CHAPTER 2

Human reasoning seems to be guided by the presence of a system of "core principles" dealing with important aspects of the external world and related both to the physical and the social domain (Carey, 2009; Spelke & Kinzler, 2007). This core knowledge appears to be in place from birth, and to be shared with other animal species (Vallortigara, 2012). In this chapter, I will describe the subcomponents that lead to an abstract representation of others' possession. Then, I will provide evidence that infants possess the cognitive abilities required for the understanding of these subcomponents. Ultimately, I will discuss the hypothesis that infants are equipped with a core sense of possession and that they are able to build a representation of possessive relationship in complex social contexts.

Representation of others' possession

Possession is an abstract property that arises from a specific set of elements characterizing a relationship between (at least) one subject and an object. A comprehensive representation of possession depends on the processing of some spatial cues and dynamic events occurring between the subject(s) and the object.

Spatial cues that can elicit a representation of possession are physical contact and physical proximity between subject and object (Kummer & Cords, 1991; Sigg & Falett, 1985). The contact condition between a subject and an object is typically represented by a direct physical connection between the body of the subject (for example a hand) and the object or part of it. Nevertheless, in some cases, the connection could be mediated through another element, for example a rope (Russ et al., 2010). The proximity condition between the subject and the object occurs when the object is located in the peripersonal space of the subject, so that it can be reached and grasped by the subject. The peripersonal space can be extended by a tool (Maravita & Iriki, 2004).

Spatial cues alone, however, are not always sufficient in eliciting a representation of possession. Another basic component that allows people to detect possession is direct control. Control can be defined as the power exerted by the subject over the fate of the object. At a basic level, a subject is considered to be in control of an object if the object's motion depends on the subject's actions and decisions (Premack & Premack, 1995).

Until here, I presented possession as a spatial and dynamic relationship between a subject and an object where possession of an object is described as a status, but not necessarily as the goal of the subject's actions. There are indeed contexts where possession of an object can be viewed both as a status and as a goal. For example, when we observe a subject pick up and move objects from one location to another, during this specific period the subject is in possession of the objects. The goal of the action though is changing the objects' location. The possessive relation between subject and object is a necessary condition in order to fulfill the action, but not the overarching goal of the action. Instead, if we observe a subject collect objects and stack them close to his body, or put them into a close container, possession can be assumed to be the goal of the subject's actions.

A component that expands the representation of possession and leads to a representation of possession as a goal is the investment of effort in gaining and maintaining possession of objects. Effort is expressed by the time and the physical energy invested by a subject in the act of acquiring, maintaining and, possibly, defending their possession.

Even if possession can be described as a dyadic subject-object relationship, a complete representation of possession emerges only when we consider a context that involves more than one subject. Several authors have indeed argued that possessive relationships are necessarily triadic (social), involving at least the presence of a person, an object, and another person. According to this view, possession exists only when it is recognized by others (Snare, 1972). Only inside a social context, certain important properties of the concept of possession can emerge, such as the power to exclude others from the object of possession. The power to exclude others derives from the power to control the object. Another emerging property of possession that arises within a social context is that possession can be transferred between subjects. Transfer of possession is the counterpart of exclusion, and similarly derives from control as well. An event of transfer can be described as the reallocation of an object from one subject to another. The nature of the transfer, however, varies depending on the circumstances and execution of the reallocation. Imagine a three-component context composed of two subjects and an object, one of the subjects being in possession of the object (the subject is in contact with the object and is able to control its motion). If the subject that performs the transfer of the object is the possessor, the process could be described as a giving-action. If the other subject is responsible for the transfer, it could be described as a taking-action. Giving- and taking-actions are therefore object-mediated interactions between subjects (Tatone, Geraci, & Csibra, 2015). Nevertheless, other situations exist where reallocation of possession occurs without a direct interaction between subjects. For example, in case the possessor relinquishes its possession first, followed by the second subject taking possession of the object, a two-steps transfer of possession without direct interaction occurs.

As demonstrated, possession seems to be a high-level cognitive construct that involves multiple representations. It requires the ability to (a) differentiate between animate subjects and inanimate objects, (b) detect and interpret their relative spatial relationships, (c) encode object-directed actions, and (d) encode object-mediated interactions between subjects. The ability to identify these components and processes is a necessary prerequisite in order to identify possession and transfers of possession. Despite this apparent complexity, detection of possession and transfer of possession in humans and non-human animals is a process that occurs in a rapid and automatic way. A body of evidence shows how animals rely on contact, proximity and direct control to recognize and respect others' possession. This behavior is typical for the human species as well: in several contexts of everyday life, possessive relationships shape our interactions with objects and other individuals even if we are not aware of it. In the absence of explicit information, moreover, adults tend to base their attribution of ownership on perceptual cues of possession. Ultimately, developmental studies show that, from a very young age on, children are able to make inferences about ownership by basing their judgments on spatiotemporal cues of possession. Collectively, these findings provide evidence for a biological foundation of ownership that, at a basic level, is based on the social cognitive ability to encode possessive relationships. It is indeed likely that early precursors of this ability can be found in the behavior of human infants as well. Following, I will present evidence that human infants are able to detect the elementary subcomponents of possessive relationship.

Psychological reasoning in early infancy

At the beginning of the 1980s, researchers began to employ looking-time methods to explore infants' cognitive abilities (Baillargeon, Spelke, & Wasserman, 1985; Kellman & Spelke, 1983; Leslie, 1984; for a review, see Baillargeon, Li, Gertner, & Wu, 2011). One of the most used looking-time techniques was the *violation-of-expectation* (VOE) method that relies on infants' tendency to look longer at events that violate their expectations and thus are inconsistent with their knowledge about a specific phenomenon. Thanks to this and other visual behavior approaches, researchers have provided evidence that young infants possess sophisticated cognitive competences regarding both the physical and the psychological world. A number of experimental works confirm the existence of a core foundation for objects, numbers, spatial relationships, events representation and for the social domain. For example, infants show preference for direct gaze and biological motion already from birth (Farroni, Csibra, Simion, & Johnson, 2002; Simion, Regolin, & Bulf, 2008) and they are able to discriminate between sets of elements of different magnitude (Izard, Sann, Spelke & Streri, 2009). Infants can represent occluded objects (Baillargeon, 2008; Bremner, Slater, & Johnson, 2015); they have expectations about when an object will fall because it lacks of support (Needham & Baillargeon, 1993); and they can recognize and categorize the spatial relations between objects (Casasola & Cohen, 2002; Quinn, Norris, Pasko, Schmader, & Mash, 1999).

Regarding the comprehension of events, the seminal works of Heider and Simmel (1944) and Michotte (1963) demonstrated that simple visual displays involving abstract entities moving and interacting with each other could give rise to percepts with high-level properties such as social and physical causality. In these experiments, adults watched video scenarios where two-dimensional geometrical figures moved on a screen following specific sequential patterns (Fig.1). After having watched the videos, participants were asked to describe and interpret the scenes. Authors showed that observers systematically tended to attribute to the figures specific roles, causal properties and mental states. Such interpretation did not depend on the perceptual qualities of figures (shape, dimension or color), but it was based on specific kinematic information such as timing, velocity and variation in the spatiotemporal contingency between the moving objects.

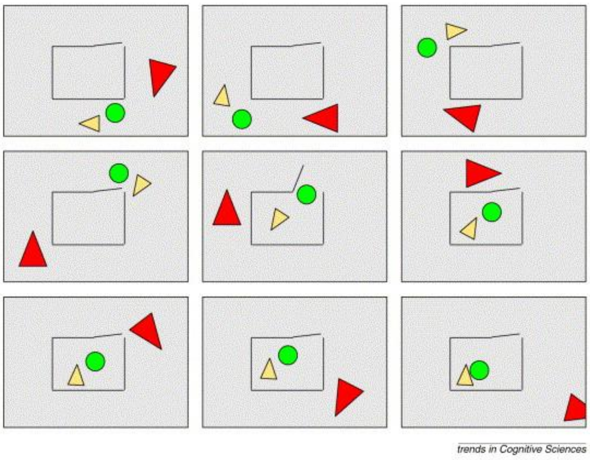


Fig. 1
Some sequential frames from a dynamic display of the type used by Heider & Simmel to demonstrate perceptual animacy.
Observers interpret this display as a chasing event where the big red triangle chases the small yellow triangle and the green circle.
(Adapted from Scholl & Tremoulet, 2000)

The same approach has been adopted in the area of social cognitive development, in order to shed light on the emergence of socially relevant mental representations and processes such as agency, intentionality, social relationship and social judgments (see Baillargeon et al. 2015, for an extensive review). In many of these experimental studies, infants are presented with video scenarios showing interactions between entities. An outstanding body of evidence shows that the dynamic properties of the moving figures lead to a representation of them as either physical inanimate objects or as intentional (or psychological) agents. For example, agents' movement appears to be self-propelled (i.e., they are capable of autonomous motion) and biological (non-rigid, irregular), while objects' motion requires external causes and appears to be more rigid and mechanical. Agents moreover produce actions that could be described as goal-directed and that are guided by a *principle of rationality*. This means, for example, that agents' actions should be consistent with their goals and dispositions (*consistency principle*) and agents should be as much efficient as possible in achieving their goals (*efficiency principle*).
Several works show how infants rely on dynamic features and on psychological principles to create representations of agents, attribute intentions to their actions and

predict their behavior. In a seminal work, Gergely and colleagues (Gergely, Nádasdy, Csibra, & Biro, 1995) demonstrated that by 9 months of age infants are able to view an abstract entity as an agent and attribute to it a specific goal (i.e., reach a target). Infants specifically expect the agent to use the shortest possible path to reach a target, in accordance with the efficiency principle (Fig.2).

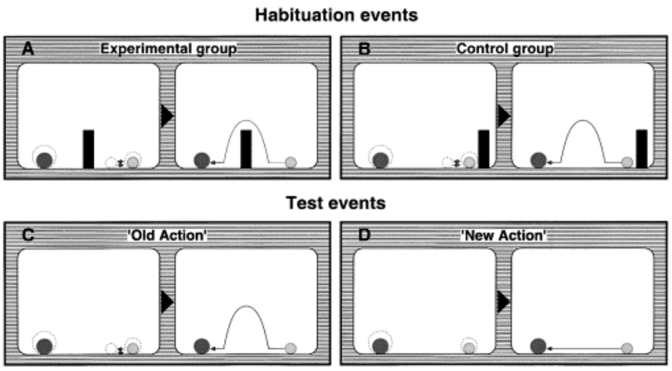


Fig. 2 Stimuli by Gergely et al. (1995)
During the habituation phase, infants see an agent jumping over an obstacle in order to reach a target.
During the test phase, the obstacle is removed and infants watch two test events: the old (indirect and inefficient) action and the new (direct and efficient) action.

In the same period, with an elegant set of experiments, Amanda Woodward demonstrated that infants by 9 months of age are able to encode agents' behavior in terms of goals (or preferences) and they expect the agent to maintain the goal, in accordance with the consistency principle (Woodward, 1998) (Fig. 3).

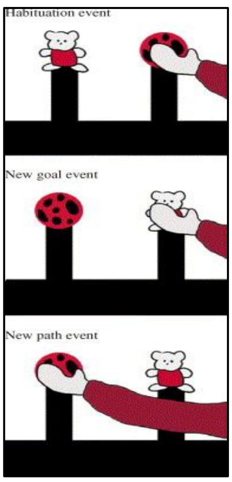


Fig. 3
Woodward paradigm, human condition.
During the habituation phase, infants see an actor repeatedly reach for and grasp one of two toys. During the test phase, position of toys is inverted and infants watch two test events: a new goal event and a new path event.
New goal event: the actor grasps a different toy than she had during habituation.
New path event: the actor reaches to a different location for the same toy that she had during habituation.
Adapted from Sommerville et al., 2003

Another property that characterizes agents is that their behavior can be affected at distance and that they can act to influence another agent from a distance (Leslie, 1994). Developmental research has demonstrated that infants are able to represent dynamic interactions between agents and understand their roles in specific contexts. For example, very young infants prefer coordinated and interacting moving shapes to randomly moving stimuli (Rochat, Morgan, & Carpenter, 1997). Other studies provide evidence that, toward the end of the first year, infants begin to encode complex interactive schemata such as chasing (Schlottmann, Surian, & Ray, 2009; Southgate & Csibra, 2009) or helping (Hamlin, Wynn, & Bloom, 2007).

Representation of possession in infants

In 1995, Premack and Premack developed a theory about the origins of human social competences as a domain-specific module (Premack & Premack, 1995). According to the theory, social competence consists of three units. One module (intentional) allows infants to distinguish between animate and inanimate objects. One module (social) allows infants to interpret agents' actions. One module (theory of mind) allows the attribution of mental states to agents. The social module allows infants to understand that agents' actions are goal-directed and that a value (positive or negative) can be attributed to them. Moreover, three secondary properties identify intentional agents: they reciprocate value, join groups, and take possessions. Possession, indeed, is described as a fundamental element of the social system and its recognition depends on the ability to identify connection and co-movement of two objects, and their relative power. Thus, when a scene depicts two entities and one of those controls the movements of the other, a representation of possession arises.

In the previous chapter, I briefly illustrated that infants are able to differentiate between animate agents and inanimate objects, attribute goals to the agents' actions, interpret the meaning associated with a complex pattern of events, and possess expectations about social interactions among agents. Following, I will describe representative studies where infants are presented with video scenarios showing agents-objects interactions. In these works, possessive relationships and transfers of objects between characters play a relevant role in the chain of events. Authors assume that infants have an implicit knowledge about these constructs.

In a study about prelinguistic events representation, Gordon (2003) investigated infants' sensitivity to the relevance of an argument inside the structure of a specific event. For example, the three arguments of a giving action are: the giver, the recipient, and the object. All of the arguments are essential for a representation of a giving action; the subtraction of any one argument would cause the meaning of the event to change. In the experiment, infants were habituated to scenarios showing a three-argument event (a girl gave a toy to a boy) and a two-argument event (a girl hugged a boy while carrying a toy). Later, infants saw an old test event identical to the one seen before, and a new test event showing the same event (giving or hugging) without the toy. Results show that between 8 and 10 months of age, infants expect the argument *object* (the toy) to be present in the giving event, but not in the hugging event, showing recovery of attention for the new test event in the giving condition. These results clearly show that infants, toward the end of the first year, are able to understand the meaning of a triadic interaction entailing transfer of possession from one subject to another, and the essential function of the object in the structure of the event.

As mentioned before, the nature of a transfer of possession varies depending on the circumstances and execution of the reallocation (i.e., giving, taking, transfer of possession without direct interaction). The difference between giving and taking has been widely investigated in a recent study by Tatone, Geraci, and Csibra (2015) (Fig.4). Authors demonstrated that 12-month-old infants encode abstract object-transfer events between agents differently. Importantly, results show that infants represent a giving action as a three-argument social event including two animate elements (an active agent, the giver, and a passive agent, the recipient) and an object. On the other hand, infants interpret a taking action as a two-argument non-social event. In the case of taking, indeed, infants' representation seems to include the active agent (taker) and the object, but not the passive social element (the previous possessor of the taken object). Authors hypothesize that humans possess an *action schema* for giving specific for representing social interactions involving transfer of objects. The act of taking in the demonstrated situation is instead encoded as an object-directed event.

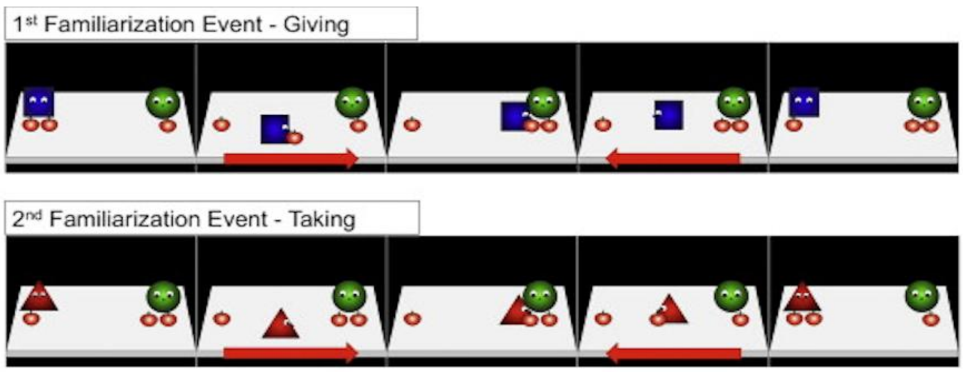


Fig. 4 Selected frames from Tatone et al. (2015). Familiarization phase: infants see a Giving event where the blue square gives an object to the green circle or a Taking event where the red triangle takes an object from the green circle.

The difference between a giving event and a transfer of possession without direct interaction between agents has been addressed in a study by Schoppner, Sodian, and Pauen (2006). In their work, authors analyzed infants' ability to encode action roles in a three-argument interaction involving two agents and an object. Nine to 12-month-old infants were habituated to events of a puppet giving a flower to another puppet. During the test phase, the positions of giver and taker were changed, and infants were presented with movies showing role reversal or direction reversal events. Results show that from 10 months, infants are able to encode the roles of giver and taker, differentiating between role reversal and change in the perceptual features of the event. In another condition, infants were presented with an event where the previously described interaction was divided into two parts: first, one of the puppets dropped the flower and then the other puppet picked it up. In this case, infants did not show a preference for one of the test phases (role reversal versus direction reversal). The combined results demonstrate that, by the age of 10 months, infants are sensitive to the give-and-take exchange in terms of intentional relation between agent and recipient. They do not however interpret the transfer of possession without direct interaction as a social event occurring between the two agents.

Possessive relationships and transfer of objects also play a central role in experiments dealing with social evaluations and sensitivity to fairness. Geraci and Surian (2011) and Meristo and Surian (2013) for example, were interested in infants' sensitivity to distributive justice and tested their reaction to equal and unequal distributions of resources. In both experiments, infants were presented with movies showing a fair and an unfair distributive event. In the first case, infants saw an agent (the distributor) distributing objects equally between two recipients, in the second case only one of the recipients received the objects. Results from Meristo and Surian (2013) show that 10-month-old infants are sensitive to unequal resource distribution and expect an unfair distributor not to be reciprocated by a third-party. Results (looking time measures and manual choices) from Geraci and Surian (2011) show that infants by 16 months evaluate agents on the basis of their distributive actions, preferring the fair to the unfair distributor. These findings provide further evidence that infants are able to encode transfers of objects between agents and keep track of the amount of objects transferred. Moreover, the attribution of valence (positive/negative) to the distributive action (equal/unequal) suggests that infants interpret transfers of objects to have a beneficial effect on the recipient and, in general, possession of objects as an advantage.

Attribution of valence to actions and social evaluation of agents are also the focus of a work by Hamlin and Wynn (2011). In one of their experiments, 3 and 5-month-old infants were presented with a live puppet scenario with three characters. At the beginning, one character played with a ball and accidentally dropped it. At this point, the ball was either given back to the previous possessor by a second character (the giver), or taken away by the third one (the taker). In both cases, the first possessor expressed the will to have the ball back. Results (looking times and manual choices) show that infants evaluate positively the giver and negatively the taker, suggesting that they attribute a social meaning to the taking action and to the restitution event, even when transfers of objects between characters do not occur through direct interaction.

Evidence for infants' ability to build a high-level interpretation of possessive relationships emerges from a study by Mascaro & Csibra (2012). In their work, researchers were interested in infants' capacity to represent a social hierarchy, differentiate between dominant and subordinate individuals, and expect the dominance relation to be stable across contexts. Infants from nine to 15 months of age were presented with events where two different geometrical entities competed to reach a goal, and one of the agents (the dominant) prevailed over the other (the subordinate). One of the conflicting situations considered by authors was an event representing competition over objects' possession. At the beginning, only one agent was present on the scene and small objects fell from above on the center of the screen. Infants watched the agent repeatedly collecting the objects and amassing them on one side of the screen. Subsequently, the other agent entered the scene. At this point, the two agents approached the object at the same time, and the newcomer prevailed over the first agent (Fig. 5). Results from this study demonstrate that infants from 12 months are able to differentiate between dominant and subordinate individuals; from 15 months, they are able to generalize the dominance relation across contexts. The finding that infants mentally represent social dominance provides evidence that they represent possession of object as a goal: they understand that agents pursued their goal through direct control and collection of objects; they understand that the power of one agent to exclude the other from possession is an expression of dominance.

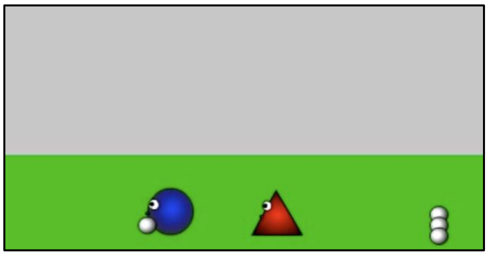


Fig. 5 A frame from the dynamic display showed by Mascaro & Csibra (2012)
Infants first see a red triangle collecting objects and pushing them on its side of the screen. Subsequently, a blue circle enters the scene. In the current frame, the blue circle (dominant) prevails over the red triangle (subordinate) in collecting the object.

Taken together, results from these experiments provide evidence that infants are able to: (1) build a representation of possession based on available spatial and dynamic cues, (2) differentiate between different kinds of transfers of possession between agents, (3) ascribe social valence (positive or negative) to agents performing object-mediated interactions, (4) interpret possession of objects as an advantage, and (5) understand when possession of objects is the goal of an agent's actions.

PART 2 – EXPERIMENTAL STUDIES

The general aim of this research is to examine the cognitive bases of sense of ownership and to explore how the understanding of the social norms concerning ownership evolves during the first year of life. In two experimental studies, I examined (a) infants' ability to identify spatial-temporal cues of possession such as subject-object physical contact and proximity, actual control and first possession, (b) infants' ability to recognize violation of possession and to differentiate between a taking action (a three-argument social event including an active agent, the *taker*, an object, and a passive agent, the *original possessor* of the object) and an acquisition event (a two-argument non-social event including an active agent and an object), and (c) infants' ability to respect others' possession.

Several experimental works have shown that infants seem to possess sophisticated social competence when their abilities are measured through passive experimental tasks (infants observe others interacting but do not participate in these interactions themselves). Nevertheless, when their social abilities were measured through first-party tasks (the infants are directly involved in social interactions) infants failed to produce behaviors consistent with their knowledge (Baillargeon & Scott, 2014) A possible explanation could be that evaluating interactions between third-party individuals involves cognitive mechanisms that are partly different from those involved during active participation. Thus, a part of the theoretical and empirical research on developmental processes emphasized the role of participatory aspects of social understanding and encourages executing research via adopting both classical visual paradigms and behavioral measures where the child is directly involved in social interactions (Allen & Bickhard, 2013; De Jaegher, Di Paolo, & Gallagher, 2010; De Jaegher, 2009; Schmidt & Sommerville, 2011).

Following this advice, a key goal of this research was to examine ownership cognition adopting two different methodological approaches: a classical visual paradigm where the infant was observing a subject-object interaction (Study 1) and an interactive paradigm where the infant was directly involved in a subject-object interaction (Study 2).

In Study 1, we analyzed infants' social-cognitive abilities from a third-person perspective. Six and 9 months old infants were presented with video animations displaying object-oriented scenarios involving social interactions between agents. Infants' spontaneous visual behavior (looking time) was measured.

In Study 2, we focused on ownership cognition by analyzing infants' behavior from a first-person perspective. Six and 9-month-olds were involved in a social interaction involving two objects, one of which was possessed by the experimenter. Infants' preference (manual choice) towards one of the objects was coded.

STUDY 1

Introduction

Several developmental studies on ownership cognition have focused on the emerging ability to evaluate property transgressions such as alteration or destruction of others' property, illegitimate acquisition (theft) or no-restitution. As previously said, research on this topic has mostly been carried out using third-party tasks, where participants are passive observers of third-party interactions involving objects.

In children studies, participants were typically presented with verbal stories, vignettes or live puppet scenarios representing ownership rights violations and later asked to attribute ownership to one of the characters or to judge their behavior (Blake & Harris, 2009; Kim & Kalish, 2009; Vaish, Carpenter, & Tomasello, 2010). The explicit methodology used in those paradigms (verbal attributions of ownership and evaluations of characters and events) requires high-level language skills (comprehension and production), socio-moral reasoning, and perspective-taking abilities. Overall, there is general agreement that around 5 years of age, children possess a relatively mature understanding of the normative obligations associated with objects ownership (F Rossano, Fiedler, & Tomasello, 2015).

Children's understanding of ownership transgressions seems however to emerge earlier when investigated through implicit (non-verbal) measures (Kanngiesser & Hood, 2014; Rossano et al., 2011; Vaish et al., 2009, 2011). In these studies, rather than administering explicit interviews, children were directly involved in interactive paradigms and their spontaneous reactions towards ownership transgressions were observed. Objects ownership, in some cases, was displayed via physical possession and verbal information (children saw the victims of the transgression in physical possession of the object and heard them talk about their property) (Rossano et al., 2011; Vaish et al., 2009). In other cases, the ownership relationship between a subject and an object emerged from the investment of effort into creating that object (Kanngiesser & Hood, 2014; Vaish et al., 2009, 2011). Results from these experiments show that very young children emotionally react against transgressions of others' ownership rights. Rossano and colleagues (2011), for example, showed that 3-year-olds spontaneously protest against property rights violation when they see a puppet stealing or throwing away someone else's pieces of clothes. Similarly, Vaish and colleagues (2011) found that 3-year-olds react during the destruction of a newly made object (a picture or a clay sculpture) and behave prosocially towards the victim of the transgression (but see Kanngiesser & Hood, 2014 for contrasting results with 3-year-olds). Ultimately, Vaish et al. (2009) showed that even toddlers (from 18 months of age) exhibit prosocial behavior towards the victim of theft and property destruction, even in the absence of the victim's emotional reaction upon being harmed. Taken together, these findings suggest that, from a very young age, children recognize the ownership rights of others, enforce third-party ownership rights by reacting and protesting against property transgressions, and behave prosocially towards the victim showing affective perspective-taking and a sense of restorative justice (see also Riedl, Jensen, Call, & Tomasello, 2015). Nevertheless, from the results of these experiments, it is not completely clear which one of the ownership transgressions children are reacting to, because the stealing events were often followed by harmful events involving the object being destroyed or discarded, and these forms of transgression have often been analyzed together (see Rossano et al., 2011 for an exception). However, in none of these cases, children have been exposed to events where the object is taken directly from the hands of the possessor, and violations of ownership have never been compared to violations of possession. It is likely that the emotional reaction caused by a violation of possession event would be stronger and, possibly, would emerge earlier compared to emotional reaction caused by violations of ownership.

Indirect evidence of infants' ability to encode others-ownership transgressions is limited to the work of Hamlin and Wynn (2011; see also Hamlin, Wynn, Bloom, & Mahajan, 2011), and, to some extent, to the work of Tatone and colleagues (2015). As previously mentioned, Hamlin and Wynn tested three and 5-month-olds' evaluation of a prosocial/antisocial event through looking time measures and manual choice. In their paradigm, infants saw three puppets on a stage, one of them playing with a ball. Subsequently, the puppet accidentally lost possession of the ball. Depending on which one of the other two puppets collected the ball, infants were exposed to a prosocial event (the *giver* puppet returned the lost object to the original possessor) or to an antisocial event (the *taker* puppet did not return the object to the original possessor). In this experiment, infants saw a two-step transfer of possession without direct interaction between characters (first one puppet relinquished its possession, than a second puppet took possession of the object). After its loss, the original possessor of the object showed the willingness to have the object back, turning several times towards the second possessor and opening its arms "apparently 'asking' for the ball back" (Hamlin & Wynn, 2011). The ownership transgression was expressed in the form of a no-restitution event. Results showed that infants positively evaluated a restitution event (and/or negatively evaluated the no-restitution) preferring the prosocial agent to the antisocial one.

According to these results, very young infants seem to encode transfers of possession as social events (negative in the case of taking away, positive in the case of giving back) even when they do not occur through a direct interaction between subjects.

Nevertheless, a possible alternative explanation could be that infants built their preference solely on the basis of the positive interaction between the prosocial agent and the previous possessor, without attributing any social meaning to the no-restitution event. This explanation would be in line with the findings of Tatone et al. (2015). The focus of their work was to analyze whether infants encode direct object-transfer events occurring between agents (giving and taking) as social events, differentiating them from object-directed non-social events (disposing and acquiring). Results from their experiments have shown that while infants interpret a giving action as a social event involving an object transfer from a giver to a receiver, they do not seem to encode a taking action differently from an acquiring event. Authors suggest that infants interpret a taking event as an object-directed action where the goal of the agent is the acquisition of an object, regardless if possessed or not. The previous possessor of the object is not included in the representation.

However, it is possible that infants need more elements to set up a representation of possession in order to build a representation of a taking action as a social event occurring between two agents (the original possessor and the taker). A stronger representation of possession as a goal (and not just as a status) could emerge, for example, if the value associated with the possessed object is explicit or when the cost of losing possession of an object is evident. On the one hand, the potential cost of losing possession could be expressed by the possessor's attempt to resist to the taking event, or by the emotional distress displayed after the taking event. On the other hand, the attribution of value to a possessed object could be elicited, for example, by the investment of time and effort in taking possession of that object.

The aim of the present study was to investigate if infants differentiate between a taking action (the acquisition of a possessed object) and the acquisition of a non-possessed object. In order to prompt a representation of possession as a goal, and elicit an attribution of value to the possessed object, infants were exposed to a familiarization phase showing a first agent repeatedly collecting one of two available objects. Subsequently, in a within-subjects design, infants were presented with two test conditions: in one of them, a second agent collects the other available object. In the other, the second agent steals the object from the first possessor. Importantly, during testing infants could see that both of the options (taking the possessed object and acquiring the non-possessed object) were possible and equally feasible to achieve. The evolutionary approach to the origins of ownership rights suggests that first possession rule and respect for possession are parts of an evolutionary stable strategy that modulates the interactions between individuals over resources under certain circumstances (Maynard Smith & Parker, 1976). If a resource is abundant, the most efficient (and less risky) way to exploit it is take possession of the available part, and leave the possessed part to the original possessors. According to the evolutionary approach, humans (as well as other animals) are predisposed to recognize the observable characteristics of ownership, and respect others' property is a hardwired behavior (Stake, 2004). We hypothesized that if infants expect individuals to act in accordance with the first possession rule and respect of possession principle, they would look longer at events showing violation of possession, compared to events showing the acquisition of non-possessed objects.

As said, the perceptual cues that can elicit a representation of possession are physical contact and physical proximity between a subject and an object. Thus, a further goal of this study was to investigate whether infants encode a taking event differently depending on the available possession cue (contact or proximity).

Experiment 1

The first experiment addressed the question whether 6 and 9-months-old infants discriminate between a taking action (the acquisition of a possessed object) and an acquiring action (the acquisition of a non-possessed object). Infants were familiarized with an agent (the Possessor) collecting one of two available objects. During tests, infants watched two different conditions: in the Allowed condition, a second agent (the Competitor) collected the other available object. In the Not-allowed condition, the Competitor stole the object from the Possessor. If infants encoded the taking action as an object-directed action, without including the representation of the previous possessor of the object, they would look equally long at the two conditions. Otherwise, if they are able to build a representation of possession during the familiarization phase, their gaze duration will differ across the two conditions. Our hypothesis was that infants would look longer at the Not-allowed condition, where possession was violated.

Participants

The study was conducted at the Pediatric Unit of the Hospital of Monfalcone, Italy. Sixteen healthy full-term 6-month-old infants (5 girls and 11 boys; age M = 185 days, SD = 7) and sixteen healthy full-term 9-month-old infants (5 girls and 11 boys; age M = 277 days, SD = 9) participated in Experiment 1. Five 6-month-olds were excluded from the sample due to inattentiveness; three 9-month-olds were excluded because of fussiness (1), experimental error (1), and inattentiveness (1). Infants of the appropriate age were recruited for participation through phone calls. Parents gave their informed consent before the infants participated. After testing, they received a certificate of participation.

Setting

Infants were tested in a quiet, dimly lit room. During test sessions, infants sat on their parents' lap, 50-70 cm away from a 27-inch-monitor used to display the stimuli. The parents were asked not to communicate with the infants and not to direct their attention in any way during the testing. A hidden camera mounted on the top of the screen filmed the infants' looking behavior. The experimenter was behind a black curtain: from this position, she was able to monitor the infants' looking behavior and to control the stimuli presentation.

Stimuli

The stimuli were non-verbal colorful 2D animations generated with Synfig Studio software. Animations displayed two animated agents (Possessor and Competitor) and two unanimated objects. Animated agents were a red and a blue square of the same size, provided with eyes (with moving pupils). They moved on a uniform background and acted over the objects. Objects were two identical brown circular shapes (hereafter: first object and second object) (Fig. 1). All infants were shown a Familiarization phase and a Test phase. A short attention-getting animation of a pulsating heart combined with a trilling sound was presented before each familiarization and test trial.

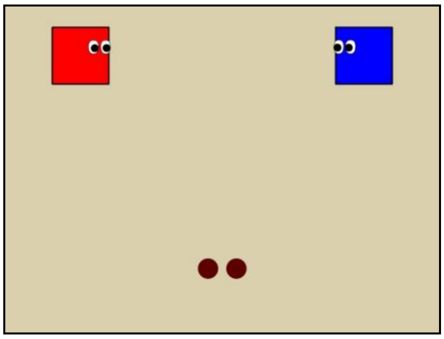


Fig. 1
One frame from the stimuli presented in Experiment 1.The scene displays the two animated agents (a red and a blue square provided with eyes: Possessor and Competitor respectively) and the two objects (two brown circular shapes: first and second object).

Familiarization phase

Infants were presented with four familiarization trials. Each trial started showing the two objects positioned in the center of the lower part of the screen. After 0.5 seconds, infants saw Possessor and Competitor entering the scene at the same time, respectively from the left and the right side of the upper part of the screen. While entering, Possessor and Competitor were looking at each other; afterwards, they slowly shifted their gaze towards the objects. At this point, the Possessor moved toward the objects, picked up the first object and returned with it to the Possessor's initial position. Due to the absence of hands or arms, the acquisition of the object was simply realized through the attachment of the object to the agent's body (Fig. 2, first row).

To keep the attention of the infant, the trajectory of the possessor toward the objects slightly changed for each of the four familiarization trials. The time to reach the object and return to the starting position was always identical (8 sec). Each familiarization trial lasted 12 seconds.

Test phase

All infants saw two different test conditions, two trials per condition: an Allowed condition (two trials) and a Not-allowed condition (two trials). In total, infants saw four test trials presented in the order ABAB or BABA. All test trials started by showing the last frame of the familiarization trials. The scene displayed the Possessor in contact with the first object on the upper part of the scene, facing the Competitor, and the second object still available on the lower part of the scene. The eyes of the two agents were pointed downward.

In the Allowed condition, first the two agents looked at each other, then the Competitor moved toward the lower part of the screen, picked up the second object and returned to the Competitor's initial position carrying the object (Fig 2, second row).

In the Not-allowed condition, first the Possessor and the Competitor looked at each other, then the Competitor moved toward the Possessor, picked up the first object and returned to the Competitor's initial position carrying the object (Fig 2, third row). Each test trial lasted 7.5 seconds.

Order of test trials (Allowed first vs. Not-allowed first), colors of agents (red vs. blue) and side of entry of agents (left vs. right) were fully counterbalanced across participants, for a total of 8 different conditions (see Table in Fig. 3)

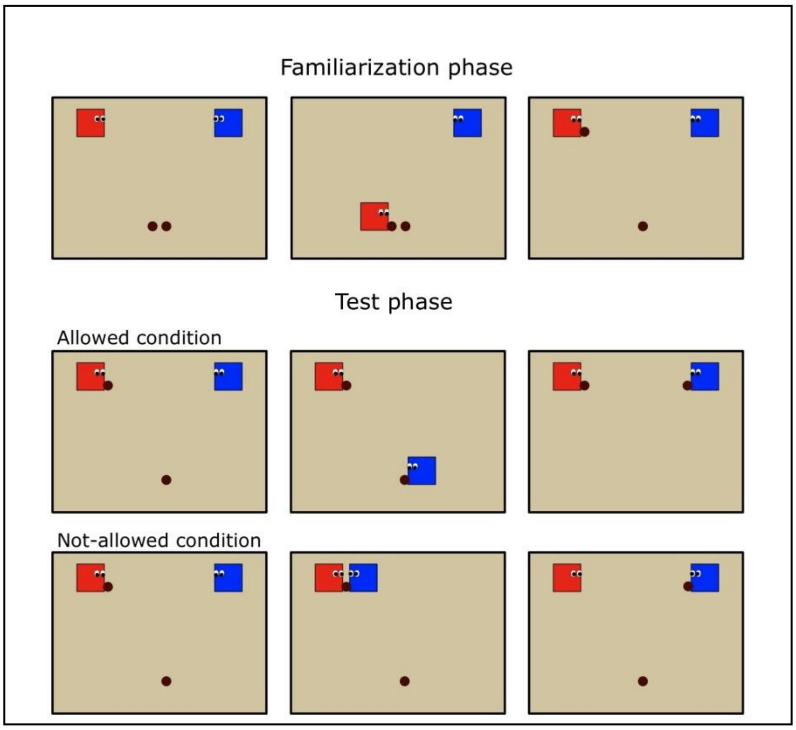


Fig.2 Some selected frames from one of the movies presented in Experiment 1. First row: familiarization phase. The red agent (the Possessor) collects one of two available objects. Second row: Test phase, Allowed condition. The blue agent (the Competitor) collects the other available object. Third row: Test phase, Not-allowed condition. The blue agent (the Competitor) steals the object from the Possessor.

COLORS OF AGENTS	RED POSSESSOR BLUE COMPETITOR		BLUE POSSESSOR RED COMPETITOR	
SIDE OF ENTRY OF POSSESSOR	LEFT	RIGHT	LEFT	RIGHT
TEST ORDER: ALLOWED NOT-ALLOWED (ABAB)	**1**	**3**	**5**	**7**
TEST ORDER: NOT-ALLOWED ALLOWED (BABA)	**2**	**4**	**6**	**8**

Fig. 3 Conditions of Experiment 1 as a function of counterbalanced variables. Each number represents one condition. In condition 1, for example, Possessor was a red square and Competitor a blue square; infants saw Possessor enter from the left and Competitor from the right side of the scene; and during test phase, infants were first presented with the Allowed condition and then with the Not-allowed condition.

Coding

An off-line frame-by-frame analysis of looking behavior was performed. Blinks were considered as look-away if they lasted for more than 0.25 s. To be included in the final data analysis, infants had to follow at least 3 familiarization trials and 75% of each test trial type to be included in the analysis. The dependent variable was the time the infant spent looking at the still picture at the end of each test trial, from the time the Competitor returned to the initial position, until the infant looked away for at least 2 consecutive seconds or 60 second had elapsed.

Results and discussion

Infants' looking times for each age group were analyzed in two separate 2 (test conditions type: Allowed vs. Not-allowed) x 2 (order of test trials: Allowed first vs. Not-allowed first) x 2 (colors of agents: red or blue) and side of entry of agents (left or right) repeated measures analyses of variance (ANOVA). The only significant effect found was a significant effect for test condition type in the 9-month-olds group, $F(1, 14)$

$= 20.1$, $p = .002$, $\eta_p^2 = .71$. Six-month-old infants did not look reliably longer at test trials showing the stealing event (Not-allowed condition) compared to trials showing the acquisition of the non-possessed object (Allowed condition) (*M* = 30.27 s, SD = 17.37 s and *M* = 22.12 s, SD = 13.61 s respectively), $t_{15} = 1.82$, $p = .08$. By contrast, 9-month-olds looked significantly longer at test trials showing the Competitor stealing the object from the Possessor than at test trials showing the Competitor acquiring the non-possessed object (*M* = 20.77 s, SD = 10.40 s and *M* = 15.74 s, SD = 7.80 s respectively), $t_{15} = 2.61$, $p = .01$, effect size: $d = .55$. Looking times during the test trials are depicted in Fig. 4.

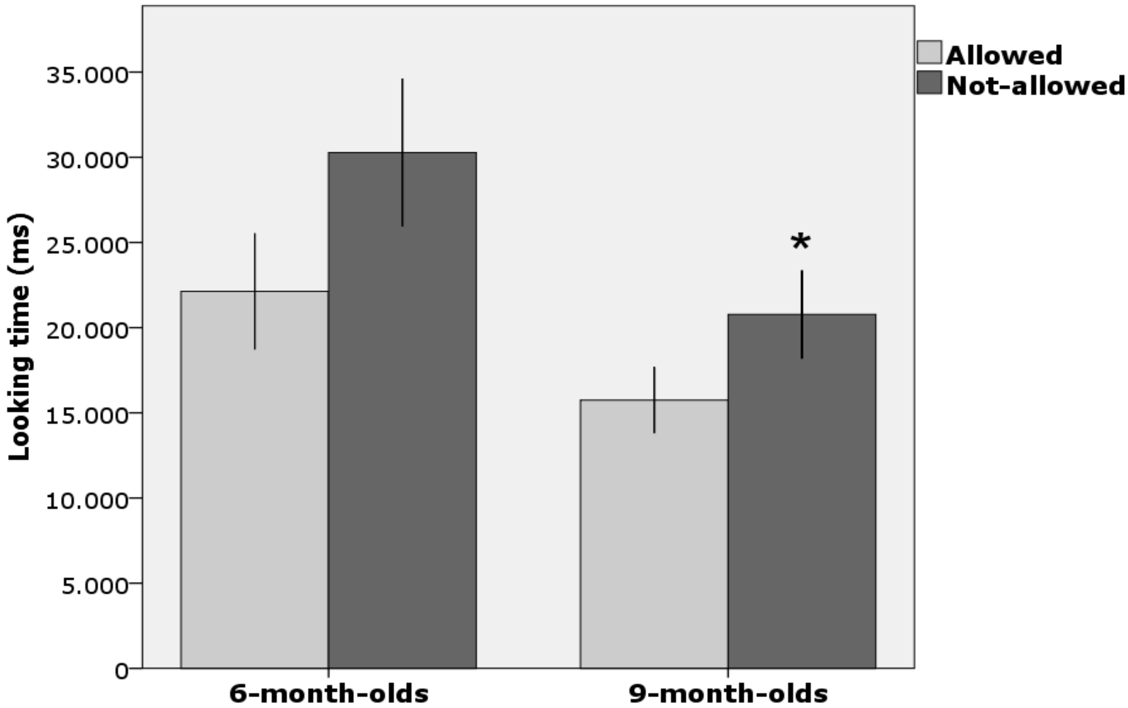


Fig.4 Average looking times (with standard error bars) during test conditions in the two age groups. Asterisks represent statistically significant differences ($p = .01$) between the two test conditions.

Results from the current experiment show that 9-month-olds, but not 6, look significantly differently at the two test conditions. As predicted, they look longer at the event showing violation of possession. These results suggest that older infants encode an acquiring event as less salient compared to a taking event showing transfer of possession between two agents. A possible alternative explanation, however, is that nine months old infants might have simply responded to perceptual aspects that differed between the two conditions. Even if the global perceptual complexity (the number of elements presented on the scene) was identical, the two conditions differed in the number of elements involved in the dynamic event. In the Allowed condition, the dynamic event involved two elements: the Competitor and the first object. In the Not-allowed condition, the dynamic event involved three elements: the Competitor, the second object and the Possessor. If infants have a spontaneous preference for dynamic events involving a higher number of elements, it is possible that this disposition affected the results of Experiment 1.

Another possible explanation is that 9-month-olds looked longer at the Not-allowed condition compared to the Allowed one because of the different conceptual saliency of the displayed events. In the Allowed condition, infants saw an object-directed action (the Competitor collects an object) while in the Not-allowed condition, they saw an object-directed action *and* an interaction between two agents. If infants have a spontaneous preference for events showing social interactions between agents, it is possible that this disposition affected the results of Experiment 1.

In order to exclude both alternative explanations, two control experiments were conducted on two separate groups of 9-month-olds: a Non-social Control Test (Experiment 2) and a Social Control Test (Experiment 3).

Experiment 2- Non-social Control Test

Results from Experiment 1 demonstrate that 9-months-old infants show longer looking times during the Not-allowed condition compared to the Allowed condition. A possible explanation of these results is that infants responded to the perceptual difference between the two conditions. The current experiment addressed the question whether infants have a spontaneous preference for dynamic events involving a higher number of elements compared to events with lower complexity. Infants were presented with movies showing one animated agent and three inanimate objects. In the Low Complexity condition (LC), the dynamic event involved two elements (an agent and an object). In the High Complexity condition (HC), the dynamic event involved three elements (an agent and two objects). If perceptual differences between the two conditions drove infants' preference in Experiment 1, similar results should be obtained here, and infants should prefer the HC condition to the LC one.

Participants

The study was conducted at the Pediatric Unit of the Hospital of Monfalcone, Italy. Sixteen healthy full-term 9-month-old infants (12 girls and 4 boys; age M = 276 days; SD = 7) participated in this experiment. Two infants were excluded from the sample because of fussiness (1) or inattentiveness (1). Infants of the appropriate age were recruited for participation through phone calls. Parents gave their informed consent before the infants participated. After testing, they received a certificate of participation.

Stimuli and procedure

Animations displayed one animated agent and three unanimated objects. The animated agent was a red (or blue) square provided with eyes, identical to the ones used in Experiment 1. Objects were two identical brown circular shapes (first object and second object) and another colorful square without eyes (third object). All infants were presented with two conditions, two trials per condition: a Low Complexity condition (LC) and a High Complexity condition (HC). In total, infants saw four trials presented in the order ABAB or BABA.

Each trial started showing the agent on the upper part of the scene, facing the first and the third object in contact with each other. The second object was located on the lower part of the scene. At the beginning of each test movie, the eyes of the agent were pointed downward (Fig. 5).

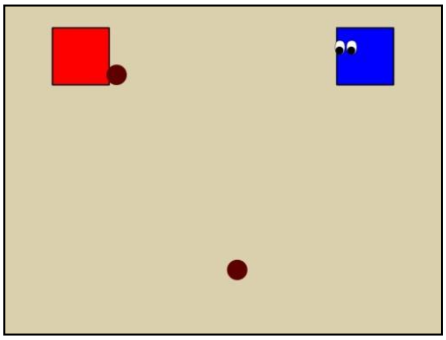


Fig. 5 First frame from one of the movies presented in Experiment 2. The scene displays an animated agent (the blue square) and three objects. First and third objects are respectively the brown circular shape and the red square on the upper part of the scene. Second object is the brown circular shape on the lower part of the scene.

In the LC condition, infants saw the agent move towards the second object, pick it up and return to the agent's initial position carrying the object (Fig. 6, first row). In the HC condition, the agent looked up, than it moved toward the first and third object, picked up the first object and returned to the agent's initial position carrying the object (Fig. 6, second row). Each test movie lasted 7.5 seconds.

Order of trials (LC first vs. HC first), color of the agent (red vs. blue) and side of agent (left vs. right) were fully counterbalanced across participants, for a total of 8 different conditions. Setting and procedure were identical to Experiment 1.

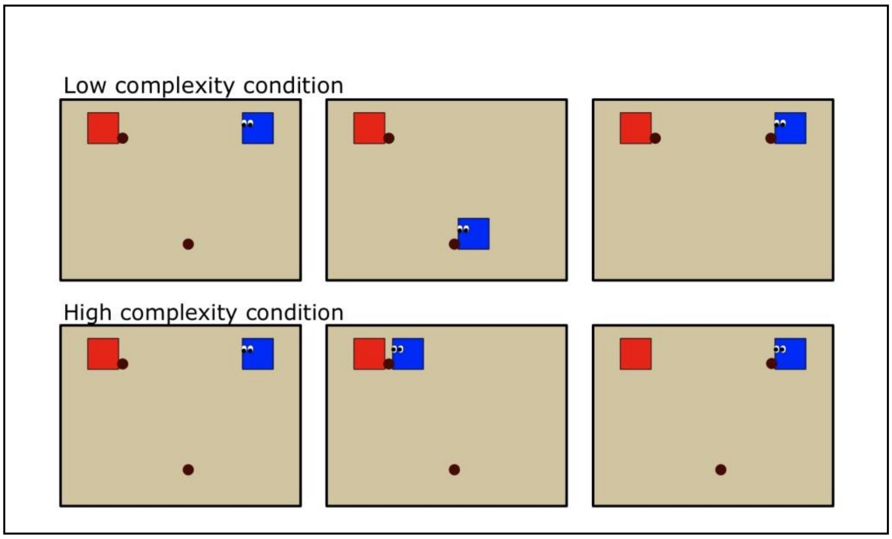


Fig.6 Some selected frames from one of the movies presented in Experiment 2. First row: Low Complexity condition. The agent collects the second object. Second row: High Complexity condition. The agent moves towards the first and the third object and collects the first object.

Coding

An off-line frame-by-frame analysis of looking behavior was performed. To be included in the analysis, infants had to follow at least 75% of each trial type. The dependent variable was the time the infant spent looking at the still picture at the end of each trial, from the time the agent returned to its initial position, until the infant looked away for at least two consecutive seconds or 60 seconds had elapsed.

Results and discussion

Preliminary analyses have been run to assess the possible effect of the order of trials (LC first vs. HC first), color of the agent (red vs. blue) and side of agent (left vs. right). This analysis found neither a significant main effect for any of these variables, nor significant interactions with infants' looking time (all *ps* > .14). Infants did not show significant differences in their looking behavior between the Low complexity condition and the High complexity condition (*M* = 21.92 s SD = 18.46 s and *M* = 23.62 s SD = 16.69 s, respectively), t_{15} =.44, *p* = .66. Looking times during trials are depicted in Fig.

7. Results demonstrated that infants did not show a spontaneous preference for the dynamic event involving three elements (High complexity condition) compared to the event involving two elements (Low complexity condition). This finding seems to exclude the possibility that results found in Experiment 1 were due to perceptual differences between the two conditions.

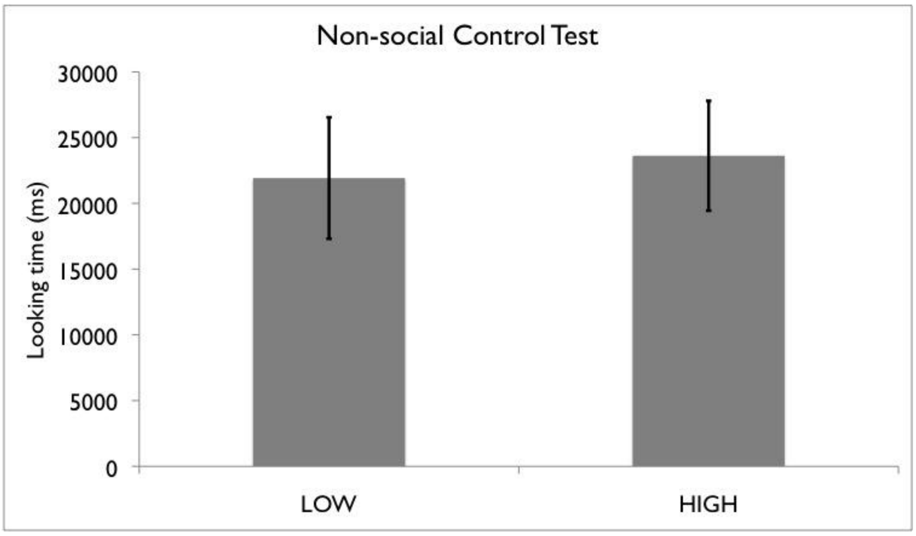


Fig. 7 Average looking times (with standard error bars) to the Low and to the High complexity conditions.

Experiment 3 - Social Control Test

Results from experiment 2 (Non-social Control Test) show that infants do not seem to prefer dynamic events involving a higher number of elements compared to dynamic events with lower complexity. However, another possibility is that infants looked longer at the Not-allowed condition of Experiment 1 because of the higher conceptual saliency of the displayed event. The current experiment addressed the question whether infants have a spontaneous preference for events showing a social interaction between agents compared to events showing an object-directed action.

Infants were presented with movies showing two animated agents and two unanimated objects. In the Object-Directed Action condition (ODA), infants saw one agent collecting one object. In the Interaction condition (INT), infants saw one agent move towards the other one and return to the agent's initial position without carrying any object. If infants did not have a spontaneous preference for events showing social interactions between agents, looking patterns between conditions should not differ significantly.

Participants

The study was conducted at the Pediatric Unit of the Hospital of Monfalcone, Italy. Fifteen healthy full-term 9-month-old infants (9 girls and 6 boys; age M = 273 days; SD = 12) participated in this experiment. An additional infant was excluded from the sample because of inattention. Infants of the appropriate age were recruited for participation through phone calls. Parents gave their informed consent before the infants participated. After testing, they received a certificate of participation.

Stimuli and procedure

Animations displayed two animated agents (A and B) and two unanimated objects (first object and second object). The animated agents were a green and a yellow hexagon of equal size, each provided with eyes. Objects were two identical brown circular shapes. All infants were presented with two conditions, two trials per condition: an Object-Directed Action Condition (ODA) and an Interaction Condition (INT). In total, infants saw four trials presented in the order ABAB or BABA.

Each trial started showing the two agents on the upper part of the scene. Agent A was in contact with the first object, facing agent B. The second object was located on the lower part of the scene. At the beginning of each test trial, the eyes of the two agents were pointed downward (Fig. 8).

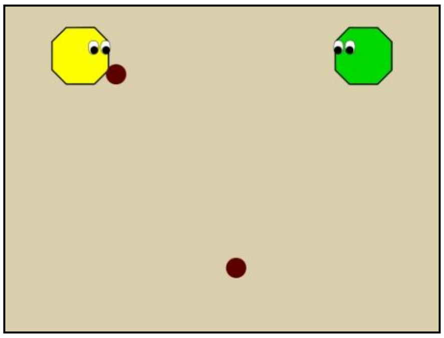


Fig. 8

First frame from one of the movies presented in Experiment 3. The scene displays the two animated agents (a yellow and a green hexagon provided with eyes: agent A and B) and the two objects (two brown circular shapes: first and second object). Agent A is in contact with the first object.

In the ODA condition, first the two agents looked at each other. Then, agent B moved toward the second object, picked it up and returned to agent B’s initial position carrying the object (Fig. 9, first row). In the INT condition, first agent A and agent B looked at each other. Then, agent B moved toward agent A, made contact with the first object and returned to agent B’s initial position without carrying the object (Fig. 9, second row). Each test movie lasted 7.5 seconds.

Order of trials (ODA first vs. INT first), color of the agents (yellow vs. green) and side of agents (left vs. right) were fully counterbalanced across participants, for a total of 8 different conditions. Setting and procedure were identical to Experiment 1.

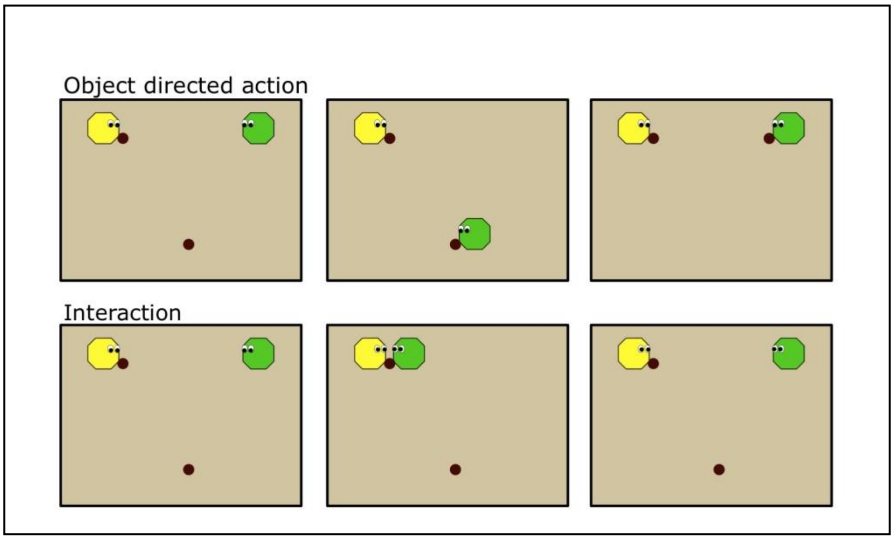


Fig.9 Some selected frames from one of the movies presented in Experiment 3. First row: Object-Directed Action Condition. Agent B collects the second object. Second row: Interaction Condition. Agent B moves toward agent A, makes contact with the first object and returns to agent B's initial position without carrying any object.

Coding

An off-line frame-by-frame analysis of looking behavior was performed. To be included in the analysis, infants had to follow at least 75% of each trial type. The dependent variable was the time the infant spent looking at the still picture at the end of each trial, from the time the agent B returned to its initial position, until the infant looked away for at least two consecutive seconds or 60 seconds had elapsed.

Results and discussion

Preliminary analyses have been run to assess the possible effect of the order of trials (ODA first vs. INT first), color of the agent (yellow vs. green) and side of agent (left vs. right). The analysis found neither a significant main effect for any of these variables, nor significant interactions with infants' looking time (all *ps* > .30). Infants did not show significant differences in their looking behavior between the Object-Directed Action Condition and the Interaction Condition (*M* = 17.42 s SD = 10.28 s and *M* =

18.76 s SD = 22.77 s, respectively), t_{14} = .31, p = .75. Looking times during trials are depicted in Fig. 10. Results demonstrated that infants did not show a spontaneous preference for the event showing an interaction between agents compared to the event showing an object-directed action (the acquisition of an object).

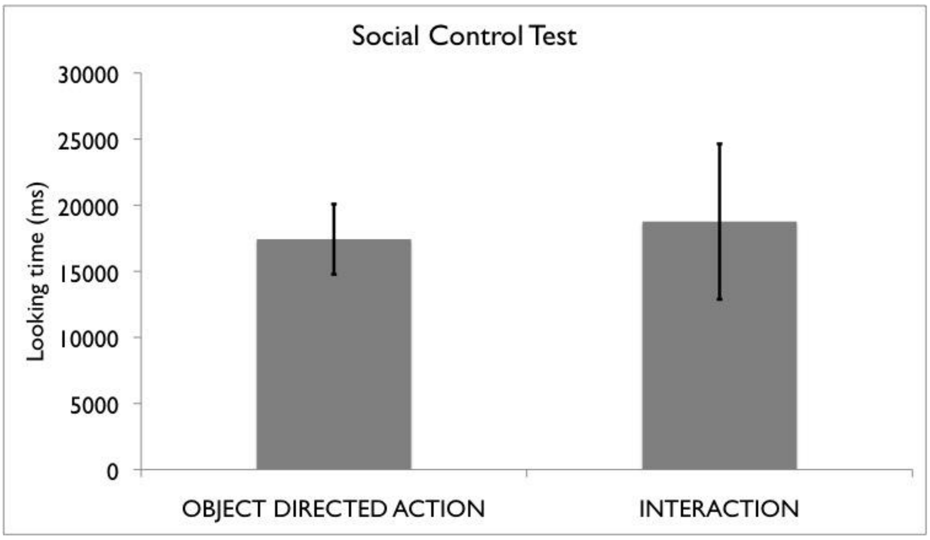


Fig. 10 Average looking times (with standard error bars) to the Object-Directed Action and to the Interaction conditions.

Experiment 4

As said, the perceptual cues that can elicit a representation of possession are physical contact and physical proximity between a subject and an object. Results from Experiment 1 demonstrate that 9-month-old infants show longer looking times during the Not-allowed condition compared to the Allowed condition. The current experiment addressed the question whether 9-month-old infants discriminate between a taking action (the acquisition of a possessed object) and an acquiring action (the acquisition of a non-possessed object) when possession is expressed through proximity instead of contact. Infants were familiarized with an agent (the Possessor) collecting and dropping one of two available objects. During tests, infants watched two different conditions: in the Allowed condition, a second agent (the Competitor) collected the other available object. In the Not-allowed condition, the Competitor collected the object previously relinquished by the Possessor. Thus, in the current experiment, the reallocation of possession occurs without a direct interaction between agents. If infants consider proximity as a cue of possession, they should show a similar looking pattern as in Experiment 1.

Participants

The study was conducted at the Baby Lab of the University of Padova, Italy. Eleven healthy full-term 9-month-old infants (5 girls and 6 boys; age *M* = 258 days, SD = 22) participated in Experiment 4. Two infants were excluded from the sample due to experimental error. Infants of the appropriate age were recruited for participation through phone calls. Parents gave their informed consent before the infants participated. After testing, they received a certificate of participation.

Stimuli and procedure

Animations displayed two animated agents (Possessor and Competitor) and two unanimated objects (first and second object) identical to the ones used in Experiment 1. All infants were shown a Familiarization phase (four trials) and a Test phase (two conditions: Allowed and Not-allowed condition; two trials per condition).

Movies displayed during the familiarization phase were identical to Experiment 1 except for the last part of the event. After having acquired the first object, the Possessor returned to the Possessor's initial position. At this point, instead of staying in that position, the Possessor dropped the object and withdrew towards the border of the screen (Fig 11, first row). Each familiarization trial lasted 14 seconds.

All test trials started by showing the last frame of the familiarization trials. The scene displayed the Possessor in proximity with the first object on the upper part of the scene, facing the Competitor, and the second object still available on the lower part of the scene. The events shown during the Allowed and the Not-allowed condition were identical to Experiment 1. The only exception was the Possessor's spatial position in relation to the first object (Fig 11 second and third rows).

Each test trial lasted 7.5 seconds. Order of test trials (Allowed first vs. Not-allowed first), colors of agents (red vs. blue) and side of entry of agents (left vs. right) were fully counterbalanced across participants. Setting and procedure were identical to Experiment 1.

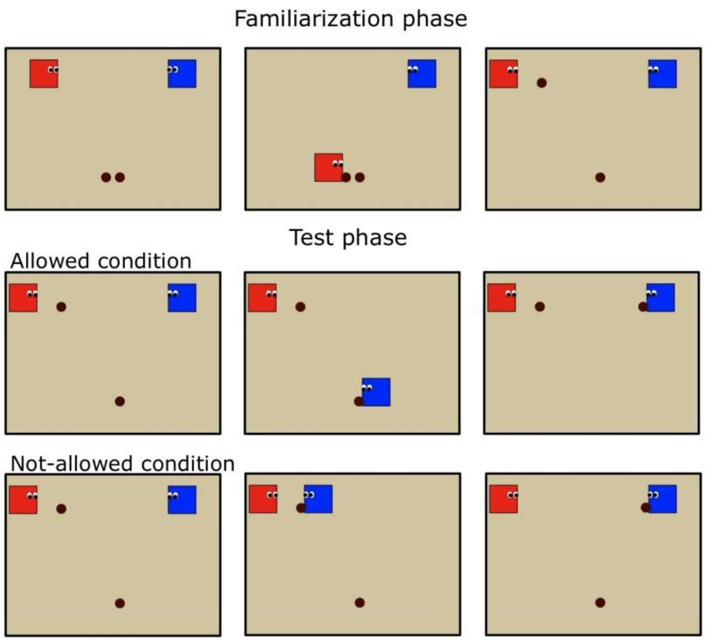


Fig. 11 Some selected frames from one of the movies presented in Experiment 4. First row: familiarization phase. The red agent (the Possessor) collects one of two available objects. Immediately after, the Possessor drops the object and withdraws towards the border of the screen. Second row: Test phase, Allowed condition. The blue agent (the Competitor) collects the other available object. Third row: Test phase, Not-allowed condition. The blue agent (the Competitor) takes the object from the Possessor.

Coding

An off-line frame-by-frame analysis of looking behavior was performed. Blinks were considered as look-away if they lasted for more than 0.25 s. To be included in the final data analysis, infants had to follow at least 3 familiarization trials and 75% of each test trial type. The dependent variable was the time the infant spent looking at the still picture at the end of each test trial, from the time the Competitor reached the final position, until the infant looked away for at least 2 consecutive seconds or 60 seconds had elapsed.

Results and discussion

Infants' looking times at the still picture at the end of each test condition were analyzed in a 2 (test conditions type: Allowed vs. Not-allowed) x 2 (order of test trials: Allowed first vs. Not-allowed first) x 2 (colors of agents: red or blue) and side of entry of agents (left or right) repeated measures analysis of variance (ANOVA). This analysis found neither a significant main effect of any of these variables, nor significant interactions with infants' looking time (all *ps* > .12). Infants did not show significant differences in their looking times between the Not-allowed condition and the Allowed condition (M = 16.22 s, SD =13.06 s and M = 14.63 s, SD = 9.32 s respectively), t_{10} =.63, p = .54. Looking times during test trials are depicted in Fig. 12. The results of the current experiment demonstrated that nine-months-old infants did not look reliably longer at test trials showing a taking event when they saw the Possessor losing contact with the object.

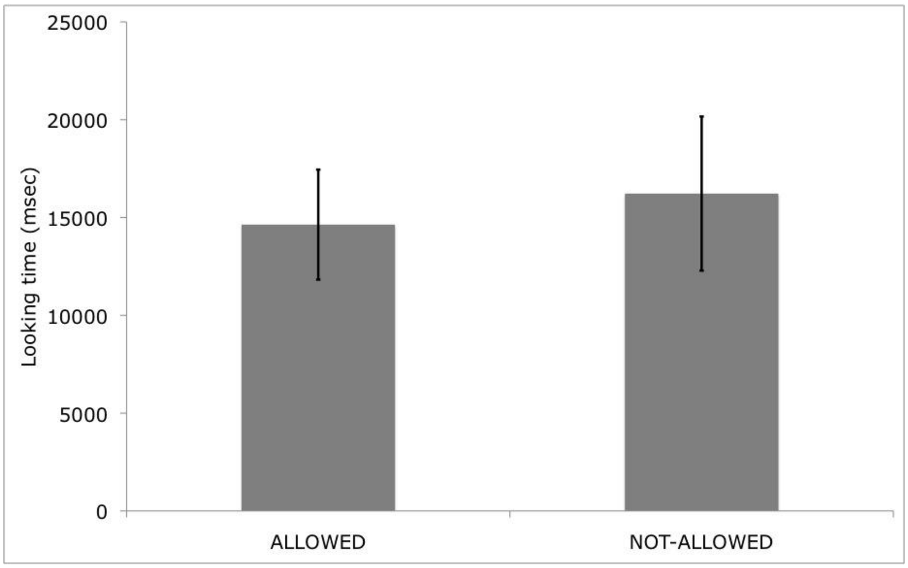


Fig. 12 Average looking times (with standard error bars) to the Allowed and to the Not-allowed condition.

General discussion

As predicted, results from Experiment 1 showed that 9-month-olds looked longer at the Not-allowed condition compared to the Allowed-condition. These results suggest that infants differentiate between an acquiring event and a taking event. Moreover, the direction of infants' preference demonstrates that they consider violation of possession to be more salient compared to the acquisition of a non-possessed object. These results seem to contradict the recent findings of Tatone and colleagues (2015) regarding giving and taking interactions. Nevertheless, some important differences between the studies could explain the contradicting results. First, our infants were exposed to a familiarization phase explicitly designed to elicit a representation of possession both as a status (the object's motion was controlled by the Possessor) and as a goal (the Possessor's goal was to collect one of the objects and maintain its possession through physical contact) as well as elicit an attribution of value to the possessed object. Second, during testing, infants could see that both the possessed object and the non-possessed object were available and that the distance between the Competitor and each of the two objects was identical. This spatial relation made the two options equally feasible to achieve. Despite these similarities, infants showed increased interest towards the event involving violation of possession. Therefore, we propose that infants' differential looking was due to the infants expecting the agents' behaviour to be guided by the respect of possession principle.

By contrast, six months old infants did not look reliably longer at test trials showing the stealing event compared to test trials showing the acquisition of a non-possessed object. The lack of differential responses to the test events in the 6-month-old group could potentially be due to either their failure to track the agents and process social relationships or due to methodological reasons. In general, experimental works on infants' ability to encode complex social interactions show negative results before 9 months of age. For example, Csibra et al. (1999) demonstrated that 9-month-olds, but not 6, are able to discriminate between rational and irrational dynamic events (see also Gergely et al., 1994, 1995). By the age of 9 months, infants are able to encode reaction events between geometrical figures such as chasing events on the basis of dynamic cues (Morgan & Rochat, 1998; Schlottmann, Surian, & Ray, 2003). By the end of the first year infants start to evaluate third-party social interactions according to the contexts in which the observed behaviors are performed (Hamlin et al., 2011). Despite this evidence, our results showed that, although non-significant, a trend to look longer at the Not-allowed condition already at 6 months of age. Moreover, the inter-individual variability we found at 6 months of age was very high compared to the variability at 9 months of age. An alternative explanation could therefore be related to methodological issues, specifically to the number of trials shown during the familiarization phase. As previously said, the familiarization phase was conceptualized with the intent to prompt a representation of possession as a goal, and to elicit an attribution of value to the possessed object. The number of familiarization trials was kept identical for both age groups tested. Several habituation/dishabituation studies demonstrated that the number of trials required to reach the habituation differs between individuals and decreases with increasing age (Houston-Price & Nakai, 2004; Oakes, 2010). If six-month-olds require more time of exposure in habituation/dishabituation tasks compared to 9-month-olds, it is possible that the four trials they were exposed to in our experiment were not sufficient to prompt a conceptual representation of possession. This aspect might have affected the 6-month-olds' ability to differentiate between the subsequent events presented during the test phase and explain the comparatively high variability in looking behavior between participants.

The 9-month-olds' differential attention to the two test conditions allows us to draw two types of inferences: 1) the difference between the events has been discriminated and 2) the direction of infants' preference reflects the relative salience of the presented events. The salience of the stimuli can be determined by different properties, such as perceptual features, level of complexity, conceptual or affective differences between the events, and by their relative familiarity or novelty (Kidd, Piantadosi, & Aslin, 2012); Quinn et al. 2002; Shaddy & Colombo, 2004). Experiment 2 and 3 served as controls to investigate if infants had a priori preferences for certain types of stimuli, and to disambiguate low-level perceptual differences from high-level conceptual differences between the two conditions presented in Experiment 1. Experiment 2 controlled for the possibility that infants responded to perceptual differences between the two scenes, specifically to different levels of perceptual complexity. The difference between test trials of Experiment 1 and trials of Experiment 2 was the nature of the elements involved in the events (2 agents and two objects in Experiment 1 and only one agent and three objects in Experiment 2). Thus, Experiment 2 controlled for the perceptual complexity of the events by presenting the Possessor from Experiment 1 as an unanimated object instead of an animated agent. In Experiment 3, we wanted to investigate if infants were sensitive to the differences in high-level conceptual saliency of an interaction event compared to an object-directed event. The two tested conditions differed in the goal of the acting agent. In the Interaction condition, infants were exposed to a simple interaction between two animated agents. This condition was explicitly designed in order to disambiguate the combined effects of the interaction and the object-directed event displayed in the Not-allowed condition of Experiment 1. In both Experiment 2 and 3 infants showed neither a spontaneous preference for events with higher perceptual complexity, nor a spontaneous preference for interactions over goal-directed actions. These findings support the hypothesis that infants' preferential looking at the Not-allowed condition in Experiment 1 was due to the higher saliency of the violation of possession event compared to the acquisition of a non-possessed object.

A further possible explanation of the results of Experiment 1 is that infants might have responded to the relative novelty of the Not-allowed condition compared to the Allowed condition. During the familiarization phase of Experiment 1, infants were familiarized with an agent (Possessor) following a specific path in order to reach one of two objects located in the lower part of the scene. Subsequently, during the test phase, infants were exposed to a similar event (Allowed condition) and a completely different event (Not-allowed condition). In the Allowed condition, the path of the Competitor towards the non-possessed object mirrored the one followed by the Possessor in the previous phase. In the Not-allowed condition, instead, the Competitor followed a different path in order to reach and pick up the Possessor's object. It is well known that infants show a predisposition to shift their preference from familiar to novel stimuli, after having been exposed to the familiar stimulus (Cohen, Gelber, & Lazar, 1971). Other studies demonstrated that infants rapidly form expectations for spatial and temporal parameters of stimulus sequences and use this information to anticipate subsequent events (Canfield & Haith, 1991). Thus, the infants' preference for the Not-allowed condition could be due to a recovery of attention to the new stimulus. Nevertheless, results of Experiment 4 seem to rule out this possibility. The dynamic events shown in the two test conditions of Experiment 4 were identical to those presented in Experiment 1. The only difference between them was the relative spatial position of the Possessor to the other elements of the scene. Since infants exposed to Experiment 1 and 4 did not show a similar looking behavior, we conclude that the infants' preference for the Not-allowed condition in Experiment 1 was not driven by the relative novelty of the Not-allowed condition compared to the Allowed one.

Results of Experiment 4 demonstrated that nine months old infants did not look reliably longer at test trials showing a stealing event when possession was expressed through proximity instead of contact. In Experiment 4, infants were familiarized with an agent (the Possessor) collecting and dropping one of two available objects. The dynamic events shown during the Allowed and the Not-allowed condition were identical to Experiment 1. The only exception was the Possessor's spatial position with respect to the object previously collected. Several alternative interpretations of these results are possible. One possible interpretation is that infants did not have enough elements to build a representation of possession as in Experiment 1. The familiarization phase of Experiment 4, indeed, presents some elements of ambiguity. First, infants saw the Possessor collecting the object, then they saw the Possessor losing contact with its possession. It is possible that the infants interpreted this dropping action as an abandon of the object, making the object a non-possessed object again. Another possibility is that the first part of the movie (collecting the object) was not sufficient in order to elicit a representation of possession as a goal. Infants might have interpreted the Possessor's actions as moving objects from one place to another, without attributing possession as the goal of the action. The other possible alternative interpretation is that infants did not differentiate between the taking event and the acquiring event because the reallocation of possession occurred as a two-step transfer of possession without a direct interaction between agents. Evidence of infants' ability to encode a two-step transfer of possession between agents is contrasting. In Shoppner et al. (2006), 10 months old infants did not interpret a transfer of possession without direct interaction as a social event occurring between two agents. By contrast, according to Hamlin & Wynn, 2011, infants are able to evaluate a taking event negatively, even when it does not occur through a direct interaction between subjects (no restitution event). Results of Experiment 4 suggest that proximity per se is not a sufficiently strong cue in order to maintain the notion of a possessive relationship between agent and object, and infants encode the acquisition of the previously possessed object in the same way as they encode the acquisition of the non-possessed object. It is possible that in order to encode the Not-allowed event of Experiment 4 as a violation of possession, infants need additional cues such as an attempted resistance or an emotional reaction of the possessor towards the Competitor's actions.

Summarizing, the results of our investigation provide evidence of an early form of ownership understanding, in the specific sense of sensitivity to certain cues of possession. This ability has been tested in events involving animated geometrical figures, the results suggesting that infants apply this ability to all entities recognized as agents, not only to humans. Our findings are in line with other studies demonstrating infants' ability to track transfers of possession between agents (Geraci & Surian, 2011; Mascaro & Csibra, 2012; Tatone et al., 2015). Nevertheless, this is the first study to specifically investigate from a third-person perspective the evaluation of different cues of possession and sensitivity to violation of possession in infants. If provided with enough information, infants are able to build a representation of possession as a goal and differentiate between violation of possession and the acquisition of a non-possessed object. We interpreted the direction of their preference as evidence of an early appreciation of first possession rule and respect of possession principle. These behavioural rules, which are grounded in minimal perceptual information, specify what is permissible, convenient and less risky in social interactions involving resources. Our findings provide support to the theory that an early sense of ownership is a basic cognitive mechanism rooted in our evolutionary history.

STUDY 2

Introduction

Results from Study 1 suggest that, as third-party observers, nine months old infants seem to recognize others' possession and, possibly, the social rules concerning ownership by showing interest when possession is violated. In the second part of my research, I focused on analyzing infants' behavior related to cues of possession from a first-person perspective.

The majority of conflicts among children involve possession and use of objects (Dunn, 1988; Hay & Ross, 1982; Ramsey, 1987; Shantz, 1987). Several developmental studies on ownership understanding from the child's first-person perspective are indeed based on behavioral observations of children during peers' interactions involving objects (Hay et al., 2011; Hay & Ross, 1982; Ross et al., 2011). Even if self-interest tends to prevail during peer interactions, and children try to maximize their own gain, they still seem to apply an intuitive knowledge of basic ownership concepts to solve their conflicts (Bakeman & Brownlee, 1982; Ross et al., 2011; Winegar & Renninger, 1989). At two years of age, for example, toddlers are already able to resolve conflicts about objects ownership by applying the first possessor rule. Moreover, the first child to gain possession of an object is usually also the one to win the dispute over it (Ross, 1996). In the mid-1980s, Weigel (1984) adapted the theoretical evolutionary model on animal conflict developed by Maynard Smith and Parker (Maynard Smith & Parker, 1976; Maynard Smith, 1974) for an experimental study on preschool children social conflicts. Specifically, he tested some predictions of the model on the strategies adopted by children during social conflicts involving possession of objects. Results from this study showed that the probability for a child to continue or terminate a conflict depended on the possession of the object (children resisted more if they were in possession of the object), on the relative distance of children from the object, and on the level of aggressiveness of the opponent. Similar results have been obtained by DeScioli & Wilson (2011) in an experiment about human territorial disputes and fighting decisions in a virtual environment. Indeed, being the first in possession of an object (or seeing someone else having the first contact with an object) seems to elicit a set of decisions and behaviors aimed at maximizing the probability of obtaining a benefit and minimizing the probability of incurring a cost (Weigel, 1984). This evidence seems to support the hypothesis that, during development, the abstract concept of ownership arises from a hardwired set of core competences and that children progressively integrate their knowledge of ownership rights into a set of strategies that they spontaneously apply during object-interactions with others.

As previously mentioned, our interaction with the surrounding physical and social environment can be described in terms of affordances. Despite the fact that the notion of affordance has been introduced by Gibson more than 30 years ago (Gibson, 1979), only within the last few years researcher have started to thoroughly investigate the interaction between perception, action, and cognition, and how the activation of specific affordances can be modulated by the external environment or by the context. A recent approach suggests that objects' affordances are flexible and context depended (Borghi, Flumini, Natraj, & Wheaton, 2012; Borghi & Riggio, 2015). For example, experimental works on adults demonstrated that the same object can evoke multiple and sometimes conflicting affordances, depending both on its structure and function, and on the physical context in which it is embedded (for example, when an object is presented together with another object either functionally or spatially related to the first) (Jax & Buxbaum, 2010; Kalénine, Shapiro, & Flumini, 2014). The social context plays an important role as well. Several studies have demonstrated that the activation of affordances can be modulated by the presence of another individual, by the strength of our relationship with the other individual, and by the behavioral dispositions of others (Becchio et al. 2008; Costantini et al., 2011; Ferri et al., 2011, Scorolli et al. 2014a; Gianelli, Scorolli & Borghi, 2013).

With regard to object ownership, recent studies on adults have demonstrated that physical interaction with objects is affected once individuals know that those objects belong to someone else (Constable et al., 2011, 2014). In these works, participants were asked to perform simple movements with mugs that differed in terms of ownership (i.e., self-owned, other-owned, not owned). Results showed that objects' affordances are inhibited when participants had to manipulate other people's property compared to the manipulation of self-owned objects or not owned objects.

Despite this growing body of research, to my knowledge this methodological approach has not yet been adopted in infants and young children studies in order to investigate the developmental trajectory of ownership cognition, how perception of affordances changes during the first year of life, and how the social context affects the kinematics of infants' interaction with objects. During development, it has been suggested that the sensory-motor experience associated with object possession plays an important role in self-ownership cognition and that an early understanding of others-ownership is primarily based on the visual association between individuals and objects (Friedman, 2008; Friedman & Neary, 2008; Rochat, 2010). However, there are no recent studies that have investigated how cues of others' possession affect the infants' interaction with objects (but see Hay et al., 1983 for an exception).

The aim of the current study was to explore early ownership cognition by analyzing infants' behavior from a first-person perspective using an interactive paradigm where the infant was directly involved in a subject-object interaction. The study was exploratory in nature and was primarily designed to assess how and when the abilities to respect others' possession emerge during development and if the acquisition process (i.e., the act of taking possession of an object) could be affected by others' possession. Six and 9 months old infants have been tested in a choice task involving two identical objects, one of which was possessed by the experimenter (depending on the condition, one of the two objects was either in physical contact or in proximity to the experimenter's hand). By making the objects themselves equally salient, only the presence of the experimenter's hand should influence infants' choices. Infants' preference (manual choice) for one of the objects was coded. We hypothesized that if infants recognized contact and proximity as cues of others' possession and those cues acted as a social constraint, the acquisition process would be affected by respect of possession and infants would prefer to choose the non-possessed object. Considering the results of Study 1, we could hypothesize that because 6-month-olds did not recognize contact and proximity as cues of possession, they would not show a preference for either object. Nine-month-olds, on the other hand, should recognize the cues of possession and accordingly choose the non-possessed object. An alternative hypothesis, however, might be that at this age cues of others-possession could drive the preference of the infants toward the possessed object. In the first stage of life, until the child becomes independent, interactions with objects are indeed strongly mediated by the presence of a caregiver. Objects presented and offered to the infants are constantly associated with the presence of another individual, specifically with a giving hand. Others' possession represents thus the *condicio sine qua non* that facilitates the onset of infants' possession and allows infants-objects interactions.

Participants

The study was conducted at the Uppsala Child and Baby Lab of the Uppsala University, Sweden. The sample consisted of 22 6-month-old infants (11 girls and 11 boys; age *M* = 182 days, SD = 6.5) and 22 9-month-old infants (8 girls and 14 boys; age *M* = 278 days, SD = 7). An additional 24 infants were excluded from the final sample for failing to complete testing due to fussiness (four 6-month-olds and six 9-month-olds), for having shown lateral bias in reaching (three 6-month-olds and eight 9-month-olds) (see Coding part for explanation), or due to experimental error (two 6-month-olds and one 9-month-olds). Participants were recruited from the database of parents who expressed interest in participating in studies with their child. Infants were tested only after parents gave their informed consent. For participation, parents received a gift voucher of 100 Swedish Crowns (12 Euro).

Apparatus

The apparatus consisted in a theatre with a curtain that the experimenter could lift up and lower through a pulley system (Fig 1, left). The theatre's stage was surrounded by black screens, which created a neutral environment that was free of distractions. During the experiment, the stage was lit while the rest of the room was darkened. Infants sat on their parent's lap, facing the opening of the theatre, while the experimenter sat on the back side of the theatre (Fig 1, right). The distance from the table to the infant's chest was approximately15 cm.

Infants were presented with sixteen pairs of objects. Each pair was composed by two identical objects. Objects were items available for purchase in large markets and they differed in shapes, colours and dimensions (Fig. 2). They have been chosen to be attractive and easily graspable. In order to allow the objects' movement during the second phase of each trial (see procedure), they were placed on a plastic board of 40 cm x 53 cm. A camera to the left of the infant was focused to include the infant's upper body and part of the stage.

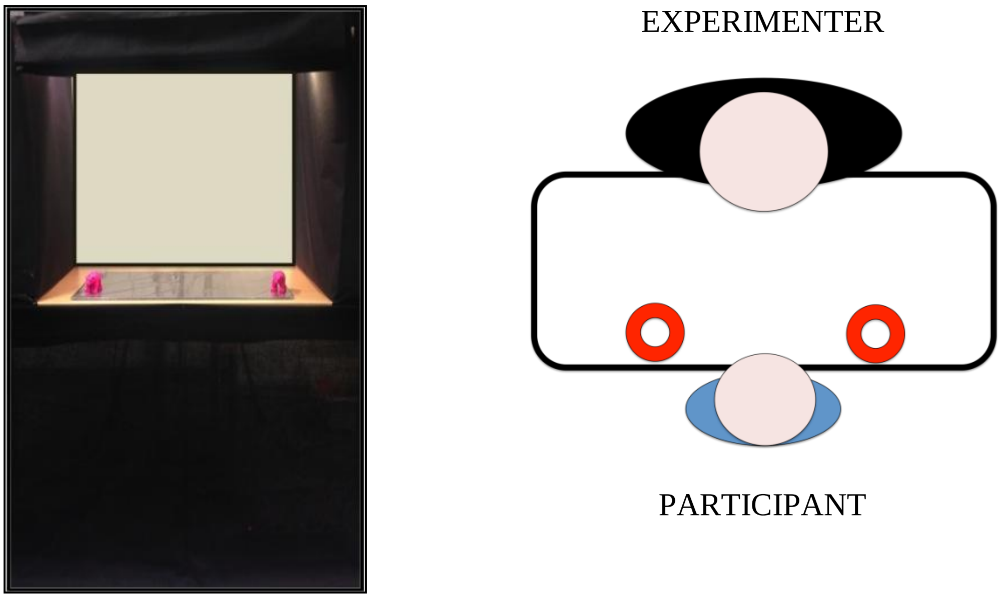


Fig 1 Left: theatre, frontal view (infant perspective). Two identical objects are placed on the board. Right: schematic representation of the stage (above view).

Fig 2 Object presented in Study 2

Procedure

At the beginning of the experiment, infants were familiarized with the apparatus and the procedure: the curtain was lifted up and lowered a few times, and each time the curtain was raised the experimenter smiled and said “Hello” to the infant. Infants were not presented with objects during familiarization.

Experiment consisted in 16 trials, and each trial was composed by two phases. The first phase allowed the infants to look at the objects, without the opportunity to touch them; during the second phase, infants could reach for the objects.

At the beginning of each trial the curtain was closed and the experimenter placed a pair of identical objects on the board. Objects were 20 cm distant to each other and 15 cm distant from the stage edge (infant side). A trial started with a bell ring during which the curtain was partially lifted up (20 cm from the tabletop) revealing the two objects, but not the experimenter. Even if the two objects were out of reach for the infant, in case of attempted reaching during this phase parents were instructed to gently hold back their babies. After eight seconds the curtain was lowered and the first phase ended.

In the second phase, each infant was presented with two different conditions that expressed two different cues of possession. Before the curtain was lifted up, the experimenter placed one of her hands in contact or in proximity with one of the two objects (i.e., the right hand was placed on the right side of the right object, or vice versa). In the Contact condition, the hand was positioned so that fingers and part of the palm touched the object (see Fig 3 A); in the Proximity condition, the palm lied flat on the board without touching the object (see Fig 3 B).

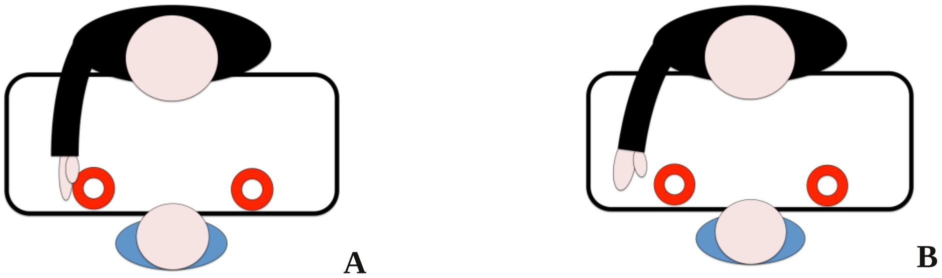


Fig. 3 A: Contact condition. The experimenter’s hand touches the object
B: Proximity condition. The experimenter’s hand lies flat on the board without touching the object.

The second phase of each trial started with a bell ring, during which the curtain was totally lifted up, revealing both the objects and the experimenter. After smiling for a few seconds, the experimenter slid the board toward the infant until the board and the stage edges were coincident, and the objects were in reach for the infant. While sliding, the experimenter’s gaze was directed toward the infant and never toward the objects. When the board movement ended, the experimenter looked downwards lowering her head and waited in this position until the infant made a choice; the trial ended when the infant touched or grasped one of the objects, or after 20 seconds without any contact. If one object was grasped, the infant was allowed to hold it for a few seconds; then the parent, previously instructed on the procedure, removed the object from the infant’s hands and put it inside a box on the floor. After that, the curtain was lowered and a new pair of objects was set in place. This procedure was repeated for sixteen times.

Each infant faced 8 trials per condition (contact and proximity). The two conditions were presented in a ABBA or BAAB order counterbalanced between participants. The position of the experimenter hand (left or right) was balanced across trials and conditions; objects were presented in a random order across participants.

Coding

Coding was done off-line from video recordings. We considered as choice the first contact the infant made with one of the two objects. A choice was classified as *same* when the infant touched or grasped the object that was in contact or proximity with the experimenter's hand (the possessed object) or as *different* when the infant touched or grasped the other object (the non-possessed object). When the infant didn't touch any objects or touched both of the objects at the same time (within a range of 40 ms) we classified the trial as *no-choice* (see Fig. 4). Due to the low number of *no-choice* occurrences (15 cases in the 9-month-old group and 13 cases in the 6-month-old group), these trials have been excluded from the analysis. Infants that showed a lateral bias in reaching were excluded from the sample. To be included, an infant had to use the non-preferred hand at least in two of the total number of performed choices.

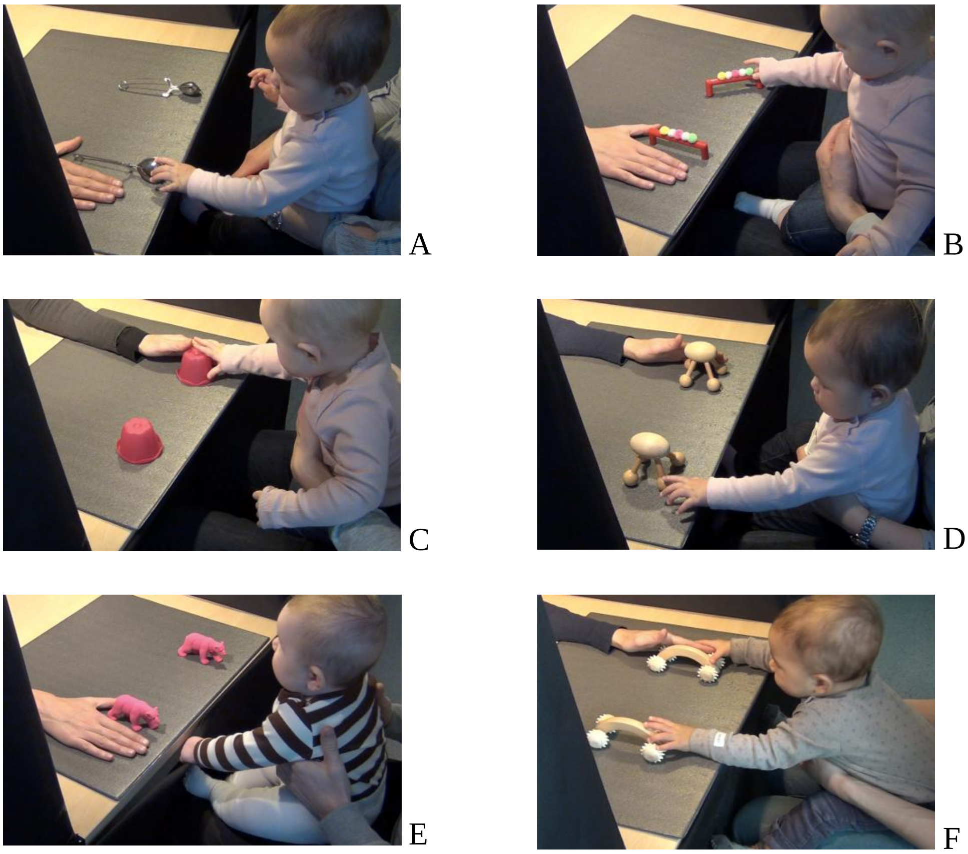


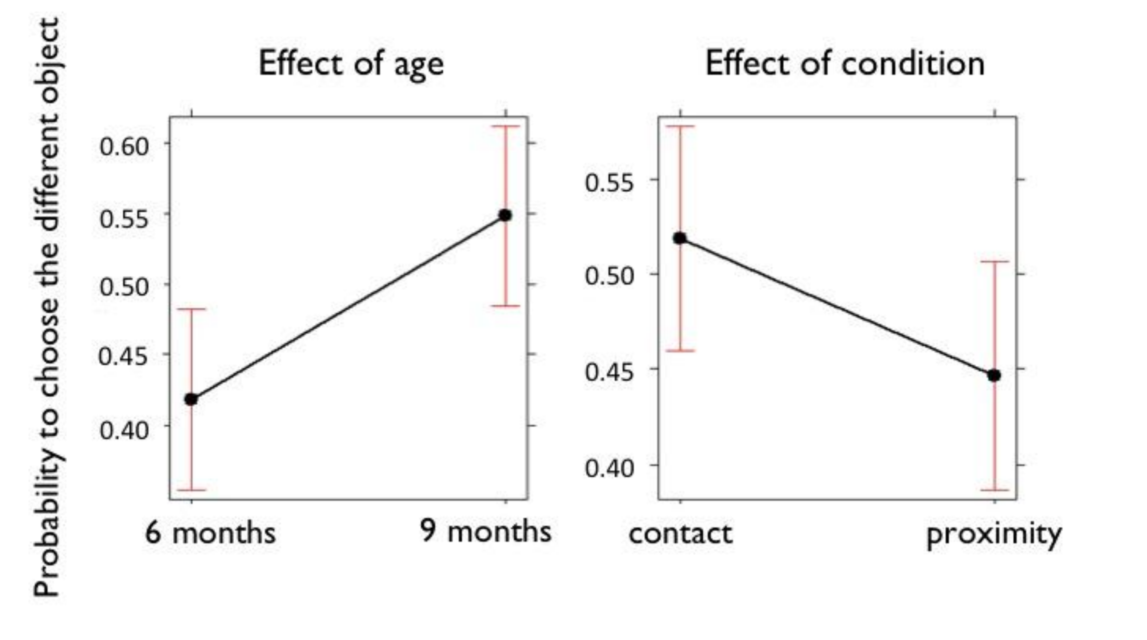
Fig. 4 Examples of coded choices. A: Proximity condition, the infant chooses the *same* object. B: Proximity condition, the infant chooses the *different* object. C: Contact condition, the infant chooses the *same* object. D: Contact condition, the infant chooses the *different* object. E, F: Two cases of *no-choice*.

Results

Analyses were performed with the open-source software R (R Core Team, 2015). Data were analyzed through *mixed-effects multiple regression model* (e.g., Jaeger, 2008) using the lme4 package for R (Bates, Mächler, Bolker, & Walker, 2014). We used the logistic link-function, which is appropriate for a dependent variable with binary distribution (i.e., binary choice).

The advantage of mixed-effects models is that analysis are performed on the number of observations rather than on number of participants (in our case 671 observations vs. 44 participants) eliminating the need to average across trials. Moreover, they do not assume independence amongst observations and they allow considering all factors that potentially contribute to the understanding of the structure of the data (Baayen, Davidson, & Bates, 2008). These factors comprise the variables controlled by the experimenter and random-effects factors (i.e., individual variability). The inclusion of random effect means that the variability associated to these variables is taken into account into the model. The statistical procedure used in GLMM allows to choose the model that fits the data best. We started from an initial model including all variables (fixed and random effects) and their interactions. Then we stepwise excluded variables one by one and performed comparisons between models through likelihood ratio tests. A variable was removed from the model if it did not contribute to significantly improve the goodness of fit of the model.

We categorized the choice performed by infants as 0 when the infant chose the *same* object (the possessed object) and as 1 when the infant chose the *different* object (the non-possessed object). In the model, the outcome (i.e., the dependent variable) was the probability to choose the different object. Age (6 months vs. 9 months), condition (contact vs. proximity) and order of presentation of conditions across trials (ABBA vs. BAAB) were treated as fixed effects. Participant and objects were treated as random effects. The model that fits the data best included the main effect of age and main effect of condition. Results of the final model are reported in Fig. 5 with odds ratios (ORs) as a measure of effect size.



	B (SE)	*z*	*p*	*OR*
Age: 9 vs 6 months	0.53 (0.19)	2.83	0.004	1.7
Condition: proximity vs contact	-0.30 (0.16)	0.16	0.06	0.74

Fig. 5 Plots and results of logistic mixed-effects model. Fixed effects of age and condition on probability to choose the different (non-possessed) object. *B*, unstandardized regression coefficient; *SE*, standard error; *z*, effect size; *OR*, odds ratio.

Results from the model are to be interpreted as follow: the probability to choose the different (non-possessed) object at 9 months of age is significantly higher than the probability to choose the non-possessed object at 6 months of age. Instead, the effect of condition is only marginally significant: the probability to choose the non-possessed object seems not to be affected by condition.

In addition, comparisons for each age group between the proportion of different choices and chance level (0.5) have been performed. The mean proportions of different choices and their 95% confidence intervals by age and condition are presented in Fig. 6. In addition, chance level is reported (0.5). When tested against chance level, results show that 9 months old chose significantly more the different object than chance level in the contact condition, but not in the proximity condition ($M_{contact}$ = 0.6, $SE_{contact}$ = 0.04, $t(21)$ = 2.42, p = 0.02; $M_{proximity}$ = 0.50 $SE_{proximity}$ = 0.04, t (21) = -0.01, p = 0.99). By contrast, 6 months old chose significantly more the same object (the possessed object) in the proximity condition, but not in the contact condition ($M_{contact}$ = 0.43, $SE_{contact}$ = 0.04, $t(21)$ = -1.41, p = 0.17; $M_{proximity}$ = 0.4, $SE_{proximity}$ = 0.03, t (21) = -2.57, p = 0.01).

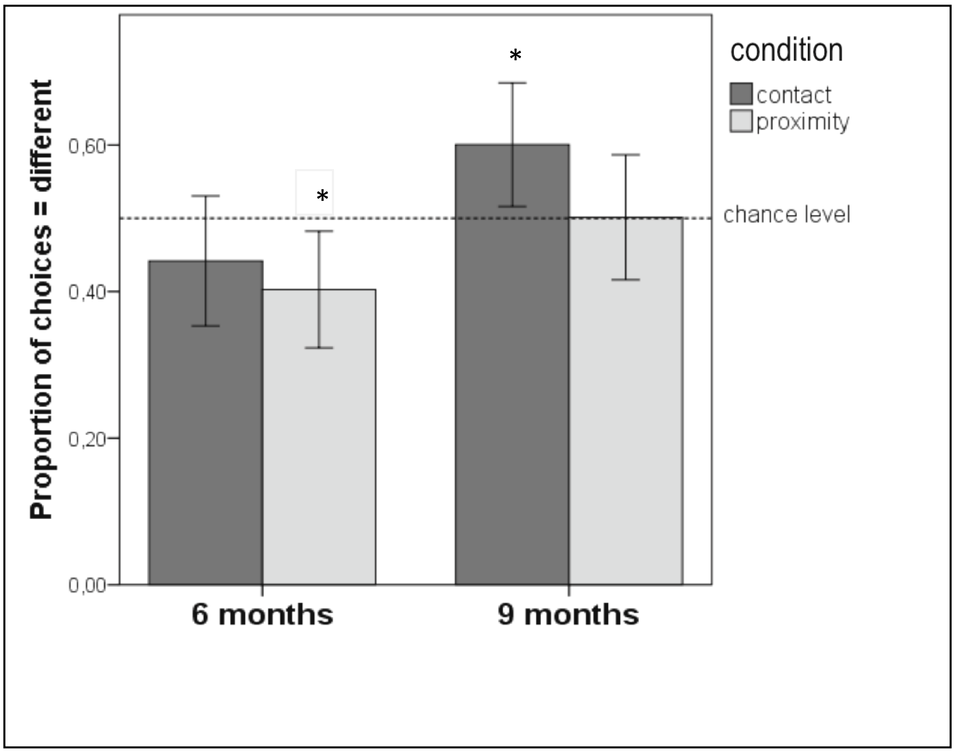


Fig. 6 Mean proportions and 95% confidence intervals of different choices in 6-month-olds, and 9-month-olds by condition. Asterisks indicate means that differ significantly from chance at p < .05

Discussion

The aim of the study was to explore the age of emergence of the ability to respect others' possession and analyze the role of different cues of possession. Infants were presented with two identical objects, one of which was indicated to be possessed by the experimenter. Possession was expressed by either physical proximity or contact of the experimenter's hand with one of the two objects. Importantly, before making a choice, infants had the possibility to see that the two objects were identical.

Results from the present study revealed that 1) infants in their first year of life are sensitive to the physical relation between object and experimenter's hand, 2) infants' choice behaviour changes considerably between 6 and 9 months of age, and 3) infants' choice is modulated by the type of spatial relation between object and experimenter's hand. Specifically, our results demonstrated that at 9 months of age infants show the tendency to choose the non-possessed object. This tendency was greater when the experimenter's hand was in contact with the object than when it was only in proximity. By contrast, 6-month-olds show an opposite trend, choosing more the possessed object. This tendency was greater when the experimenter's hand was in proximity with the object than when it was in contact. These contrasting results can be interpreted hypothesizing that the acquisition process was affected by the co-occurrence of different mechanisms that drove the infant's preference toward one of the objects: on the one side, the emerging ability to respect others' possession, on the other, the tendency of infants to follow referential cues in order to direct their own choices.

Sensitivity to communicative cues is a hallmark in human cognition and several studies demonstrated how human's gaze, facial expressions, infant-directed speech, pointing gesture and others' choices affect infants' preference towards objects present in the environment (Mumme & Fernald, 2003; Okumura, Kanakogi, Kanda, Ishiguro, &

Itakura, 2013; Repacholi, 1998). This ability plays a primary role in social learning, enabling infants to acquire information from the environment in a rapid and efficient way (Csibra & Gergely, 2006; Gergely Csibra, 2010; Tomasello, 1999).

Nevertheless, the ability to follow social cues is a developing skill as well. According to a huge body of evidence, during the first half year of life, infants have been shown to engage mostly in dyadic interactions both with objects and with other individual. For example, infants engage in turn-taking mutual gaze, face-to-face exchange of smiles, and repetitions of actions towards objects (Striano & Rochat, 1999; Tomasello, 1999). But around 9 months of age, an important transition in social cognitive development occurs, as infants start to show triadic social competence, that is the ability to engage in referential sharing with others about things in the environment (M Tomasello, 1995; Trevarthen, 1998). At this age, infants start monitoring a social partner in contexts of objects exploration. They use others' display of emotions as information to disambiguate novel situations in the environment. Importantly, they begin to understand and express communicative gestures like pointing, offering, and presenting objects. In this triangulation, objects become the medium of a social exchange and instruments to control the social environment (Rochat, 2014; Zahavi & Rochat, 2015). The emerging ability of triadic competences suggests moreover that infants begin to perceive a context as composed of social and physical elements connected to each other and to associate a global meaning to this context, instead of merely focus on salient portions of it. Most importantly, they begin to understand self and others as intentional actors, to use multiple behavioral means to achieve the same goal, and to shape their behavior according to the context (Tomasello, 1999; Tomasello & Rakoczy, 2003).

Our results showed that both 6 and 9 month olds are sensitive to the physical relation between object and experimenter's hand, but their choice behaviour shows an opposite trend. According to the aforementioned developmental trajectory of infants' socio-cognitive abilities, we propose the following interpretation.

Six-month-old infants chose more the possessed object because they focused their attention on the item that was close to the hand, either because the human hand itself has a high saliency or because the position of the hand was interpreted as an indicator for the object that should be chosen. Moreover, since before 6-months of age infants' ability to grasp objects and actively explore the environment is strongly limited and their interaction with objects depends on the presence of another individual, we hypothesize that at this age cues of others' possession increase the affordance of an object instead of act as a social constrain.

By contrast, nine-month-olds chose more the non-possessed object most likely due to their emerging ability to understand the global complexity of a context and associate a meaning to it. They start to differentiate between the different meanings that underlie the relationship between a subject and an object, and they begin to shape their behavior according to these different meanings. As infants start to differentiate others' gestures and intentional actions, possessed objects start to have different affordances depending on the context in which they are embedded. We propose that the strength of the cues of possession (contact vs. proximity) affected the infants' choice leading to differential outcomes and hypothesize that the emerging abilities to respect others' possession and globally evaluate the context do not completely replace the pre-existing preference for the referential cued object. When the cue was stronger (contact condition), 9 months old preferred the non-possessed object. When the cue was weaker (proximity condition), they performed on chance level.

Being able to interact with other individuals *and* objects in the environment is an essential component of human sociality and in this context the notions of ownership and possession cover a fundamental role. In everyday life, respecting others' property is an automatic behavior that we perform without a conscious thought due to the rapid detection of physical cues of possession. Our exploratory study demonstrated that infants show a different sensitivity to diverse cues of possession and that an important shift in infants' behavior occurs between 6 and 9 months of age. Since the choice that we measured in our experiment can be viewed as the result of several mechanisms concurring and conflicting in order to produce an outcome, these contrasting results could be interpreted in the light of a dual process interaction: on the one side, the emerging ability to respect others' possession, on the other, the infants' tendency to prefer the socially signaled object. Moreover, it is likely that inter-individual variability in socio-cognitive skills and motor abilities inside the two groups of age had an important role in modulating infants' preference and subsequent choice. Our study represents a first empirical step towards the exploration of the developmental trajectory of ownership understanding during the first year of life. Nevertheless, it is far from being able to exhaustively answer all aspects of how infants deal with others' possession. Several questions remain open to investigation, for example concerning the role of multiple variables on infant-object interaction. A first improvement would be to consider the effect of possessor's identity (familiar vs. unfamiliar adult) on infant's preference and behavior. A further possible limitation of our paradigm could be the relative ambiguity of the task. In order not to drive infants' attention toward one of the two objects or towards her own face, the experimenter's gaze was directed downward. The absence of joint engagement might have contributed to infants' performance, especially at 9 months of age when infants have been shown to take into great account the affective behavior of unfamiliar individuals (Striano & Bertin, 2005). Moreover, the way the experimenter touched the object in the contact condition could be opaque for infants because it did not represent the classical forms of giving and taking infants are familiar with, leaving them unsure about what the experimenter was doing and what they are expected to do. This ambiguity did not affect infants' willingness to grasp the objects though, as is evident from the very low occurrence of no-choices. Using a similar paradigm, another possibility would be to analyze which the other physical, spatial and attentional cues are that mediate the recognition and respect of others' possession during infancy. Further research should also take into account the potential role of objects' physical features (e.g., dimension, shape, equality/inequality of the two objects) as well as their abstract properties (e.g., familiarity, attractiveness, affective value). Finally, from a methodological point of view, a fine-grained analysis of infants' motor behavior during the task could add important and reliable information to the understanding of the phenomenon. If our hypothesis about the co-occurrence of different processes is correct, a kinematic analysis of the action performed towards the objects could shed light on the potential conflicting mechanisms that guide infants' preference and underlie the acquisition process of the possessed/non-possessed object.

REFERENCES

Allen, J. W. P., & Bickhard, M. H. (2013). Stepping off the pendulum: Why only an action-based approach can transcend the nativist–empiricist debate. *Cognitive Development*, *28*(2), 96–133. doi:10.1016/j.cogdev.2013.01.002

Baayen, R., Davidson, D., & Bates, D. (2008). Mixed-effects modeling with crossed random effects for subjects and items. *Journal of Memory and Language*. , *59*(4), 390-412.

Baillargeon, R., & Scott, R. (2014). Psychological and sociomoral reasoning in infancy. *APA Handbook of personality and social psychology*, 1, 79-150.

Bakeman, R., & Brownlee, J. (1982). Social rules governing object conflicts in toddlers and preschoolers. *Peer Relationships and Social Skills in Childhood*. (pp. 99-111). Springer New York.

Bates, D., Mächler, M., Bolker, B., & Walker, S. (2014). Fitting Linear Mixed-Effects Models using lme4. *arXiv preprint arXiv:1406.5823*.

Becchio, C., Sartori, L., & Castiello, U. (2010). Toward You: The Social Side of Actions. *Current Directions in Psychological Science*, *19*(3), 183–188. doi:10.1177/0963721410370131

Beggan, J. K. (1992). On the social nature of nonsocial perception: The mere ownership effect. *Journal of Personality and Social Psychology*, *62*(2), 229–237. doi:10.1037//0022-3514.62.2.229

Belk, R.W. (1988). Possession and the extended self. *Journal of Consumer Research*, 15, 139-168.

Berti, A., & Frassinetti, F. (2000). When far becomes near: remapping of space by tool use. *Journal of cognitive neuroscience, 12(3), 415-420*

Blake, P. R., Ganea, P. a, & Harris, P. L. (2012). Possession is not always the law: with age, preschoolers increasingly use verbal information to identify who owns what. *Journal of Experimental Child Psychology*, *113*(2), 259–72. doi:10.1016/j.jecp.2012.06.008

Blake, P. R., & Harris, P. L. (2009). Children's understanding of ownership transfers. *Cognitive Development*, *24*(2), 133–145. doi:10.1016/j.cogdev.2009.01.002

Blake, P. R., & Harris, P. L. (2011). Early representations of ownership. *New Directions for Child and Adolescent Development*, *2011*(132), 39–51. doi:10.1002/cd.295

Borghi, A. M., Flumini, A., Natraj, N., & Wheaton, L. a. (2012). One hand, two objects: emergence of affordance in contexts. *Brain and Cognition*, *80*(1), 64–73. doi:10.1016/j.bandc.2012.04.007

Borghi, A. M., & Riggio, L. (2015). Stable and variable affordances are both automatic and flexible. *Frontiers in Human Neuroscience*, *9*, 351. doi:10.3389/fnhum.2015.00351

Bremner, J. G., Slater, A. M., & Johnson, S. P. (2015). Perception of Object Persistence: The Origins of Object Permanence in Infancy. *Child Development Perspectives*, *9*(1), 7–13. doi:10.1111/cdep.12098

Brosnan, S. (2011). Property in nonhuman primates. *New Directions for Child and Adolescent Development*, *2011*(132), 9–22. doi:10.1002/cd.293

Brosnan, S. F., Jones, O. D., Lambeth, S. P., Mareno, M. C., Richardson, A. S., & Schapiro, S. J. (2007). Endowment effects in chimpanzees. *Current Biology*, *17*(19), 1704-

Brown, G., Pierce, J. O. N. L., & Crossley, C. (2013). Toward an Understanding of the Development of Ownership Feelings, (April). doi:10.1002/job

Brownell, C. a, Iesue, S. S., Nichols, S. R., & Svetlova, M. (2013). Mine or yours? Development of sharing in toddlers in relation to ownership understanding. *Child Development*, *84*(3), 906–20. doi:10.1111/cdev.12009

Canfield, R. L., & Haith, M. M. (1991). Young infants' visual expectations for symmetric and asymmetric stimulus sequences. *Developmental Psychology*,*27*(2), 198.

Casasola, M., & Cohen, L. B. (2002). Infant categorization of containment, support and tight-fit spatial relationships. *Developmental Science*, *5*(2), 247–264. doi:10.1111/1467-7687.00226

Cohen, L. B., Gelber, E. R., & Lazar, M. A. (1971). Infant habituation and generalization to differing degrees of stimulus novelty. *Journal of Experimental Child Psychology*, *11*(3), 379-389.

Constable, M. D., Kritikos, A., & Bayliss, A. P. (2011). Grasping the concept of personal property. *Cognition, 119*(3), 430–7. doi:10.1016/j.cognition.2011.02.007

Constable, M. D., Kritikos, A., Lipp, O. V, & Bayliss, A. P. (2014). Object ownership and action: the influence of social context and choice on the physical manipulation of personal property. *Experimental Brain Research*. doi:10.1007/s00221-014-4063-1

Costantini, M., Ambrosini, E., Tieri, G., Sinigaglia, C., & Committeri, G. (2010). Where does an object trigger an action? An investigation about affordances in space. *Experimental Brain Research*, *207*(1-2), 95–103. doi:10.1007/s00221-010-2435-8

Costantini, M., Committeri, G., & Sinigaglia, C. (2011). Ready both to your and to my hands: mapping the action space of others. *PloS One*, *6*(4), e17923. doi:10.1371/journal.pone.0017923

Cram, F., & Paton, H. (1993). PERSONAL POSSESSIONS AND SELF-IDENTITY: THE EXPERIENCES OF ELDERLY WOMEN IN THREE RESIDENTIAL SETTINGS. *Australian Journal on Ageing*, *12*(1), 19-24.

Csibra, G. (2010). Recognizing Communicative Intentions in Infancy. *Mind & Language*, *25*(2), 141–168. doi:10.1111/j.1468-0017.2009.01384.x

Csibra, G., & Gergely, G. (2006). Social learning and social cognition: The case for pedagogy. *Processes of change in brain and cognitive development. Attention and performance XXI*, *21*, 249-274.

Cunningham, S. J., Brady-Van den Bos, M., & Turk, D. J. (2011). Exploring the effects of ownership and choice on self-memory biases. *Memory (Hove, England)*, *19*(5), 449–61. doi:10.1080/09658211.2011.584388

Cunningham, S. J., Turk, D. J., Macdonald, L. M., & Neil Macrae, C. (2008). Yours or mine? Ownership and memory. *Consciousness and Cognition*, *17*(1), 312–8. doi:10.1016/j.concog.2007.04.003

Cunningham, S. J., Vergunst, F., Macrae, C. N., & Turk, D. J. (2013). Exploring early self-referential memory effects through ownership. *The British Journal of Developmental Psychology*, *31*(Pt 3), 289–301. doi:10.1111/bjdp.12005

Davies, N. B. (1978). Territorial defence in the speckled wood butterfly (Pararge aegeria): The resident always wins. *Animal Behaviour*, *26*, 138–147. doi:10.1016/0003-3472(78)90013-1

De Jaegher, H. (2009). Social understanding through direct perception? Yes, by interacting. *Consciousness and Cognition*, *18*(2), 535–42; discussion 543–50. doi:10.1016/j.concog.2008.10.007

De Jaegher, H., Di Paolo, E., & Gallagher, S. (2010). Can social interaction constitute social cognition? *Trends in Cognitive Sciences*, *14*(10), 441–7. doi:10.1016/j.tics.2010.06.009

Demsetz, H. (1974). *Toward a theory of property rights* (pp. 163-177). Palgrave

Macmillan UK.

DeScioli, P., & Wilson, B. J. (2011). The territorial foundations of human property. *Evolution and Human Behavior, 32*(5), 297–304. doi:10.1016/j.evolhumbehav.2010.10.003

Dewey, J. (2002). *Human nature and conduct*. Courier Corporation.

Dittmar, H. (1989). Gender identity-related meanings of personal possessions.*British Journal of Social Psychology*, *28*(2), 159-171.

Dittmar, H. (1991). Meanings of Material Possessions as Reflections of Identity: Gender and Social-Marterial Position in Society. *Journal of Social Behavior and Personality*, *6*(6), 165.

Dunn, J. (1988). *The beginnings of social understanding*. Harvard University Press.

Ellis, L. (1985). On the rudiments of possessions and property. *Social Science Information/sur Les Sciences Sociales*.

Ellis, R., & Tucker, M. (2000). Micro‐affordance: The potentiation of components of action by seen objects. *British journal of psychology*, *91*(4), 451-471.

Farnè, A., & Làdavas, E. (2000). Dynamic size-change of hand peripersonal space following tool use. *Neuroreport*, *11*(8), 1645-1649.

Farroni, T., Csibra, G., Simion, F., & Johnson, M. (2002). Eye contact detection in humans from birth. *Proceedings of the National Academy of Sciences of the United States of America*, *99*(14), 9602–5. doi:10.1073/pnas.152159999

Fasig, L. G. (2000). Toddlers' Understanding of Ownership: Implications for Self‐Concept Development. *Social Development*, *9*(3), 370-382.

Ferri, F., Campione, G. C., Dalla Volta, R., Gianelli, C., & Gentilucci, M. (2011). Social requests and social affordances: how they affect the kinematics of motor sequences during interactions between conspecifics. *PloS One*, *6*(1), e15855. doi:10.1371/journal.pone.0015855

Friedman, O. (2008). First possession: An assumption guiding inferences about who owns what. *Psychonomic Bulletin & Review*, *15*(2), 290-295.

Friedman, O., & Neary, K. K. R. (2008). Determining who owns what: do children infer ownership from first possession? *Cognition*, *107*(3), 829–49. doi:10.1016/j.cognition.2007.12.002

Friedman, O., Neary, K. R., Defeyter, M. a, & Malcolm, S. L. (2011). Ownership and object history. *New Directions for Child and Adolescent Development*, *2011*(132), 79–89. doi:10.1002/cd.298

Friedman, O., Van de Vondervoort, J. W., Defeyter, M. a, & Neary, K. R. (2013). First possession, history, and young children's ownership judgments. *Child Development*, *84*(5), 1519–25. doi:10.1111/cdev.12080

Furby, L. (1980). The origins and early development of possessive behavior.*Political Psychology*, 30-42.

Furby, L. (1991). Understanding the psychology of possession and ownership: A personal memoir and an appraisal of our progress. *Journal of Social Behavior and Personality*, *6*(6), 457.

Gelman, S. a, Noles, N. S., & Stilwell, S. (2014). Tracking the actions and possessions of agents. *Topics in Cognitive Science*, *6*(4), 599–614. doi:10.1111/tops.12106

Geraci, A., & Surian, L. (2011). The developmental roots of fairness: infants' reactions to equal and unequal distributions of resources. *Developmental Science*, *14*(5), 1012–20. doi:10.1111/j.1467-7687.2011.01048.x

Gergely, G., Nádasdy, Z., Csibra, G., & Bíró, S. (1995). Taking the intentional stance at 12 months of age. *Cognition*, *56*(2), 165-193.

Gianelli, C., Scorolli, C., & Borghi, A. M. (2013). Acting in perspective: the role of body and language as social tools. *Psychological Research*, *77*(1), 40–52. doi:10.1007/s00426-011-0401-0

Gibson, J. (1977). The theory of affordances. *Hilldale, USA*.

Gintis, H. (2007). The Evolution of Private Property, *7756*, 1–22.

Goodenough, O., & Decker, G. (2009). Why do good people steal intellectual property? *Law, Mind and Brain, Ashgate*.

Gordon, P. (2003). The origin of argument structure in infant event representations. *In Proceedings of the 26th Boston University Conference on Language Development. Somerville, Mass: Cascadilla Press.*

Grèzes, J., & Decety, J. (2002). Does visual perception of object afford action? Evidence from a neuroimaging study. *Neuropsychologia*, *40*(2), 212-222.

Gros-Louis, J. (2004). The function of food-associated calls in white-faced capuchin monkeys, Cebus capucinus, from the perspective of the signaller.*Animal Behaviour*, *67*(3), 431-440.

Hamlin, J. K., & Wynn, K. (2011). Young infants prefer prosocial to antisocial others. *Cognitive Development*, *26*(1), 30–39. doi:10.1016/j.cogdev.2010.09.001

Hamlin, J. K., Wynn, K., & Bloom, P. (2007). Social evaluation by preverbal infants. *Nature*, *450*(7169), 557–9. doi:10.1038/nature06288

Hamlin, J. K., Wynn, K., Bloom, P., & Mahajan, N. (2011). How infants and toddlers react to antisocial others. *Proceedings of the National Academy of Sciences of the United States of America*, *108*(50), 19931–6. doi:10.1073/pnas.1110306108

Hay, D. F. (2006). Yours and mine: Toddlers' talk about possessions with familiar peers. *British Journal of Developmental Psychology*, *24*(1), 39–52. doi:10.1348/026151005X68880

Hay, D. F., Hurst, S.-L., Waters, C. S., & Chadwick, A. (2011). Infants' Use of Force to Defend Toys: The Origins of Instrumental Aggression. *Infancy*, *16*(5), 471–489. doi:10.1111/j.1532-7078.2011.00069.x

Hay, D. F., Nash, A., & Pedersen, J. (1983). Interaction between Six-Month-Old Peers. *Child Development*, *54*(3), 557. doi:10.2307/1130042

Hay, D. F., & Ross, H. S. (1982). The social nature of early conflict. *Child development*, 105-113.

Holmes, R. (1967). THE OWNERSHIP OF WORK: A PSYCHOLOGICAL APPROACH. *British Journal of Industrial Relations*, *5*(1), 19–27. doi:10.1111/j.1467-8543.1967.tb00495.x

Houston-Price, C., & Nakai, S. (2004). Distinguishing novelty and familiarity effects in infant preference procedures. *Infant and Child Development*, *13*(4), 341–348. doi:10.1002/icd.364

Iriki, A., Tanaka, M., & Iwamura, Y. (1996). Coding of modified body schema during tool use by macaque postcentral neurones. *Neuroreport*, *7*(14), 2325-2330.

Jaeger, T. F. (2008). Categorical data analysis: Away from ANOVAs (transformation or not) and towards logit mixed models. *Journal of memory and language*, *59*(4), 434-446.

Jax, S. A., & Buxbaum, L. J. (2010). Response interference between functional and structural actions linked to the same familiar object. *Cognition*, *115*(2), 350–5. doi:10.1016/j.cognition.2010.01.004

Kahneman, D., Knetsch, J. L., & Thaler, R. H. (1991). Anomalies: The endowment effect, loss aversion, and status quo bias. *The journal of economic perspectives*, *5*(1), 193-206.

Kalénine, S., Shapiro, A. D., Flumini, A., Borghi, A. M., & Buxbaum, L. J. (2014). Visual context modulates potentiation of grasp types during semantic object categorization. *Psychonomic bulletin & review*, *21*(3), 645-651.

Kalish, C. W., & Anderson, C. D. (2011). Ownership as a social status. *New Directions for Child and Adolescent Development*, *2011*(132), 65–77. doi:10.1002/cd.297

Kamptner, N. L. (1991). Personal possessions and their meanings: A life-span perspective. *Journal of Social Behavior and Personality*, *6*(6), 209.

Kanngiesser, P., Gjersoe, N., & Hood, B. M. (2010). The effect of creative labor on property-ownership transfer by preschool children and adults. *Psychological Science*, *21*(9), 1236-1241.

Kanngiesser, P., & Hood, B. M. (2014). Young children's understanding of ownership rights for newly made objects. *Cognitive Development*, *29*, 30–40. doi:10.1016/j.cogdev.2013.09.003

Kanngiesser, P., Rossano, F., & Tomasello, M. (2015). Late Emergence of the First Possession Heuristic: Evidence From a Small-Scale Culture. *Child Development*. doi:10.1111/cdev.12365

Kidd, C., Piantadosi, S. T., & Aslin, R. N. (2012). The Goldilocks effect: human infants allocate attention to visual sequences that are neither too simple nor too complex. *PloS One*, *7*(5), e36399. doi:10.1371/journal.pone.0036399

Kim, K., & Johnson, M. K. (2014). Extended self: spontaneous activation of medial prefrontal cortex by objects that are "mine". *Social Cognitive and Affective Neuroscience*, *9*(7), 1006–12. doi:10.1093/scan/nst082

Kim, S., & Kalish, C. W. (2009). Children's ascriptions of property rights with changes of ownership. *Cognitive Development*, *24*(3), 322–336. doi:10.1016/j.cogdev.2009.03.004

Knetsch, J. L., & Sinden, J. A. (1984). Willingness to pay and compensation demanded: Experimental evidence of an unexpected disparity in measures of value. *The Quarterly Journal of Economics*, 507-521.

Krebs, J. R. (1982). Territorial defence in the great tit (Parus major): do residents always win?. *Behavioral Ecology and Sociobiology*, *11*(3), 185-194.

Krier, J. E. (2009). Evolutionary theory and the origin of property rights. *Cornell L. Rev.*, *95*, 139.

Krigolson, O. E., Hassall, C. D., Balcom, L., & Turk, D. (2013). Perceived ownership impacts reward evaluation within medial-frontal cortex. *Cognitive, Affective & Behavioral Neuroscience*, *13*(2), 262–9. doi:10.3758/s13415-012-0144-4

Kummer, H. (1991). Evolutionary transformations of possessive behavior.*Journal of*

Social Behavior and Personality, *6*(6), 75.

Kummer, H., & Cords, M. (1991). Cues of ownership in long-tailed macaques, Macaca fascicularis. *Animal Behaviour*, *42*(4), 529-549.

Lakshminaryanan, V., Chen, M. K., & Santos, L. R. (2008). Endowment effect in capuchin monkeys. *Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences*, *363*(1511), 3837–44. doi:10.1098/rstb.2008.0149

Leslie, A. M. (1994). ToMM, ToBy, and Agency: Core architecture and domain specificity. *Mapping the mind: Domain specificity in cognition and culture*, 119-148.

Levene, M., Starmans, C., & Friedman, O. (2015). Creation in judgments about the establishment of ownership. *Journal of Experimental Social Psychology*, *60*, 103–109. doi:10.1016/j.jesp.2015.04.011

Litwinski, L. (1942). IS THERE AN INSTINCT OF POSSESSION? 1. *British Journal of Psychology. General Section*.

Maravita, A., & Iriki, A. (2004). Tools for the body (schema). *Trends in Cognitive Sciences*, *8*(2), 79–86. doi:10.1016/j.tics.2003.12.008

Maravita, A., Spence, C., Kennett, S., & Driver, J. (2002). Tool-use changes multimodal spatial interactions between vision and touch in normal humans. *Cognition*, *83*(2), B25–B34. doi:10.1016/S0010-0277(02)00003-3

Mascaro, O., & Csibra, G. (2012). Representation of stable social dominance relations by human infants, *2012*. doi:10.1073/pnas.1113194109/-/DCSupplemental.www.pnas.org/cgi/doi/10.1073/pnas.1113194109

Maynard Smith, J. (1974). The theory of games and the evolution of animal conflicts.*Journal of theoretical biology*, *47*(1), 209-221.

Maynard Smith, J., & Parker, G. A. (1976). The logic of asymmetric contests. *Animal Behaviour*, *24*(1), 159–175. doi:10.1016/S0003-3472(76)80110-8

Meristo, M., & Surian, L. (2013). Do infants detect indirect reciprocity? *Cognition*, *129*(1), 102–13. doi:10.1016/j.cognition.2013.06.006

Merrill, T. W. (1998). Property and the Right to Exclude. *Neb. L. Rev.*, *77*, 730.

Merrill, T. (2015). Ownership and possession. *Law and Economics of Possession*.

Mumme, D. L., & Fernald, A. (2003). The infant as onlooker: Learning from emotional reactions observed in a television scenario. *Child development*, *74*(1), 221-237.

Needham, A., & Baillargeon, R. (1993). Intuitions about support in 4.5-month-old infants. *Cognition*, *47*(2), 121–148. doi:10.1016/0010-0277(93)90002-D

Nelson, D. A. (1984). Communication of intentions in agonistic contexts by the pigeon guillemot, Cepphus columba. *Behaviour, 88*(1), 145-188.

Oakes, L. M. (2010). Using Habituation of Looking Time to Assess Mental Processes in Infancy. *Journal of Cognition and Development: Official Journal of the Cognitive Development Society*, *11*(3), 255–268. doi:10.1080/15248371003699977

Okumura, Y., Kanakogi, Y., Kanda, T., Ishiguro, H., & Itakura, S. (2013). The power of human gaze on infant learning. *Cognition*, *128*(2), 127–33. doi:10.1016/j.cognition.2013.03.011

Olson, K. R., & Shaw, A. (2011). 'No fair, copycat!': what children's response to plagiarism tells us about their understanding of ideas. *Developmental Science*,*14*(2), 431-439.

Peck, J., Barger, V. A., & Webb, A. (2012). In search of a surrogate for touch: The effect of haptic imagery on perceived ownership. *Journal of Consumer Psychology*, *Forthcoming*.

Peck, J., & Shu, S. B. (2009). The effect of mere touch on perceived ownership.*Journal of consumer Research*, *36*(3), 434-447.

Pierce, J. L., Kostova, T., & Dirks, K. T. (2003). The state of psychological ownership: Integrating and extending a century of research. *Review of general psychology*, *7*(1), 84.

Pierce, J. L., Kostova, T., & Dirks, K. T. K. (2001). Toward a theory of psychological ownership in organizations. *Academy of Management Review*, *26*(2), 298–310. doi:10.5465/AMR.2001.4378028

Prelinger, E. (1959). Extension and structure of the self. *The journal of Psychology*, *47*(1), 13-23.

Premack, D., & Premack, A. J. (1995). Origins of human social competence.

Quinn, P. C., Norris, C. M., Pasko, R. N., Schmader, T. M., & Mash, C. (1999). Formation of a Categorical Representation for the Spatial Relation Between by 6- to 7-month-old Infants. *Visual Cognition*, *6*(5), 569–585. doi:10.1080/135062899394948

Rakoczy, H., & Schmidt, M. F. H. (2013). The Early Ontogeny of Social Norms. *Child Development Perspectives*, *7*(1), 17–21. doi:10.1111/cdep.12010

Ramsey, P. G. (1987). Possession episodes in young children's social interactions. *The Journal of genetic psychology*, *148*(3), 315-324.

Reb, J., & Connolly, T. (2007). Possession, feelings of ownership and the endowment effect. *Judgment and Decision Making*, *2*(2), 107.

Repacholi, B. M. (1998). Infants' use of attentional cues to identify the referent of another person's emotional expression. *Developmental psychology*, *34*(5), 1017.

Riedl, K., Jensen, K., Call, J., & Tomasello, M. (2015). Restorative justice in children. *Current Biology*, *25*(13), 1731-1735.

Rochat, P. (2011). Possession and morality in early development. *New Directions for Child and Adolescent Development*, *2011*(132), 23–38. doi:10.1002/cd.294

Rochat, P. (2014). *Origins of possession: Owning and sharing in development*. Cambridge University Press.

Rochat, P., Morgan, R., & Carpenter, M. (1997). Young infants' sensitivity to movement information specifying social causality. *Cognitive Development*,*12*(4), 537-561.

Rose, C. M. (1985). Possession as the Origin of Property. *The University of Chicago Law Review*, *52*(1), 73-88.

Ross, H. S. (1996). Negotiating principles of entitlement in sibling property disputes. *Developmental Psychology*, *32*(1), 90.

Ross, H., Conant, C., & Vickar, M. (2011). Property Rights and the Resolution of Social Confl ict, (132), 53–64. doi:10.1002/cd

Ross, H. S. (2013). Effects of Ownership Rights on Conflicts Between Toddler Peers. *Infancy*, *18*(2), 256–275. doi:10.1111/j.1532-7078.2012.00121.x

Rossano, F., Fiedler, L., & Tomasello, M. (2015). Preschoolers' understanding of the role of communication and cooperation in establishing property rights.*Developmental psychology*, *51*(2), 176.

Rossano, F., Rakoczy, H., & Tomasello, M. (2011). Young children's understanding of violations of property rights. *Cognition*, *121*(2), 219–27. doi:10.1016/j.cognition.2011.06.007

Rudmin, F. (1988). Dominance, Social Control, and Ownership A History and a Cross-Cultural Study of Motivations for Private Property. *Cross-Cultural Research*.

Rudmin, F. (1991). To have possessions: a handbook on ownership and property. Rudmin, F. W. (1996). Cross-cultural correlates of the ownership of private property: Zelman's gender data revisited. *Cross-cultural research*, *30*(2), 115-153.

Rudmin, F., & Berry, J. (1987). SEMANTlCS OF OWNERSHEP: A FREEwHECALL STUDY OF PROPERTY. *The Psychological Record*.

Russ, B. E., Comins, J. A., Smith, R., & Hauser, M. D. (2010). Recognizing and respecting claims over resources in free-ranging rhesus monkeys, Macaca mulatta. *Animal Behaviour*, *80*(3), 563–569. doi:10.1016/j.anbehav.2010.06.026

Sartori, L., Becchio, C., Bulgheroni, M., & Castiello, U. (2009). Modulation of the action control system by social intention: unexpected social requests override preplanned action. *Journal of Experimental Psychology. Human Perception and Performance*, *35*(5), 1490–500. doi:10.1037/a0015777

Saylor, M. M., Ganea, P. a, & Vázquez, M. D. (2011). What's mine is mine: twelve-month-olds use possessive pronouns to identify referents. *Developmental Science*, *14*(4), 859–64. doi:10.1111/j.1467-7687.2010.01034.x

Schlottmann, A., Surian, L., & Ray, E. D. (2009). Causal perception of action-and-reaction sequences in 8- to 10-month-olds. *Journal of Experimental Child Psychology*, *103*(1), 87–107. doi:10.1016/j.jecp.2008.09.003

Schmidt, M. F., & Sommerville, J. A. (2011). Fairness expectations and altruistic sharing in 15-month-old human infants. *PloS one*, *6*(10), e23223.

Scholl, B. J., & Tremoulet, P. D. (2000). Perceptual causality and animacy. *Trends in Cognitive Sciences*, *4*(8), 299–309. doi:10.1016/S1364-6613(00)01506-0

Schöppner, B., Sodian, B., Pauen, S., Schoppner, B., Sodian, B., & Pauen, S. (2006). Encoding Action Roles in Meaningful Social Interaction in the First Year of Life. *Infancy*, *9*(3), 289–311. doi:10.1207/s15327078in0903_2

Scorolli, C., Borghi, A., & Tummolini, L. (2015). Visual cues and implicit judgments of ownership: An experimental study. *Sistemi Intelligenti*.

Scorolli, C., Miatton, M., Wheaton, L. a, & Borghi, A. M. (2014). I give you a cup, I get a cup: a kinematic study on social intention. *Neuropsychologia*, *57*, 196–204. doi:10.1016/j.neuropsychologia.2014.03.006

Shantz, C. U. (1987). Conflicts between children. *Child development*, 283-305.

Shaw, A., Li, V., & Olson, K. R. (2012). Children apply principles of physical ownership to ideas. *Cognitive Science*, *36*(8), 1383–403. doi:10.1111/j.1551-6709.2012.01265.x

Sigg, H., & Falett, J. (1985). Experiments on respect of possession and property in hamadryas baboons (Papio hamadryas). *Animal Behaviour*, *33*(3), 978-984.

Simion, F., Regolin, L., & Bulf, H. (2008). A predisposition for biological motion in the newborn baby. *Proceedings of the National Academy of Sciences of the United States of America*, *105*(2), 809–13. doi:10.1073/pnas.0707021105

Snare, F. (1972). The concept of property. *American Philosophical Quarterly*.

Southgate, V., & Csibra, G. (2009). Inferring the outcome of an ongoing novel action at 13 months. *Developmental psychology*, *45*(6), 1794.

Stake, J. E. (2004). The property "instinct". *Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences*, *359*(1451), 1763–74. doi:10.1098/rstb.2004.1551

Striano, T., & Bertin, E. (2005). Coordinated affect with mothers and strangers: A longitudinal analysis of joint engagement between 5 and 9 months of age. *Cognition & Emotion*, *19*(5), 781–790. doi:10.1080/02699930541000002

Striano, T., & Rochat, P. (1999). Developmental link between dyadic and triadic social competence in infancy. *British Journal of Developmental Psychology*, *17*(4), 551–562. doi:10.1348/026151099165474

Tatone, D., Geraci, A., & Csibra, G. (2015). Giving and taking: representational building blocks of active resource-transfer events in human infants. *Cognition*, *137*, 47–62. doi:10.1016/j.cognition.2014.12.007

Thill, S., Caligiore, D., Borghi, A. M., Ziemke, T., & Baldassarre, G. (2013). Theories and computational models of affordance and mirror systems: an integrative review. *Neuroscience and Biobehavioral Reviews*, *37*(3), 491–521. doi:10.1016/j.neubiorev.2013.01.012

Tomasello, M. (1995). Understanding the self as social agent.

Tomasello, M. (1999). Social cognition before the revolution. *Early social cognition: Understanding others in the first months of life*, 301-314.

Tomasello, M., & Rakoczy, H. (2003). What Makes Human Cognition Unique? From Individual to Shared to Collective Intentionality. *Mind and Language*, *18*(2), 121–147. doi:10.1111/1468-0017.00217

Trevarthen, C. (1998). The concept and foundations of infant intersubjectivity.*Intersubjective communication and emotion in early ontogeny*, 15-46.

Tucker, M., & Ellis, R. (2001). The potentiation of grasp types during visual object categorization. *Visual Cognition*, *8*(6), 769–800. doi:10.1080/13506280042000144

Tummolini, L., & Castelfranchi, C. (2011). L ' INCORPORAZIONE DELLA PROPRIETÀ: IL PROBLEMA DELLE ISTITUZIONI TRA SCIENZE COGNITIVE SOCIALI, (2009), 345–358.

Tummolini, L., Scorolli, C., & Borghi, A. M. (2013). Disentangling the sense of ownership from the sense of fairness. *The Behavioral and Brain Sciences*, *36*(1), 101–2. doi:10.1017/S0140525X1200088X

Turk, D. J., van Bussel, K., Waiter, G. D., & Macrae, C. N. (2011). Mine and me: exploring the neural basis of object ownership. *Journal of Cognitive Neuroscience*, *23*(11), 3657–68. doi:10.1162/jocn_a_00042

Vaish, A., Carpenter, M., & Tomasello, M. (2009). Sympathy through affective perspective taking and its relation to prosocial behavior in toddlers. *Developmental Psychology*, *45*(2), 534–43. doi:10.1037/a0014322

Vaish, A., Carpenter, M., & Tomasello, M. (2010). Young children selectively avoid helping people with harmful intentions. *Child Development*, *81*(6), 1661–9. doi:10.1111/j.1467-8624.2010.01500.x

Vaish, A., Missana, M., & Tomasello, M. (2011). Three-year-old children intervene in third-party moral transgressions. *The British Journal of Developmental Psychology*, *29*(Pt 1), 124–30. doi:10.1348/026151010X532888

Van Dyne, L., & Pierce, J. J. L. (2004). Psychological ownership and feelings of possession: three field studies predicting employee attitudes and organizational citizenship behavior. *Journal of Organizational Behavior*, *25*(4), 439–459. doi:10.1002/job.249

Verkuyten, M., Sierksma, J., & Thijs, J. (2015). First arrival and owning the land: How children reason about ownership of territory. *Journal of Environmental Psychology*, *41*, 58-64.

Van de Vondervoort, J. W., & Friedman, O. (2015). Parallels in Preschoolers' and Adults' Judgments About Ownership Rights and Bodily Rights. *Cognitive science*, *39*(1), 184-198.

Weigel, R. M. (1984). The application of evolutionary models to the study of decisions made by children during object possession conflicts. *Ethology and Sociobiology*, *5*(4), 229–238. doi:10.1016/0162-3095(84)90003-7

Winegar, L., & Renninger, K. (1989). Object Conflict and Sharing in the Preschool: Further Evidence for a Prior Possession Rule.

Winnicott, D. W. (1971). *Playing and reality*. Psychology Press.

Woodward, a. (1998). Infants selectively encode the goal object of an actor’s reach. *Cognition*, *69*(1), 1–34. doi:10.1016/S0010-0277(98)00058-4

Zahavi, D., & Rochat, P. (2015). Empathy ≠ sharing: Perspectives from phenomenology and developmental psychology. *Consciousness and Cognition*, *36*(JUNE), 543–53. doi:10.1016/j.concog.2015.05.008

Zebian, S., & Rochat, P. (2012). Judgment of land ownership by young refugee Palestinian and US children. *International Journal of Behavioral Development*,*36*(6), 449-456.