MASTERARBEIT / MASTER'S THESIS

Titel der Masterarbeit / Title of the Master's Thesis

„The Relationship Between the Number of Preschoolers' Closest Affiliative Peers and the Employment of Joint Attention Requests via Pointing Gestures"

verfasst von / submitted by

Guilherme Henrique Lima Marques Silva

angestrebter akademischer Grad / in partial fulfillment of the requirements for the degree of

Master of Science (MSc)

Wien, 2022 / Vienna, 2022

Studienkennzahl lt. Studienblatt / degree programme code as it appears on the student record sheet:	UA 066 013
Studienrichtung lt. Studienblatt / degree programme as it appears on the student record sheet:	Masterstudium Joint Degree Programme MEi :CogSci Cognitive Science
Betreut von / Supervisor:	Univ.-Prof. Mag. Dr. Thomas Bugnyar
Mitbetreut von / Co-Supervisor:	Mag. Dr. Lisa Horn-Péter

universität wien

Acknowledgments

I am grateful for each conversation I had with colleagues and faculty members during this master programme. I believe that every single breeze may lead us to a different port and the MEi:CogSci programme is certainly a windy sea.

More importantly, I would like to express my gratitude for both my supervisor's (Thomas Bugnyar) and co-supervisor's (Lisa Horn) guidance and patience. Every single piece of advice was an important stepping stone toward the thesis here presented.

At last, I would like to thank my mother and my partner for their ever-present support during my studies and for providing emotional and psychological shelter during rainy days.

Table of Contents

1 Introduction *1*

1.1 Robin Dunbar's Theory on human social network size and structure **3**

1.2 Characteristics of peer groups and friendships in early and mid-childhood **9**

1.2.3 Play and Mentalization 11

1.3 Mentalizing abilities in early and mid-childhood **12**

1.4 Mentalizing, joint Attention, and Pointing gestures **14**

2 Material and Methods *20*

2.1 Sample **20**

2.2 Video Coding **20**

2.2.1 Ethogram 21

2.2.2 Coding procedure 21

2.3 Data treatment **22**

2.3.1 Proximity and rank order of most frequent proximity partners 23

2.3.2 Obtaining the number of the support group 24

2.3.3 Pointing 25

2.4 Analyses Plan **25**

3 Results *28*

3.1 Descriptive analysis of the sample characteristics **28**

3.2 Research question 1 - exploring the social group structure **30**

3.3 Descriptive analysis of the variables *support group size* and *pointing frequency* **34**

3.4 Testing the effect of *pointing frequency* on *support group* size **36**

4 Discussion *39*

4.1 Limitations and outlook **43**

4.2 Conclusion **44**

References .... *I*

Appendices .... *VII*

Table of Figures

Figure 1. The circles of friendship. 6
Figure 2. Dunbar and Stiller's Linear Regression on Mentalization Competence and Support Group Size. 8
Figure 3. Cochet and colleagues (2016) linear regression on Pointing and ToM. 17
Figure 4. Example of an Individual Proportional Proximity time and Peer Rank. 24
Figure 5. Density and Boxplot Age distribution. 28
Figure 6. Gender Distribution. 29
Figure 7. Cluster dendrogram Group A. 30
Figure 8. Cluster dendrogram Group B. 31
Figure 9. Cluster dendrogram Group C. 31
Figure 10. Scree plot Group A. 32
Figure 11. Scree plot Group B. 32
Figure 12. Scree plot Group C. 33
Figure 13. Distribution of Support Group Size by Group. 34
Figure 14. Distribution of Posting Frequency by Group.. 35
Figure 15. Linear Regression Support Group Size and Pointing Frequency. 36
Figure 16. Linear Regression of Support Group Size as a factor of Age. 37
Figure 17. Linear Regression of Support Group Size as a factor of Pointing Frequency by the group. 37
Figure 18. Linear Regression of Support Group Size as a factor of Age by the group. 38

Table of tables

Table 1. Observation time by Group. 23
Table 2. Summary Table: Age in Months. 28
Table 3. Summary of gender distribution by group. 29
Table 4. Summary Table Support Group Size. 33
Table 5. Summary Table Pointing Frequency. 35
Table 6. Summary table Partial Spearman correlation. Pointing Frequency, Age, and Support Group Size. 38

1 Introduction

Living among conspecifics is a reality for most organisms. For some of these organisms, the early interaction with conspecifics is critical for survival and for the development of competencies that will be essential throughout their life (Darwin, 1859). Therefore, highly social animals are often studied due to the context in which an individual's behavioral and cognitive development unfolds (De Waal & Tyack, 2003; Heyes & Galef, 1996). For humans, the social aspects of life are omnipresent in almost everything in our immediate environment (Boyd & Silk, 2012; Fuentes, 2017; Lewis & Maslin, 2015; Tomasello, 2011). In summary, we often need others for protection, cooperation, learning, reasoning, releasing physiological stress, and making sense of our place in the world. In other words, there is nothing trivial about human social life.

It is the work of a substantial number of researchers from varied scientific fields to investigate the relationship between humans' social landscape, our environment, and the evolution of humans' behavioral repertoire. An increasing amount of this investigation addresses specific cognitive processes involved in social interactions (e.g., Moll & Tomasello, 2007; Tomasello, 2009; Tomasello & Vaish, 2013; Tomasello, 2011; Tomasello et al., 1993; Whiten et al., 2011; Csibra & Gergely, 2006, 2009; Heyes, 2012; Tomasello et al., 1993; Pust et al., 1997; Sperber et al., 2010). Additionally, a few theories have sparked the investigation of human intelligence (or cognitive processes) in general as the product of a brain evolved to deal with social complexity (Dunbar, 1998; Herrmann et al., 2007; Holekamp, 2007; Humphrey, 1976; Whiten, 2000).

The *social brain hypothesis* (Dunbar, 1998), for example, suggests that complex cognitive abilities have adapted to and evolved for species-specific social complexity management. This theoretical framework proposes that humans' complex social life is cognitively costly, and agents must selectively employ cognitive resources to efficiently manage social relationships (Dunbar, 2022; Hill & Dunbar, 2003). Moreover, Dunbar claims that the selective use of cognitive resources leads to the emergence of sequential, hierarchical clustering of relationships or “layers of interaction partners”. The first layer is composed of “closest friends” and is termed by Dunbar as the *support group*. The investigation conducted by Dunbar and Stiller (2007) indicates that the number of closest friends within this innermost layer (i.e., the *support group*), composed of closest friends, can be predicted (i.e., or at least limited) by an individual’s cognitive competence in inferring other individuals’ intentions, beliefs, and states of knowledge (i.e., mentalization capabilities) (Dunbar & Stiller, 2007).

These findings are based on the author's quantitative and qualitative research on adults (Dunbar & Stiller, 2007). However, preschoolers (2 to 6 years old) socialization among peers within childcare facilities provides a distinct social environment where individuals can develop, practice, and foster newly acquired socio-cognitive abilities. Furthermore, the specific nature of preschoolers’ socialization context and developmental processes has often provided empirical ground for developmental accounts of sociocognitive mechanisms. Therefore, it is evident that the investigation of Dunbar's findings in the context of early life affiliative competencies and cognitive development may offer critical theoretical implications. Moreover, although cognitive development has been widely investigated for more than 90 years, its primary focus has been on the child's interaction with its physical environment and interaction with adults.

Therefore, in the present work, I employ the methods and conceptual tools from the tradition of ethological observation in the research of well-established socio-cognitive processes in children. To achieve this objective, I investigated Dunbar and Stiller's (2007) paradigm (i.e., the relationship between social network size and mentalization competence) within an ecologically sensitive framework. Thus, employing ethological methods to investigate the use of joint attention requests (i.e., pointing) as an age-appropriate proxy for socio-cognitive competence (as will be discussed in the following sections) within the natural social context in which this behavior often unfolds (i.e., free play among peers).

The predictions that underlie this investigation are that it is possible to use observations of peer proximity and interactions to identify the *support group* in preschool groups and quantify individuals' number of social relationships in this cluster. Moreover, an individual's number of joint attention requests, as an age-appropriate proxy for the successful employment of socio-cognitive resources, will be positively related to the size and relative proportion of their support clique.

In the following sections, I will first elaborate on Dunbar's conceptual framework relevance for the study of social cognition. Following, I will describe the features of peer groups and friendships in preschool children's social environment. Additionally, I will present the current state of the research on mentalization capabilities in preschoolers. At last, I will argue that joint attention may offer a starting point for investigating socio-cognitive constructs through ecologically sensitive methods and contexts.

1.1 Robin Dunbar's Theory on human social network size and structure

In his latest book, *Friends: Understanding the power of our most important relationships,* Robin Dunbar (2022) describes his entire theoretical framework on how humans build and maintain social relationships, in its most complete account. First, the author explains the importance of keeping and building affiliative social network ties as a health factor. Then, by citing a series of studies indicating the impact of the quality and number of friendships (and family size; Spence et al., 1954), the author concludes that very few factors (e.g., smoking) can impact our health (physical and psychological) as much as being situated within a social support network (Dunbar, 2022; Santini et al., 2021).

While the impact of the quality of our social life on our health can also be attributed to neurophysiological events (e.g., endorphin release) associated with joint activities, Dunbar directs our attention toward other evolutionary benefits of having a healthy social life. Namely, we can rely on conspecifics for cooperation to achieve things we cannot achieve alone, access relevant information, protection, and emotional comfort. Therefore, it is essential to understand this theoretical framework (i.e., *the social brain hypothesis*) from the evolutionary perspective on which it is based. Dunbar's theory started to be developed in the 90s due to his research on primates' time budget (e.g., grooming time). Driven by the investigation of the relationship between grooming time, body size, and group size, he concluded that grooming time correlated much better with group size than body size does, making it evident that, although grooming could have primarily served a hygienic function, it seems that it has been also co-opted to serve social functions between individuals within a group (Dunbar, 2022, p.89-85). Therefore, Dunbar was driven towards the idea that the respective size of the group in a primate is situated, leading individuals to allocate social resources (i.e., grooming time) differently. Consequently, he proposed that in general, larger groups demand from individuals the employment of sophisticated cognitive capabilities. The confirmation of this hypothesis came to Dunbar in the results obtained from his investigation of the relationship between group size and primate neocortex size (Dunbar, 1992), which indicates a linear relationship between the two variables.

Contrastingly, he could not find the same linear relationship when analyzing the same features (i.e., brain and group size) in other species (i.e., birds, bats, carnivores, and ungulates; Shultz & Dunbar, 2007; Shultz & Dunbar, 2010b). For example, bird species that pair for life had larger brains (in proportion to their body size) than seasonal mating species and promiscuous species (Shultz & Dunbar, 2010a) living in larger groups. Later the relationship between brain size, group size, and foraging styles found in the research by Suzanne Schultz and Kieran Fox (2017), led Dunbar to conclude that the relationship between brain size was not related to the group size but to the complexity of social and ecological problems a species must face in a given environment (Shultz & Dunbar, 2010b; Dunbar, 2022).

Therefore, the evidence of a mutual relationship between the benefits and cognitive demands for maintaining friendships and building reliable and lasting affiliative ties, Robin Dunbar has been concentrating his work effort on the investigation of the number of affiliative relationships individuals may be able to manage, or in his own words, "…if friends are good for you, how many friends is enough?" (Dunbar, 2022, p. 40). The answer to this question (regarding humans) became known as *Dunbar's number* (150 on average). In his latest book, Dunbar mentions, for example, his investigation of data sets on small-scale societies (hunter-gatherers and traditional horticultural societies) indicating an average clan size of 148.4 individuals (Dunbar, 2014; Dunbar, 2022).

However, distinct affiliative relationships differ in many aspects. Dunbar did notice the different quality of relationships we can have within the proposed limited social network structures (e.g., in the case of small-scale societies). For example, although similar in most characteristics, *friends,* as Dunbar outlines, are mainly distinguishable from family due to the possibility of selecting the individuals we want to be affiliated with (while we cannot choose our family). In addition, some relationships are based on a sense "… of obligation and the exchange of favors" (Dunbar, 2021, p. 48) and also on the tendency to be in proximity and the proportion of time spent together. Due to these distinctions between the quality of affiliative relationships, Dunbar noticed that the 150 individuals (on average) within small-scale societies were not randomly distributed. Rather affiliative relationships of a given individual seemed to be distributed within concentric hierarchical layers of affiliative relationships that increase in size in a specific ratio (i.e., 3). More precisely, the author describes the structures of these social networks as being composed of an inner circle consisting of five individuals followed by a second circle of 15 individuals (including the first five in the inner circle), a third circle composed of 50 individuals including the first 15 and an outer ring composed in 150 encompassing all the previous (Figure 01).

Dunbar provides two distinct ways to classify individual peers within the specific layers. Firstly, the author proposes quantitative analyses of time allocated to social interactions. The innermost circle of close friends typically comprises about five individuals, for example, is composed of those individuals with whom one would be in contact at least once per week. In the following layers, we find those friends which whom one would interact at least once per month, once over six months, and at least once per year, respectively.

Dunbar's Circles of Friendship Schematic Representation

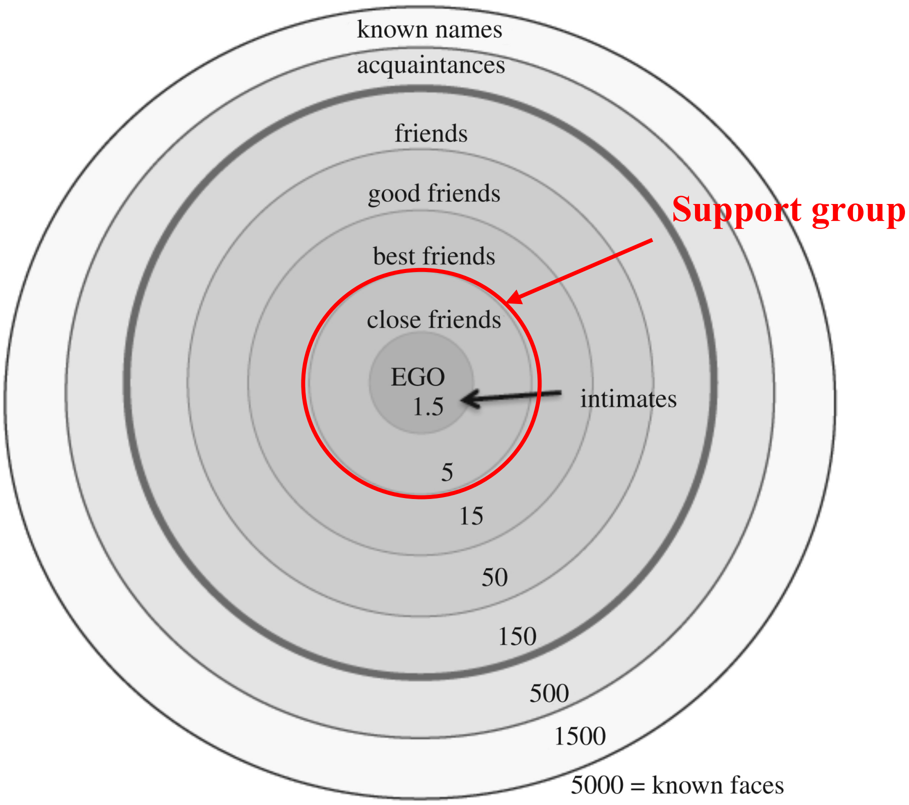


Figure 1. The circles of friendship. The circle termed ego (1.5) has a half digit that indicates that some individuals may have either one intimate partner or one best friend, or both intimate partner and best friend. The red circle indicates the support group. The subsequent circles are described below (up to the friend's *circle; n=150). The circle termed acquaintances (n=500) comprise individuals one knows by name and the last circle (n=5000) comprise individuals one is able to recognize by face. [Schematic representation adapted from Dunbar, 2022, p.121].*

Furthermore, the author also provides qualitative (and rather subject) criteria for allocating friends within each social network level. The *support group* corresponds to the innermost layer of about five close friends and is inhabited by those individuals who may provide "emotional, physical and financial help and advice." (Dunbar, 2022, p. 154). The *sympathy group* corresponds to the next layer of all of our best friends and is composed of friends we would invite for certain private events (e.g., dinner at our home). The good friends (typically around 50 individuals) are those friends whom we would invite for more intimate celebrations (e.g., a birthday party). Finally, the rest of the friend network would be invited for a more socially broader event (e.g., a wedding).

Living in a social group and keeping track of social interactions requires different cognitive capabilities (e.g., memory, categorization, face recognition). Dunbar theorized that managing different types of relationships (i.e., represented in the multilayered network; Fig 01) may require the employment of distinct cognitive capacities. For example, our ability to mentalize (i.e., the ability to infer another individual's mental state) might specifically constrain the number of individuals that we can maintain as closest friends (i.e., our *support group*). In other words, Dunbar claims that our competence to infer other individuals' mental representational states (e.g., intentions and beliefs) may constrain (enable or limit) the number of peers we can maintain as closest friends.

Therefore, in 2007 Dunbar and Stiller collected data from 65 participants (29 male; 36 female) to investigate this hypothesis. The participants were 18 to 65 years old and residents of the UK. These participants filled out questionaries on which they were required to provide information regarding their social ties and, in addition, to participate in a test to measure their competence in mentalization processes.

For the collection of data regarding an individual's social network size, participants were simply asked to rank the individuals with whom they have had contact in the last month (excluding working colleagues, professionals such as a dentist, and casual encounters). Participants were also asked to identify those who were kin and those whom they would be seeking for personal advice and comfort concerning major life problems, thereby qualifying for the conceptual requirements of the *support group*. For the mentalization competence, the participants received a series of stories depicting social contexts in which questions would have to be answered regarding the possible mental states or beliefs of their characters in different levels of intentionality (4 to 9 levels). Participants were also required to recall social facts about the story (memory test).

The results indicated that while the performance in the mentalization questions (the higher levels of intentionality answered correctly) was a predictor (or limiter) of the size of the *support group* (but not the *sympathy group*), the number of the correct answer for the memory test was correlated to the *sympathy group* (Figure 02).

Dunbar and Stiller's Linear Regression on Mentalization Competence and Support Group Size

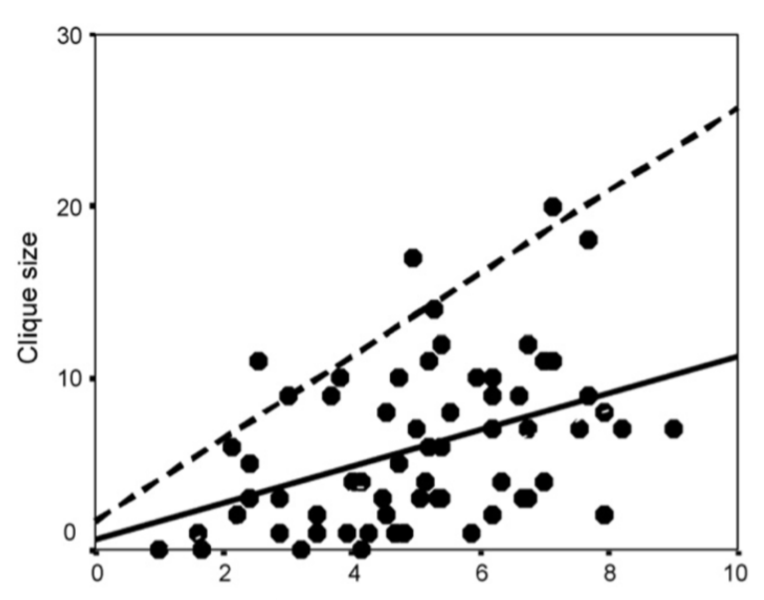


*Figure 2. Dunbar and Stiller's Linear Regression on Mentalization Competence and Support Group Size. The Y-axis (i.e., Clique size) represents the number of closest friends (i.e., support group) based on participants' answers in the questionaries. The X-axis represents the competence of participants to infer intentionality based on correct answers to the mentalization task employed by Dunbar and Stiller. The figure displays two regression lines, one for the direct relationship between the two variables (solid line) and one for the upper bound limit for the relationship between the two variables (dashed line). [*Figure adapted *from Stiller* and *Dunbar, (2007).*

Dunbar proposes that different species' number of interaction partners is constrained by socio-ecological and cognitive factors. Moreover, he presents evidence that an individual's competence to employ specific cognitive capacities has a direct influence on the size of a specific cluster of relationships. In the study described above the size of the cluster termed as the *support group* is directly influenced and/or limited by an individual's competence in "mind reading" capacities. Dunbar suggests that the correlation between competence in mentalization tasks and *support group* size may be due to humans' difficulty to cope with more than 5 levels of intentionality reading, thus, allocating this cognitive resource within the support group.

However, Dunbar does not attempt to explain or suggest how this selective apport of cognitive resources may be developed or how it may emerge at the begging of an individual's social life. Children are usually introduced to complex peer groups between the preschool age (2 to 6 years). During this stage, preschoolers have the opportunity to explore and foster both their cognitive capacities and the socialization dynamics within complex social environments (e.g., kindergarten). Therefore, it becomes relevant to investigate if the complexity of the context of peer group preschool children does influence children to allocate cognitive resources to a specific and select group of affiliative partners. Nevertheless, is it, firstly important to turn our attention to understanding what social dynamics preschool children may encounter during their first years within complex peer social groups.

1.2 Characteristics of peer groups and friendships in early and mid-childhood

The capability for cooperative and agonistic behavior as well as for sustaining dyadic relationships and representing group interactions is manifested early in infancy (after the first birthday) and is developed in parallel with the interactions with peers and caregivers (Hay et al., 2018, pp. 124-137). In the following years (2 to 6 years) preschoolers start to be integrated into peer groups (e.g., kindergartens) that provide varied opportunities for complex social interactions. Within these spaces, preschoolers may encounter peers of distinct ages, gender, and ethnical and cultural backgrounds. Moreover, children in this new social context begin to foster and practice their social competencies within a dynamic social group (Rubin et al., 2009).

Among the social dynamics that emerge in this context, researchers have given special attention to, for example, dominance (Vaughn & Santos, 2009), social and emotional competence (Linda & Denham, 2011), play behavior (Fromberg & Bergen, 2006; Singer et al., 2006) and peer selection (e.g., Coplan & Arbeau 2009; Ladd, 2009; Liberman and Shaw, 2019; Santos, 1990; Santos, 1993; Santos et al., 2008). Regarding the later contextual factor, two main modes of peer selection stand out: similarity (i.e., homophily) and prosociality (i.e., reciprocity). Similarities can be perceived in different ways by a child (Liberman and Shaw, 2019), and have been often investigated in the context of sex segregation (i.e., sex homophily; Strayer & Gauthier, 1984). Additionally, children have been reported as selecting play peers due to their prosociality competencies. In other words, children tend to affiliate with those individuals that tend to reciprocate prosocial behavior (e.g., sharing; Coplan & Arbeau 2009, p.148).

Both reciprocity and similarity are perceived by preschoolers as relevant factors for establishing relationships. Moreover, children also employ these parameters when inferencing the relationship status of other individuals in the group. Tracking third parties' relationship status is an important aspect of participating in social groups and provides individuals with relevant information about the group dynamic and how to maintain and build their own relationships (Pietraszewski & German, 2013; Liberman & Shaw, 2019). However, in addition to prosociality and similarity children also represent other individuals as friends based on proximity.

Liberman and Shaw (2019), conducted an experiment to investigate which of the three factors (i.e., proximity, loyalty, and similarity) children would be more prone to use in order to attribute a friendship status between individuals. The authors used a forced-choice method in order to inquire preschoolers (3 to 5 years old; n=174), and also older children, about which characters in a carton story they consider as friends. The relationship between characters in the story varied, based on spatial proximity (e.g., playing together), loyalty (e.g., sharing an object), and similarity (e.g., same food preference or same gender). While the answers that attribute friendship to aspects of loyalty increased respectably to the children's age, preschoolers consistently chose the factor of proximity in a relationship between the two characters as the most defining aspect of friendship (Liberman and Shaw, 2019).

Unsurprisingly, proximity has also been used as a methodological tool to access children's affiliative ties by researchers. The use of proximity as a parameter of assessment of friendship between preschoolers' has its onset in the works of Challman (1932) and Hagman (1933), these authors sought to expand the methodological tools (i.e., sociometric) by introducing direct observation to evaluate affiliative ties in preschoolers and teenagers (In addition to peer similarity and affiliative behavior; Ladd, 2009). Santos and colleagues (Santos, 1990; Santos, 1993; Santos et al., 2008) use of peer proximity derives mainly from the ethological tradition (i.e., nearest neighbor method; Kummer, 1968) argument that the "structure of animal society is directly reflected in the spatial arrangement of its members"

(Santos, 1993, p. 22). Hence, Santos (1990, 1993), suggests that an individual’s relative position within a social network could not be used to analyze the influence of the position on the employment of affiliative acts (Santos et al., 2008). Therefore, one of the arguments used by Santos and colleagues for the employment of spatial proximity as a metric for affiliative ties within a group lies in the unbiased nature of peer proximity (Santos et al., 2008).

Furthermore, some authors have suggested that proximity functions as a facilitator of social interaction (i.e., it creates an opportunity for social interaction to happen; Santos et al., 2008). Moreover, it is often the outcome of participating together in many affiliative activities related to friendships (e.g., playing together; for reviews, see Fromberg & Bergen, 2006; Singer et al., 2006). Interestingly, after the third birthday, children tend to decrease their frequency of solitary play in favor of parallel play (i.e., playing in proximity or monitoring other individuals) and subsequently engage more in social play (Coplan & Arbeau 2009, p.144). Researchers have pointed out that a gradual increase in social play participation may be related to an individual’s development of mentalization capabilities (Lee & Cameron, 2000).

1.2.3 Play and Mentalization

The importance of play in early Childhood is associated with a "...unique context for children to acquire, implement and master an array of critical skills that support and contribute to positive social interactions with peers."(Coplan and Arbeau 2009, p. 152).

These adaptive functions, in general, are related to having a safe space, learning many social abilities, asserting dominance, and emotional self-regulation (Coplan and Arbeau 2009, p. 149-151). In humans, however, the development of pretend play may implicate the development of children's competencies to attribute symbolic meaning and take others' perspectives about an object or situation.

Piaget (1962) is well known for his argument of the functional role of play in infants as means to the development of sensory-motor capabilities (when simply manipulating objects). Following the basis of the research on the topic, Coplan and Arbeau (2009) suggest a gradual increment of mentalization abilities in children's play, from understanding the functional properties of an object (i.e., constructive play) and, consequently, the later development of symbolic manipulation (i.e., sociodramatic, or pretend play; Coplan and Arbeau 2009, p. 148).

Therefore, play as a “safe space” to practice socialization mechanisms (e.g., mentalization or *Theory of Mind*) has become central to the investigation of some researchers on the subject (Smith, 2005). The importance of being able to understand the perspective of others within social interaction may implicate the essential role of mentalization in children's social development (e.g., Fitzgerald & White, 2003; Slaughter, Dennis, & Pritchard, 2002) and unbounded social play offers the place, time, and context for this development (e.g., Nielsen & Dissanayake, 2000; Young-Blade & Dunn, 1995).

The following section will present how the *Theory of Mind* in infants and preschoolers has been investigated in recent decades. However, the methodological approach in which this research unfolds does not always take a socio-ecological sensitive context (e.g., unbound social play). Nevertheless, the findings of several researchers on the topic have driven our understanding of how and when children develop the ability to represent and infer other agents' states of mind and effectively employ this knowledge within social interactions.

1.3 Mentalizing abilities in early and mid-childhood

Mentalization abilities in young children have been thoroughly investigated in the past decades. Most of this research has been concentrated on experimental settings aimed at identifying processes related to the *Theory of Mind* (e.g., false belief understanding). *Theory of Mind* (hereafter *ToM*) is defined as the individual ability to infer another individual's mental state (e.g., knowledge, goals, beliefs; Meltzoff 1999).

The well-known Sally-Anne experiment is the method most employed throughout the last four decades in the investigation of higher-order ToM mechanisms (i.e., false belief understanding). In the experimental setting, a child is presented with a story (enacted by the experimenter with puppets). In the story, Sally (the first character) places an object (usually a ball) within the box. Sally then leaves and loses visual access to the object and the location in which it was placed. When Sally is absent from the scene, Anne (the second character) changes the object's location (from one box to a different one). At the end of the story, Sally returns to scenes, and the child is asked, "where will Sally look for the ball?" If a child can indicate the first location (where Sally left the ball at the beginning of the story) as the correct answer, it demonstrates the child's capacity to understand that Sally holds a mental representation of the state of the world which does not correspond to the real state (i.e., Sally holds a false belief; Wimmer & Perner, 1983).

The replication of the experiment described and other similar experiments (e.g., smarties box; Gopnik & Astington, 1988), have constantly yielded the same result. Namely, children younger than four years struggle to provide the correct answer (Perner et al., 1987; Gopnik & Astington, 1988). These results lead researchers to term this age threshold as the age of the *cognitive revolution*.

However, other researchers have pointed out the problematic setting in which the experiment is presented to younger children. The design of the traditional experiments has been pointed out as too demanding for younger children, a few reasons are due to the reliance on verbal operationalization of the task, or the overall understanding younger children have of the task. Some researchers have employed specific methodological tools to test younger infants in response to this problem. For example, the results obtained in eye tracking paradigms indicate 25 months children (anticipatory looking; Southgate et al., 2007). Another non-verbal experimental setting (distinct from eye tracking) found that infants as young as 18 months may already understand that other individuals possess false beliefs (Buttelmann et al., 2009). These results may suggest that the aforementioned clear bounders of cognitive development (i.e., the cognitive revolution age) may, rather, represent a continuum of cognitive capabilities and competencies (Wellman et al., 2001). Moreover, these results also strongly indicate that the ability of children to employ certain mindreading capacities is directly affected by both, the complexity or specific configuration of the task at hand and an individual's age.

In summary, mentalization has been broadly associated with and described as the mechanisms involved in inferring other individuals' mental representations (e.g., goals, beliefs, knowledge). Assessing these sociocognitive constructs, however, relies mostly on well-controlled experimental settings. Investigating mentalizing capabilities within an ecologically valid context and through observations of naturalistic interactions presents a great challenge for researchers. Focusing on seemly less complex and developmentally earlier abilities that underlie mentalizing processes, such as understanding and using joint attention, might provide a good proxy for children's mentalizing capabilities that is easier observable through ethological methods and within a socio-ecological sensitive context.

Therefore, the following section will outline the developmental parallels between joint attention capabilities and later and more sophisticated socio-cognitive constructs and will present the argument that these parallels may provide a relevant age appropriated proxy for children's mentalization competencies and elaborate on the role of pointing during infant interaction.

1.4 Mentalizing, joint Attention, and Pointing gestures

Joint attention relies upon mutual monitoring of attention, directing, or responding to a request for attention. In other words, two individuals engaged in joint attention have mutual knowledge that the partner attends (or can attend) to the same entity in the environment (Bruner, 1995; Carpenter et al., 1998; Tomasello, 1995). It thus depends on capacities that allow the inference of another individual's mental content (e.g., monitoring the other's visual perspective). However, joint attention is not equivalent to an event in which two individuals simultaneously attend to the same direction in the environment (we both may look in the same direction but attend to different aspects of the environment).

By the end of the first year of age, infants manifest the ability to follow or direct adults' visual attention toward particular aspects of the environment (Carpenter et al., 1998). Moreover, researchers have also pointed out the increased sophistication that this social behavior undergoes between the start and end of the second year of life (; Bruner, 1995; Carpenter et al., 1998; Tomasello, 1995).

Carpenter and colleagues (1998) subdivide joint attention into three main categories, sharing attention (sustained visual attention between two individuals toward a particular aspect of the environment), following attention (gaze following, pointing following, imitative learning), and directing attention (e.g., pointing gestures). Pointing gestures can be divided into two distinct function purposes, imperative Gestures (i.e., Gestures aimed at directing another individual's attention toward something) and declarative gestures (i.e., gestures aimed at directing another individual's behavior toward a specific goal; Carpenter et al., 1998).

Furthermore, the relevance of pointing within the context of the study of socio-cognitive development has been a subject of investigation and debate for over 80 years (Rieber, 1997; Vygotsky, 1962/1986). Pointing gestures seem to be a core tool for initiating joint attention in young children, as it is a pivotal part of human communication skills and early participation in socio-interaction. Pointing gestures are increasingly present as a protodeclarative expression and communicative tool for infants from 12 months of age.

Additionally, developmental studies indicate that joint attention skills are related to developing early socio-cognitive skills that enable infants to understand others as intentional agents (Carpenter et al., 1998, Desrochers & Morissette, 1995, Tomasello, 2005). For instance, Carpenter and colleagues (1998) suggest that the employment of joint attention by infants relies on two subsequent developmental phases: the prior understanding that other individuals have some kind of psychological stance (i.e., attention and intentions towards outside entities) that is different from their own (i.e., knowing that) and the later capability to determine the content of the psychological state (i.e., specific attentional and intentional relation between agent and outside entities) of other individuals (i.e., knowing what).

Hence, the similarities between the main requirements for joint attention and the *ToM* have driven researchers to investigate the relationship between these distinct developmental cognitive milestones. Tomasello (1995), for example, outlines the main requirements for joint attention along the same lines as the *ToM* (Tomasello, 1995; Tomasello et al., 2007). The author suggests that likewise *false belief understanding* (at the age of four), during the second year of life, infants develop the understanding that other people have intentions, that these intentions might differ from their own, and that these intentions may not correspond to the current state of affairs (Tomasello, 1995; see also, Camaioni et al., 2004; Carpenter et al., 1998; Tomasello et al., 2007)

In addition, Tomasello (2007) outlines the distinct layers of cognitive events on which the later and more sophisticated act of pointing is embedded. The author highlights that pointing is about the external referential to be communicated. Instead, it is also about the meaning of the act when encompassed by its *communicative intention* and *relevance* (Pust et al., 1997; Tomasello et al., 2007; Wilson & Sperber, 2002).

The author emphasizes that the act of pointing is a communication tool that relies on the circumstance that the two partners in communication share a specific representational context which enables pointing to acquire relevance for the subject of the point during the communication act. In other words, the later employment of pointing (after the second birthday) is expected to take advantage of *common ground* (Clark & Brown, 2006; Clark, 2020) or *shared representational space* (Oláh et al., 2019). This common ground can take many forms of shared knowledge (e.g., technical, cultural, or contextual).

Therefore, pointing gestures must rely on the assumption that we both know what is relevant about the pointing because one can project the communication partner's mental representation before the pointing and what it will be in consequence of the pointing. Alternatively, as Buner describes:

"…its most sophisticated level, joint attention is, in effect, a "meeting of minds." It depends not only on a shared or joint focus[,] but on shared context and shared presuppositions." (Bruner, 1995, p. 6)

Furthermore, recent studies have indicated an even closer relationship between competence in *ToM* and informative pointing in preschoolers. Cochet and colleagues (2016), for example, have used two questionnaires to access children's (36 to 48 months; n=37) *ToM* competencies. One of the questionaries required the answer from primary caregivers on the competencies of a child's capability to infer others' states of knowledge, beliefs, and desires. The second questionaries addressed children's answers regarding the state of mind of fictional characters in an illustrated story (Scaling of Theory of Mind Tasks-STM; Wellman & Liu, 2004). Additionally, the researchers used socioecological sensitive methods to collect two types of declarative pointing stances: *Declarative expressive pointing* and *Declarative informative pointing.* In summary, Cochet and colleagues (2016) found that declarative informative pointing frequency does correlate with performance in the STM (see Figure 03).

Cochet and colleagues (2016) linear regression on Pointing and ToM

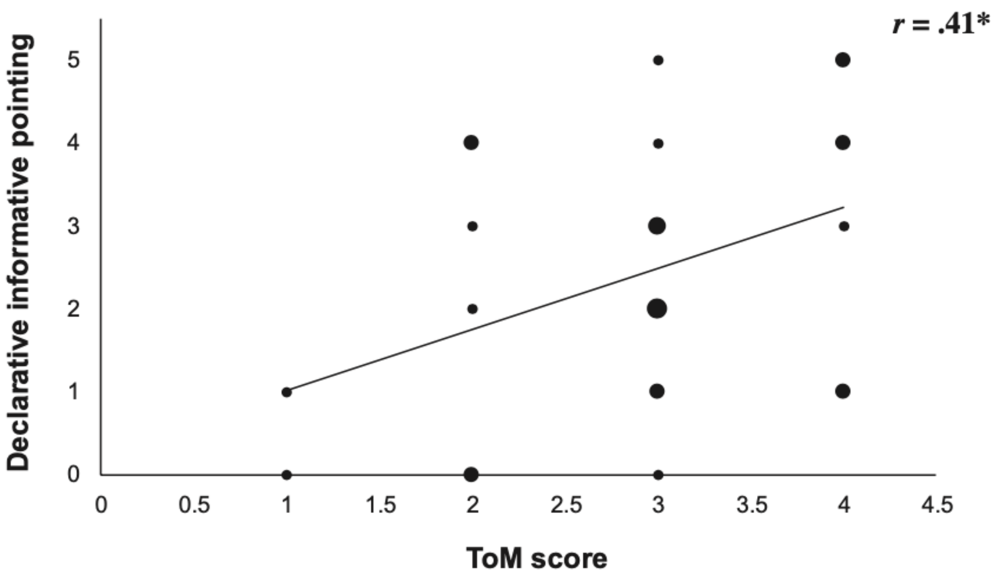


Figure 3. Cochet and colleagues (2016) linear regression on Pointing and ToM. The figure displays in the X-axis preschoolers' scores on the Scaling of Theory of Mind Tasks-STM. In the Y-axis, the figure represents the number of successful trials in which children produced declarative informative pointing. The size of the points represents the number of individuals with the same ToM score and declarative informative pointing (n=1-4). Figure adapted from Cochet and colleagues (2016).

Likewise, a longitudinal study conducted by Sodian & Kristen-Antonow (2015) investigated pointing production (in a controlled interaction with an experimenter) at 12 months and *ToM* (i.e., false belief understanding tasks) at 50 months old children. The findings indicate that the production of declarative pointing does predict the performance of children at a later age in sophisticated *ToM* tasks (Sodian & Kristen-Antonow, 2015).

Therefore, children's use of pointing gestures indicates an aspect of joint attention (i.e., joint attention request) that promises to be a valid indicator of mentalizing abilities at preschool age. Moreover, pointing gestures occur often in children's natural interactions and are easy to observe. This offers a great opportunity for testing the association between early mentalizing abilities and the number of closest friends that make up one's *support group* proposed by Dunbar (2017) in social groups of preschool peers.

1.5 Study aim and hypotheses

I employed an ethological approach composed of behavioral observation of peer proximity and interactions within an ecologically relevant setting (i.e., free play).

This thesis consists of two parts with complementary research questions:

(1) Are preschool children's social networks composed of hierarchical affiliative clusters and can one identify the innermost group of close friends (i.e., the *support group*)? What is the variation in the size of this cluster among preschool children and which factors affect this variation?

(2) Does the use of pointing gestures as a proxy for preschoolers' mentalizing skills predict the number of children's close friends within the *support group*?

To answer these questions, I used existing video recordings of three preschool peer groups recorded during free play sessions. To answer the first question (1), I conducted an exploratory investigation of the structure of preschoolers' affiliative networks. To answer the second question (2) I conducted a confirmatory investigation of the relationship between preschoolers' ability to successfully employ socio-cognitive resources and the number of their affiliative relationships.

In line with Dunbar and Stiller's (2007) findings in adults, I predict (1) that I can use observations of peer proximity and interactions to identify the *support group* and quantify individuals' number of close friends within this cluster. Moreover, I predict (2) that an individual's number of pointing gestures, as an age-appropriate proxy for the successful employment of socio-cognitive resources and mentalizing abilities, will be positively related to the size and relative proportion of their *support group*.

2 Material and Methods

The video recordings were conducted between February and April of 2018 and were made available for this project's behavioral coding and data analysis. The material consists of 10 video recordings of 30-50 min, for each group (n=3), of unrestricted playtime (with the presence of one or multiple preschool teachers in the room) within separate childcare facility rooms.

2.1 Sample

The sample consisted of 65 preschoolers (M=42; F=24) between 1.91 and 6.75 years of age (mean age: 4.3 years) who were members of three different groups. The groups' varied in size, age distribution, and sex ratio (see *Table* 2, and *Table* 3). The children were observed and recorded during unrestricted free play in a childcare facility in Vienna-Austria within an interval of 6 months. Each participant integrates one of three groups.

Ethical approval for the collection and use of the video material was obtained from the ethics committee of the University of Vienna. In addition, the children's legal guardians and kindergarten teachers gave written consent for collecting and using the video material.

2.2 Video Coding

The coding procedure followed an ethogram (appendix 2) composed of one variable for *proximity,* one variable for *pointing,* and one variable for insufficient visibility of the focus subject (i.e., *out of sight*). Moreover, within the possibility of identification of the interaction partner(s) during the proximity and joint attention events, the respective *partner(s) ID* was included as a modifier for the first two variables mentioned above. The coding process was carried out using the open-source software Boris (Boris v. 7.12.2; Friard & Gamba, 2016).

2.2.1 Ethogram

The ethogram was based on the developmental psychology literature on joint attention and preschool children's social network analysis. This ethogram defines the proximity event as the distance between two agents ranging from 0 to 1m (Messinger et al., 2019). Insufficient visibility of the focus subject was defined as an impossibility to ascertain the subject's identity and/or spatial location.

Joint attention requests were assessed by observing and coding one type of event.

Pointing: Gesture (visually accessible to a communication partner) towards some feature of the environment (e.g., object, situation, other individuals), performed to direct pattern attention towards this feature (i.e., declarative) or direct partners behavior towards a specific goal (i.e., imperative) (Mundy et al., 2003; Tomasello et al., 2007; Cochet & Vauclair, 2010) (see appendix 01).

2.2.2 Coding procedure

The coding procedure relied on a sampling scan for *proximity* and *out-of-sight* events (15s interval). Therefore, the video was paused at each interval, and all visible individuals within the given frame received the appropriate proximity attribution based on the definition established in the ethogram. Contrastingly, all instances of joint attention requests were recorded from continuous video observations via event sampling.

Multiple individuals in proximity to the focus subject were considered for the proximity coding. Moreover, the attribution of proximity instances for a given subject did not rely on the specific type of activity (e.g., playing, talking, walking together) or interaction (affiliative or agonistic) between the focus subject and the partner within proximity. Therefore, proximity was attributed between individuals, whereas the video frame relative to a sample scan (1) enabled the identification of both individuals, and (2) the assessment of the distance between these individuals. Proximity instances were only considered within the peer group individuals, and proximity to adults in the room was not attributed to any subject.

The pointing gesture event was attributed to any child that could be observed on video at the moment the gesture was displayed. The culturally usual form of pointing was predominant during the observation phase (i.e., extended index finger). Even though the probable partner to which the gesture may have been intended, may or may not respond (e.g., turn the gaze/head towards the pointing direction) or notice the gesture, every instance of pointing was considered on the bases of the visually accessible display of the gesture by a given subject. Pointing gestures were counted in bouts. Two pointing instances were counted as part of the same bout as long as these instances happened within the interval of 5 seconds.

Other distinct (and much less frequent) types of pointing attributed during the behavioral observation were pointing with an open hand (i.e., all fingers extended), pointing with the use of an object (e.g., using a pencil to drive another individual's attention towards something) and pointing with one of the feet. The pointing gesture must have been fully displayed on the video. Thus, in instances in which a pointing gesture was likely to have happened (e.g., referencing to an object inside of the box), but the subject's hands were not visible (e.g., hands inside of the box) were not considered and the *pointing* event not attributed to the given subject.

2.3 Data treatment

The data obtained from the coding process was cleaned and prepared for data analysis in the open-source software R (Ihaka & Gentleman, 1996). The same software was used for the posterior analyses of the yielded product of data treatment.

The information regarding the observation time (sum of video recording time per child) is summarized in *Table* 01. The total amount of time of observation for a given individual was calculated as the number of valid scans (the individual was visually accessible) divided by 240 (this being the number of scans of 15 seconds interval within 1 hour). Only one individual (from group A) out of 66 was excluded from the data due to insufficient observation time (6 minutes), all instances of proximity with this individual were also excluded from the data.

Table 1. Observation time by Group. The total time column indicates the total amount of time for video recording per group. The individual mean time column provides information on the average time of observation time per individual. The individual SD column provides the standard deviation between individuals' observation time within a given group.

Observation time by Group

	Total time	Individual Mean	Individual SD
Grup A	8 hr 06 min	5 h 39 min	54 min 28 sec
Grup B	7 hr 42 min	3 h 55 min	1 hr 20 min
Grup C	8 hr 06 min	3 h 50 min	1 hr 36 min

2.3.1 Proximity and rank order of most frequent proximity partners

All instances of proximity coded during the behavioral observation were direct counted within a table (sum(prox)) and the number of scan events on which an individual did not have a partner was subtracted from the total (sum(prox-prox(none))). Following, the sum of individual proximity events for each peer was divided by the sum of the total amount of proximity events on which the child was observed, yielding the relative frequency on which the subject has been in proximity with another specific individual (relative proportion of proximity time = sum(individual proximity with a specific peer) / sum(total proximity)). Subsequently, a rank order was attributed to each partner's relative proportion of proximity time. The partner with whom a given individual spent proportionally the most time received the first in rank. The subsequent partners were allocated to the rank position relative to their respective proportion of proximity time with the same individual.

2.3.2 Obtaining the number of the support group

The relative proportion of time was used as a dependent variable (Y-axis) in the scree plot that has the peer rank in its X-axis. From visually exploring this graph (Figure 04) it became obvious that most individuals spent a larger proportion of time in proximity with very few partners at the left-hand side of the X-axis. Consequently, most individuals spent very little time with the majority of their peers. The relative proportion of time and the rank were the basis for calculating a knee value (i.e., point of maximum curvature) on the scree plot.

Example of an Individual Proportional Proximity time and Peer Rank

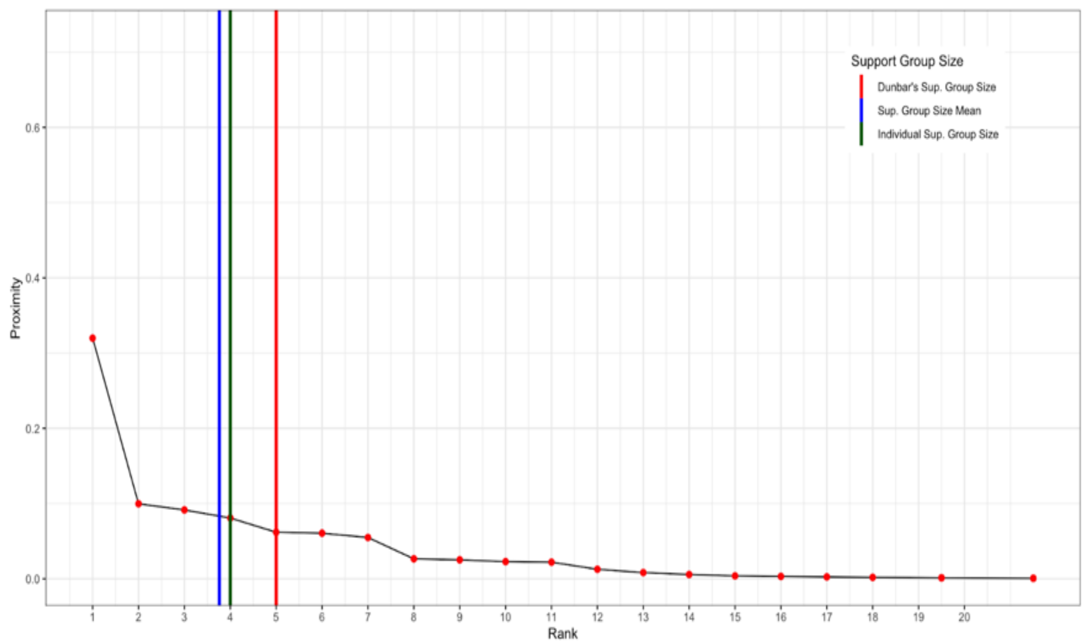


Figure 4. Example of an Individual Proportional Proximity time and Peer Rank. The X-axis shows the rank of interaction peers. Y-axis shows the respective proportional time spent with the individual in the x-axis. The red vertical line display Dunbar's predicted support group size (5). The green vertical line displays individual support group size (knee point minus 1). Blue line display group averages support group size.

The knee value was calculated using the *Kneedle algorithm* (Satopaa et al., 2011). The algorithm provided the necessary threshold that defines the statically relevant number of peers within each individual's innermost layer of affiliative relationships. The sensitivity of the knee value (i.e., 1) was selected due to the proximity of the individual value yielded to each subject to the overall mean *knee value* of the group. Lastly, the subtraction of 1 was applied to the knee value obtained through the kneedle algorithm. This subtraction was necessary to account for the number of individuals within the statistically relevant side of the curve, thus excluding the value found at the threshold. The value obtained for this variable represents the number of friends each individual has within their *support group*.

2.3.3 Pointing

All instances of pointing gestures coded during the behavioral observation were direct counted within a table (sum(*point*)). The number of pointing instances was then divided by the total amount of hours a respective child was an observer. The product of this division yielded the value of *frequency of point per hour* (*point_hour* = sum(*point*) / ((sum(*valid scans*) / 240)).

2.4 Analyses Plan

The analysis plan follows four different phases: (1) descriptive analyses of the group's age and gender variables, (2) investigation of group affiliative structure and *support group size,* (3) descriptive analyses of *support group size* and *pointing frequency* variables, and (4) the test of the effect of *pointing frequency* on the *support group size*.

The first phase of the data analysis consisted of the organization and summary of the three groups' sample characteristics through descriptive statistical methods (e.g., range, mean, median, and standard deviation). The summaries provided relevant information for the evaluation of the age and sex ratio variables distribution, spread, and central tendencies. Age was normally distributed (K = -.012, p = .42). Therefore, parametric stats were used in all statistical analyses with the variable age. A one-way ANOVA test was performed to test the effect of the age difference between groups in the overall sample, and a post hoc test was employed afterward (*Tukey Honest Significant Differences*). The difference between groups regarding the gender variable (gender distribution) was also tested with the same purpose. In this case, a ranked-based test was employed (i.e., the *Chi-square* test). These two variables were tested to guarantee that further analyses could be applied and generalized to the overall sample, or alternatively, applied to each group separately.

In the second step, the characteristics of each group's affiliative structures and individual frequency of peer proximity were analyzed in order to investigate the existence and size of the support group. Firstly, the proportional proximity time of each individual to a respective peer was first inserted into a matrix object on which the Euclidean distance between pairs was calculated. This calculation generated a graphic representation (i.e., dendrogram) of the affiliative structure within each group. For each group, a scree plot (appendix 4-6) was used to infer the possible optimal number of clusters per group, and a k-means calculation was used to analyze the fitting of an optimal number of clusters.

The *support group size* value obtained (through the *kneedle algorithm*) was averaged by the group and for the overall sample (i.e., group and overall *support group size*). The individual values of *support group size* for the overall sample and each group separately were compared (one-sample Wilcoxon) to the support group size proposed by Robin Dunbar (i.e., 5; Dunbar, 2007).

In the third step, a *Shapiro-Wilk's* method test indicates that the variable *support group size* is not normally distributed for the overall sample ($W = .938$, $p < .01$) and is moderately positively skewed ($K = .720$). Therefore, a non-parametric test was employed in the statistical analyses of the mean difference between groups (*Krustal Wallis test*). The individual *support group* size values were also tested in relation to gender (*Mann Whitney-U test*) and age (*Spearman's* correlation) in order to establish if there was an influence of these variables on the further analysis based on the size of *support group*s. The same analysis and statistical tests were used for each group separately in order to, once more, guarantee that group distribution for age and gender did not affect the overall sample analyses.

The normality test also indicates that the variable *pointing frequency* is not normally distributed for the overall sample (W = .951, p = .01) and is moderately positively skewed (K = .620). Therefore, a non-parametric test was employed in the statistical analyses on the mean difference between groups for this variable (*Krustal Wallis test*). These values were also tested concerning gender (*Mann Whitney-U test*) and age (*Spearman's* correlation) effect on support group size. The same analysis and statistical tests were used for each group separately to, once more, guarantee that group distribution for age and gender did not affect the overall sample analyses.

In the fourth and last phase of the data analyses, a multiple linear regression was used in order to test the hypothesis (i.e., does *pointing frequency* predict *support group* size?) of a possible effect of pointing frequency on the size of the *support group.* The same hypothesis was investigated in each group separately by employing static tests (*Spearman's* correlation) that could account for the reduced size represented by each group sample. This correlation test also controlled for the age variable within *Spearman's* partial correlation test.

3 Results

3.1 Descriptive analysis of the sample characteristics

Detailed descriptive information about the overall sample and the three individual groups is presented in *Table* 02. The three groups differed significantly in age (F(2,62 = 3.843, p = .02). A post hoc test for unbalanced sample size indicates that Group B was significantly younger than Group C (p = .03) but not statistically significantly different than group A (p = .05) (Figure 05).

Table 2. Summary Table: Age in Months. The table provides information on the central tendency (median and mean) and spread (range, variance, and standard deviation) of the age variable for each group and the overall sample.

Summary Table Age in Months

	min	max	range	median	mean	var	std.dev	coef.var
Group A	38.00	81.00	43.00	53.00	55.22	115.54	10.749	0.195
Group B	23.00	71.00	48.00	40.50	45.40	242.15	15.561	0.343
Group C	29.00	78.00	49.00	55.50	55.95	213.19	14.601	0.261
Overall Sample	23.00	81.00	58.00	52.00	52.45	204.06	14.285	0.272

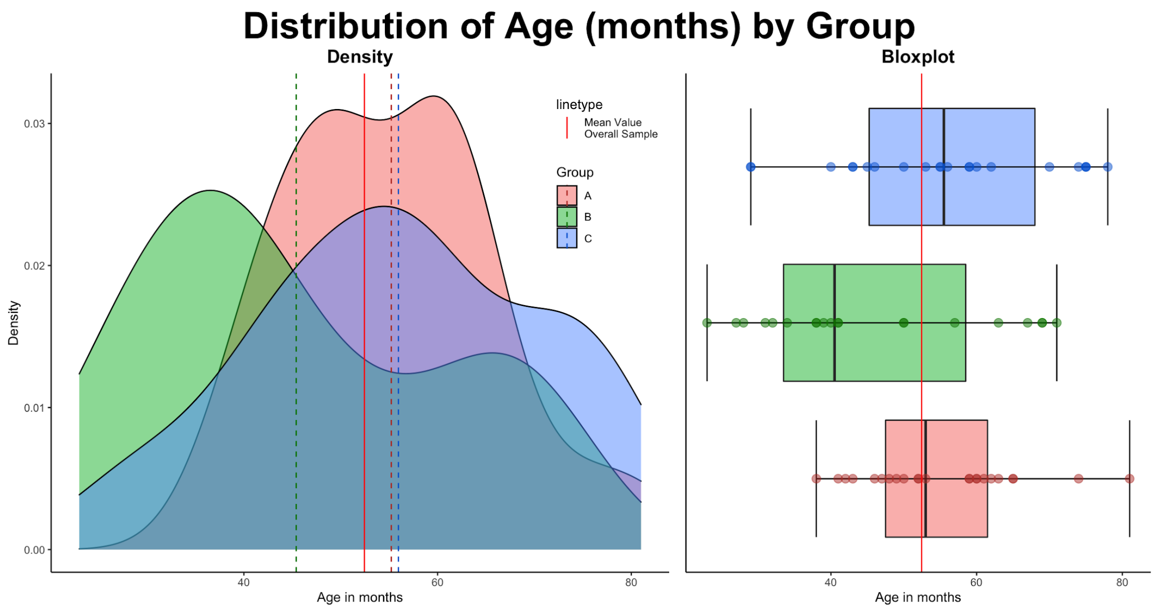


Figure 5. Density and Boxplot Age distribution. The figure displays a density plot (left) and a box plot (right) on which each group's age distribution can be seen. The red vertical line indicates the mean value for the overall sample. Dashed lines correspond to their respective group mean value

There were more male participants than female participants in all three groups (Table 03 and Figure 06)and for the overall sample (M:F = 1:0.52). There was no significant difference in gender distribution across groups ($X^2(2, N = 65) = 1.6115, p = .44$).

Table 3. Summary of gender distribution by group. The table displays the number of males, number of females, total number of individuals, and sex ratio by group.

Summary Gender Distribution

	Female	Male	Total	Ratio
Group A	10	13	23	(M:F=1:0.77)
Group B	5	15	20	(M:F=1:0.33)
Group C	8	14	22	(M:F=1:0.57)
	23	42	65	

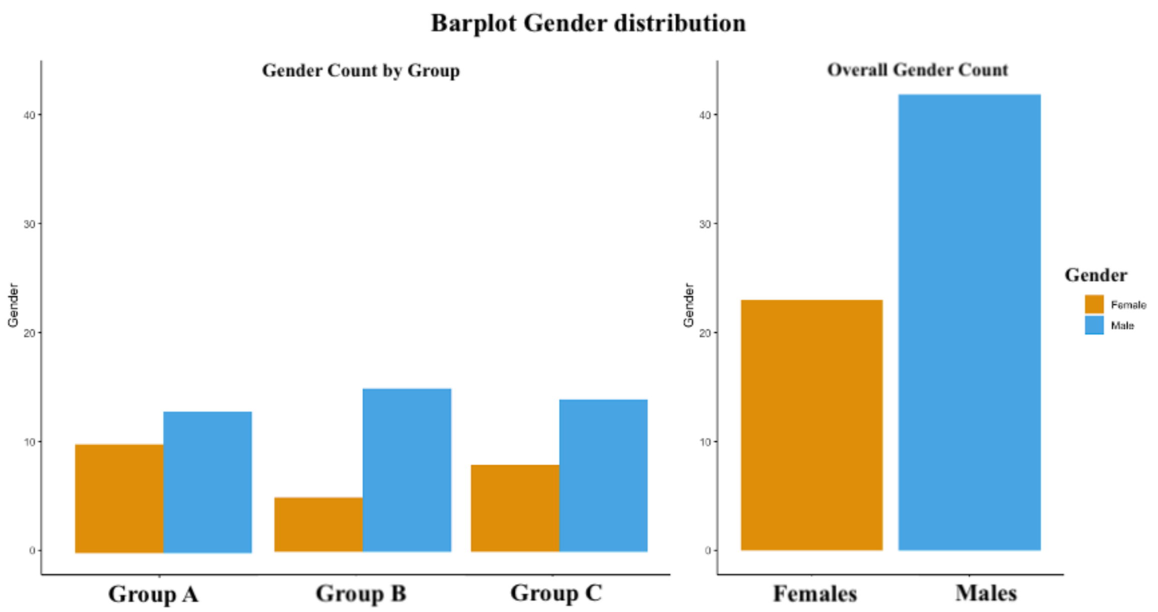


Figure 6. Gender Distribution. The bar plot displays the count of males and females within each group and for the overall sample.

In summary, the first phase of the statistical analysis indicates that there is a significant age difference between the groups, whereas the groups do not differ in their gender ratio. The difference in age between groups is likely to affect the further investigations applied to the overall sample. I, therefore, decided to look at the effect of age on the variables of interest in the overall sample, between groups, and within groups at each step of the data analysis.

3.2 Research question 1 - exploring the social group structure

The Euclidean distance between each pair was calculated. The value representing this distinction is represented in the dendrogram as an elbow placed at a relative distance between pairs (i.e., height). This graphic representation (Figures 06-08) allows the inference of specific affiliative structures with each group (i.e., cluster analysis). The k.means indicate that the number of clusters inferred from the knee explains 80.6%, 83.5%, and 82.4 % for Group A, B, and C variance in the sum of squares by cluster respectively.

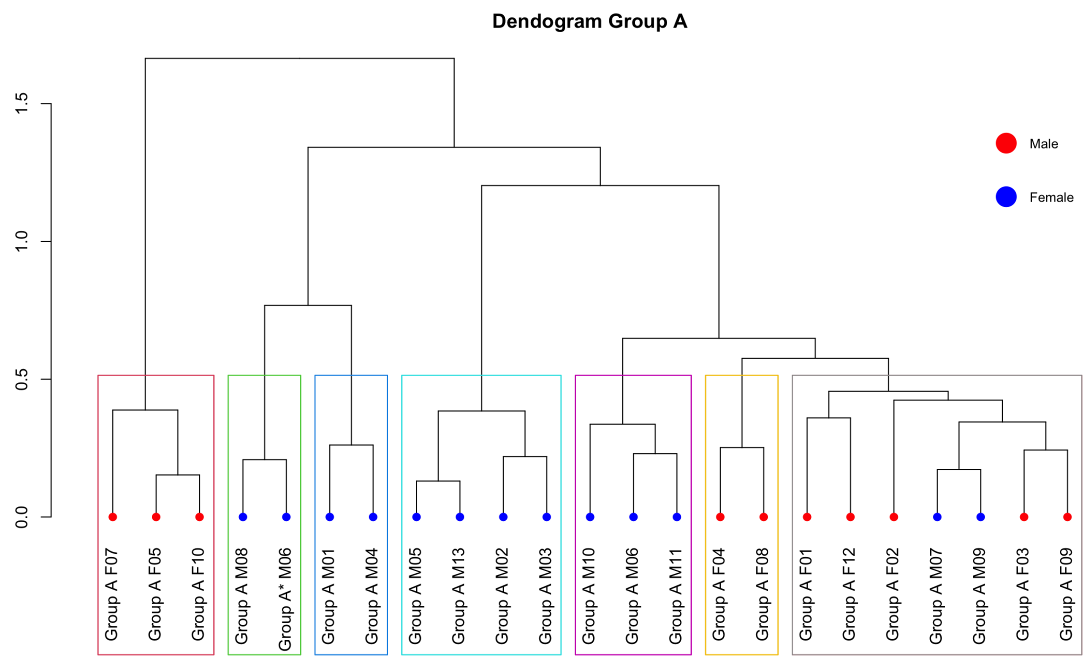


Figure 7. Cluster dendrogram Group A. Height represents the Euclidean distance between leaves. Nodes display the least distance between branches. Colors represent individuals' gender. Squares show clusters.

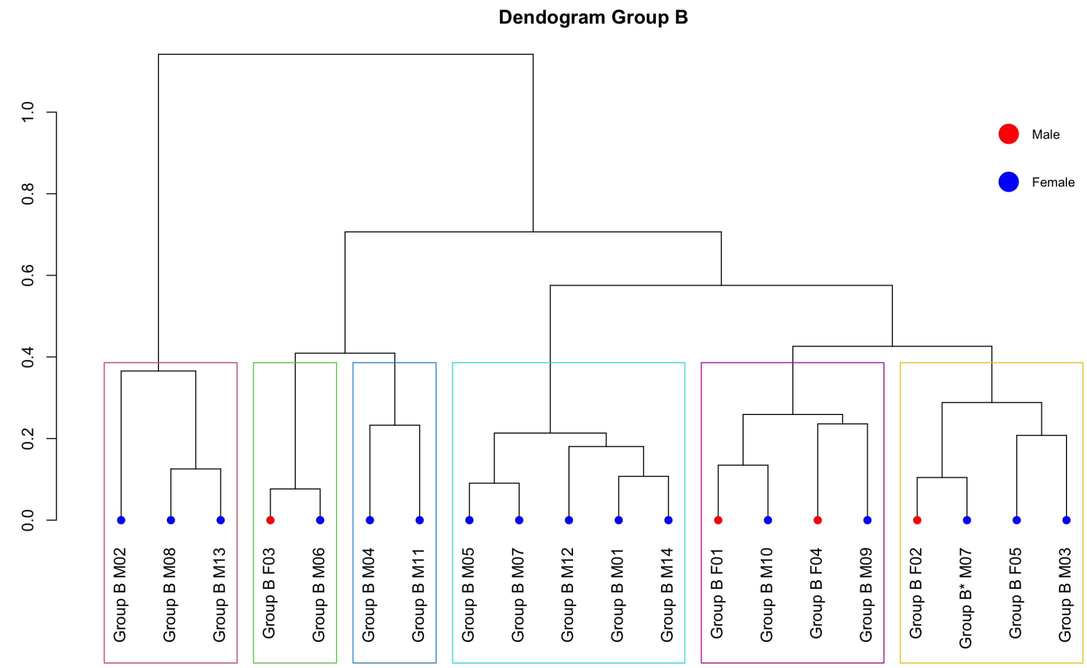


Figure 8. Cluster dendrogram Group B. Height represents the Euclidean distance between leaves. Nodes display the least distance between branches. Colors represent individuals' gender. Squares show clusters.

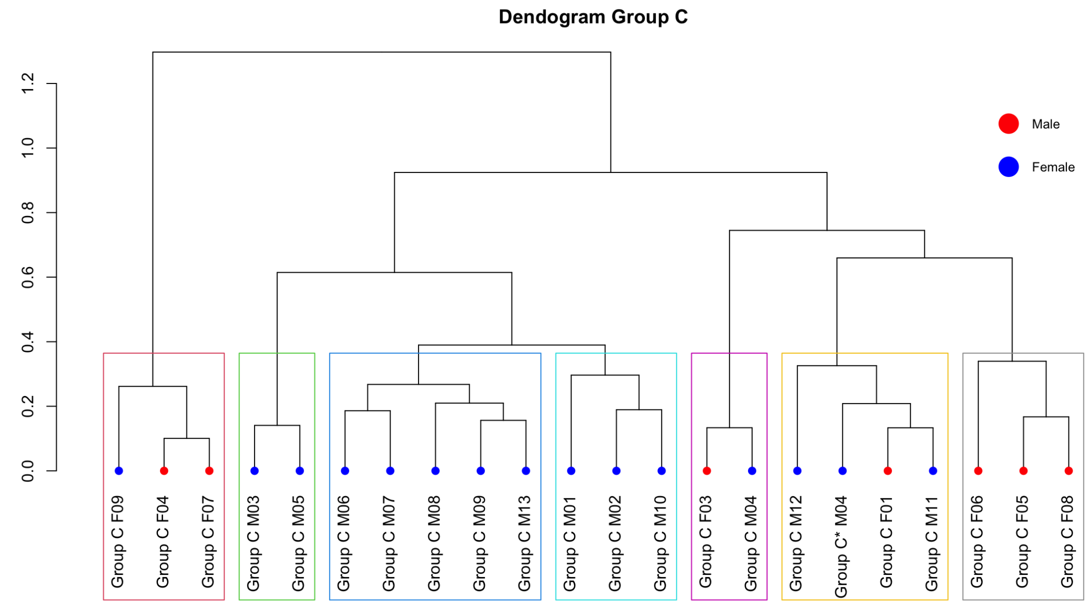


Figure 9. Cluster dendrogram Group C. Height represents the Euclidean distance between leaves. Nodes display the least distance between branches. Colors represent individuals' gender. Squares show clusters.

Using the kneedle algorithm (described in detail in the section data analysis), I additionally identified the overall/mean number of the support group size for each group). The scree plots (Figure 10-12) show the Y-axis as the proportional time an individual spent with each peer (i.e., peer equals one data point). The X-axis displays the relative rank of each peer. The vertical solid blue line shows Dunbar's prosed average *support group size.* The vertical dashed blue line shows the *group support size* mean value. All the other colored lines represent a respective individual within the group.

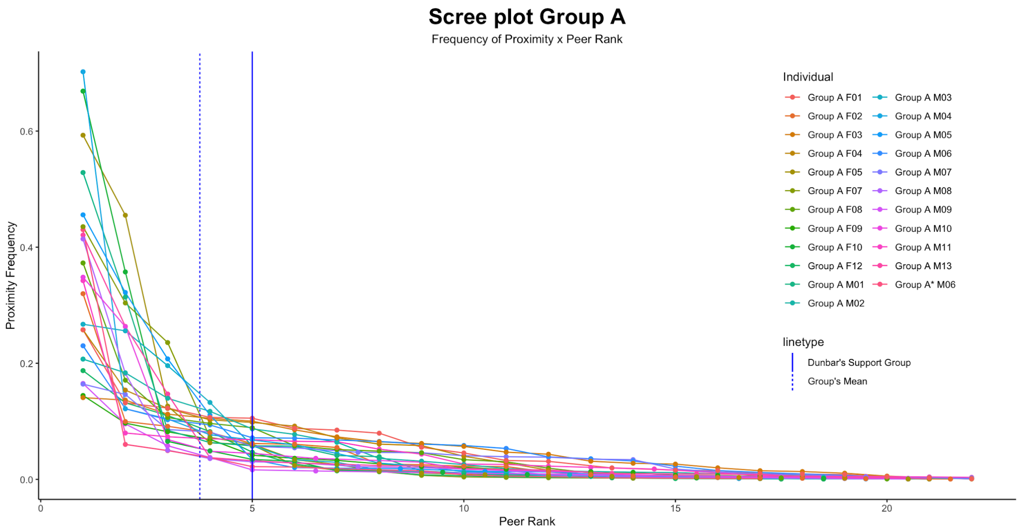


Figure 10. Scree plot Group A. The image display in the y-axis the proportion of proximity time spent with a peer. The x-axis displays the peer rank of the respective individual with the proximity time in the y-axis is shown. Lines represent individuals. The solid line shows Dunbar's proposed support group size. The dashed line shows the group's mean support group size.

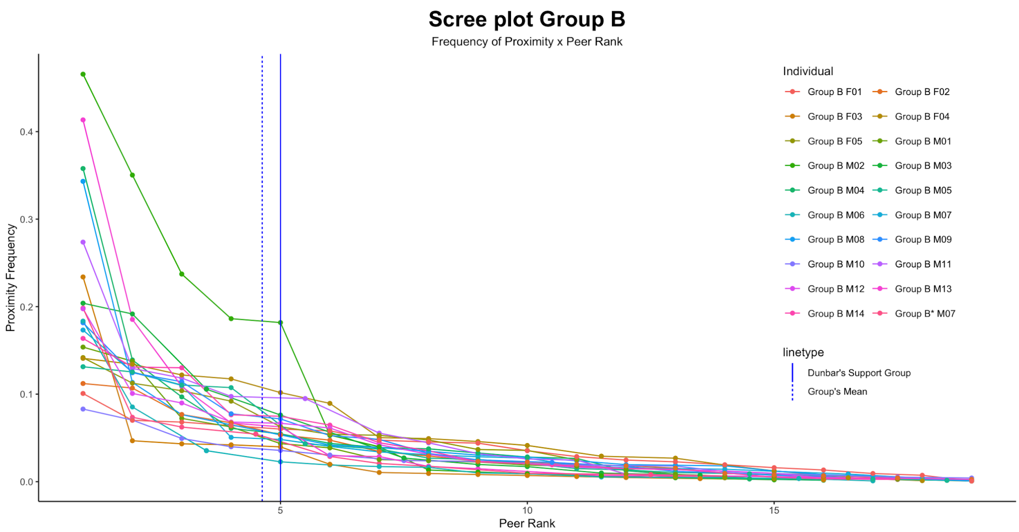


Figure 11. Scree plot Group B. The image display in the y-axis the proportion of proximity time spent with a peer. The x-axis displays the peer rank of the respective individual with the proximity time in the y-axis is shown. Lines represent individuals. The solid line shows Dunbar's proposed support group size. The dashed line shows the group's mean support group size.

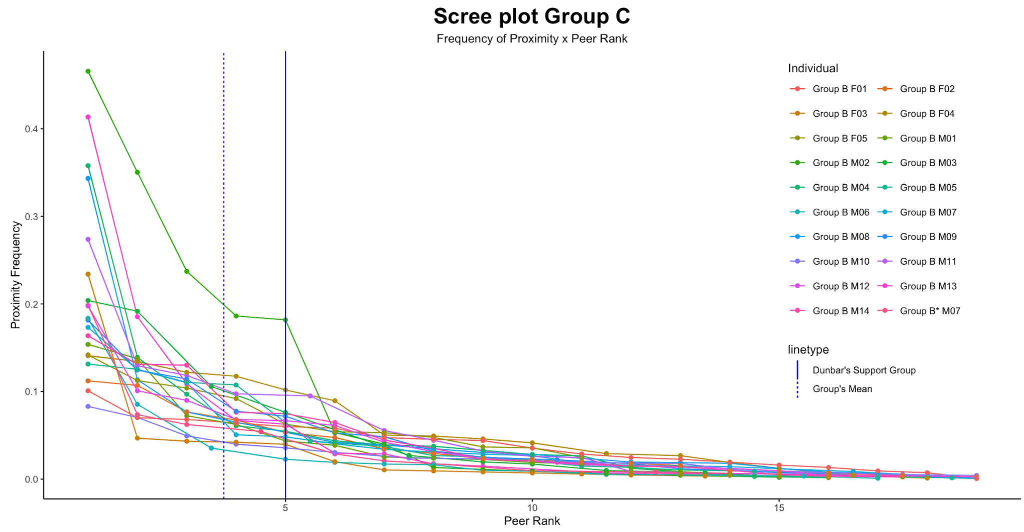


Figure 12. Scree plot Group C. The image display in the y-axis proportion of proximity time spent with a peer. The x-axis displays the peer rank of the respective individual with the proximity time in the y-axis is shown. Lines represent individuals. The solid line shows Dunbar's proposed support group size. The dashed line shows the group's mean support group size.

A one-sample Wilcoxon test was used to investigate if the number found as the values for *support group size* (*Table* 04) is significantly different from Dunbar's proposed support group size (i.e., 5 individuals). The test results indicate that for the overall sample the values for average *support group size* differ significantly from 5, the same result was obtained for groups A and C but not for group B which displayed a not significant difference from the value (z = -0.7663, p = .44).

Table 4. Summary Table Support Group Size. The table provides information on the central tendency (median and mean) and spread (range, variance, and standard deviation) of the support group size variable for each group and the overall sample.

Summary Table Support Group Size

	min	max	range	median	mean	var	std.dev	coef.var
Group A	1.0	10.0	9.0	4.0	3.76	4.36	2.09	0.56
Group B	1.0	9.5	8.5	4.5	4.63	5.58	2.36	0.51
Group C	1.0	9.0	8.0	3.0	3.75	4.26	2.06	0.55
Overall Sample	1.0	10.0	9.0	4.0	4.02	4.71	2.17	0.54

3.3 Descriptive analysis of the variables *support group size* and *pointing frequency*

The three groups did not differ (from each other) significantly in support group size ($X^2(2, N = 65) = 2.2389$, $p = .32$) (Figure 13).

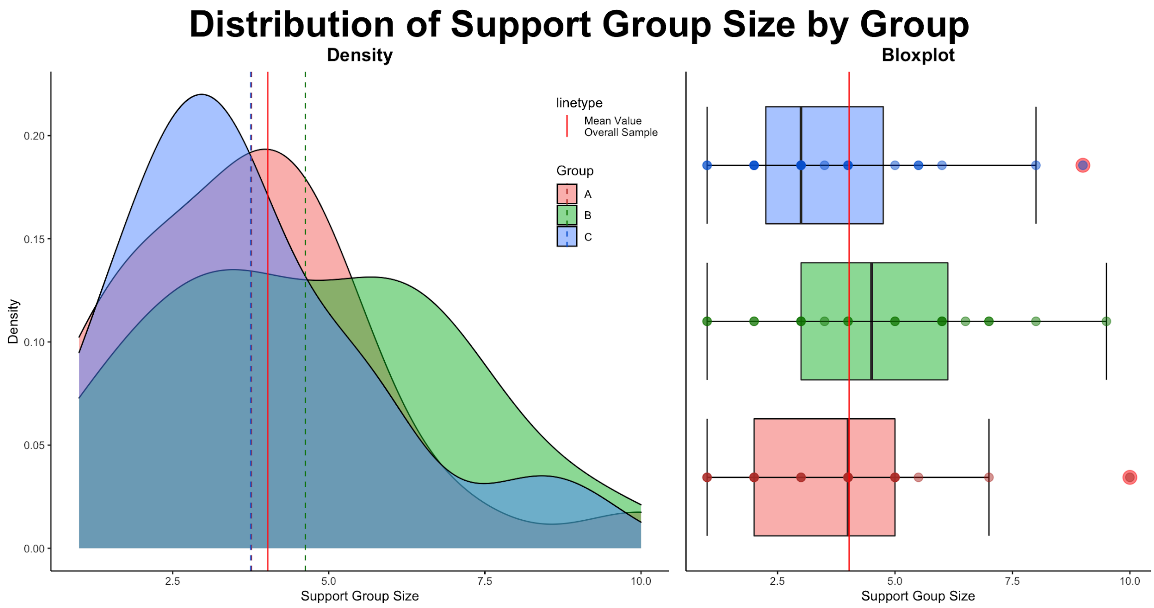


Figure 13. Distribution of Support Group Size by Group. The figure displays a density plot (left) and a boxplot (right) on which each group's age distribution can be seen. The red vertical line indicates the mean value for the overall sample. Dashed lines correspond to their respective group mean value.

Regarding the association between age and *support group size,* the *Spearman* correlation result ($r(65) = .09186781$, $p = .46$) does not indicate a meaningful relationship between the variables. Likewise, none of the three groups obtained a statistically significant result for correlation between age and *support group size* Group A ($r(22) = .273077$, $p = .20$), Group B ($r(19) = -.01475604$, $p = .95$) and Group C ($r(21) = .2974674$, $p = .17$).

The effect of gender on the *support group size* was also considered, and a ranked-based test (*Wilcoxon*) was performed in order to evaluate the effect of gender on the *support group size* variable for the overall data and each group separately. The results indicate that in the overall data, the distribution of the gender variable does not affect the *support group* size variable ($z = -0.4290779$, $p = .66$). Likewise, no effect of gender was found in Group

A (z = -1.638148, p = .10), Group B (z = -0.4385845, p = .66), and Group C (z = -0.727197, p = .46).

Detailed descriptive information regarding the *pointing frequency* of the overall sample and the three individual groups is presented in *Table* 05. The three groups did not differ significantly in pointing frequency ($X^2(2, N = 65) = 4.0786, p = .13$) (Figure 14).

Table 5. Summary Table Pointing Frequency. The table provides information on the central tendency (median and mean) and spread (range, variance, and standard deviation) of the support group size variable for each group and the overall sample.

Summary Table Pointing Frequency

	min	max	range	median	mean	var	std.dev	coef.var
Group A	0.43	12.71	12.29	4.96	6.12	10.61	3.257	0.532
Group B	1.71	19.41	17.70	9.88	8.69	19.92	4.463	0.513
Group C	1.31	17.61	16.30	5.47	6.31	16.94	4.116	0.652
Overall Sample	0.43	19.41	18.98	6.31	6.98	16.45	4.056	0.581

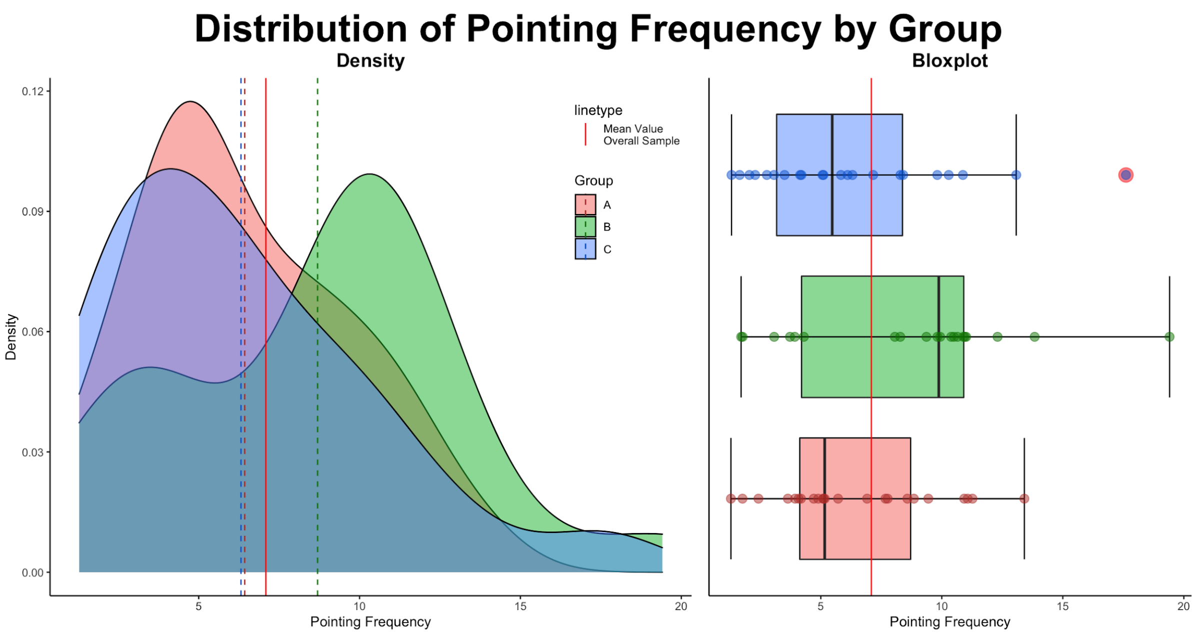


Figure 14. Distribution of Posting Frequency by Group.. The figure displays a density plot (left) and a boxplot (right) on which each group's age distribution can be seen. The red vertical line indicates the mean value for the overall sample. Dashed lines correspond to their respective group mean value.

Regarding the association between age and *pointing frequency,* the Spearman correlation result ($r(65) = .200726$, $p = .10$) does not indicate a meaningful relationship between the variables. The correlation between age and pointing frequency for Group A ($r(22) = .4203761$, $p = .04$) and Group B ($r(19) = .59488$, $p < .01$) yielded a statically significant correlation whereas Group C did not ($r(21) = .086021$, $p = .70$)

The effect of gender on the variable was also considered, and a ranked-based test (*Wilcoxon*) was performed in order to evaluate the effect of gender on the pointing frequency variable for the overall data and each group separately. The results indicate that in the overall data, the distribution of the gender variable does not affect the pointing frequency variable ($z = -0.4938981$, $p = .62$). Likewise, no effect of gender was found in Group A ($z = -0.03036$, $p = .97$), Group B ($z = -0.42275$, $p = .67$), and Group C ($z = -0.70281$, $p = .48$).

3.4 Testing the effect of *pointing frequency* on *support group* size

Due to the effect of the age variable indicated by the previous tests, age was included in the multiple regression linear model was created on the *support group* size as a factor of pointing (lm = formula = *Support group* Size ~ *Pointing frequency* + Age).

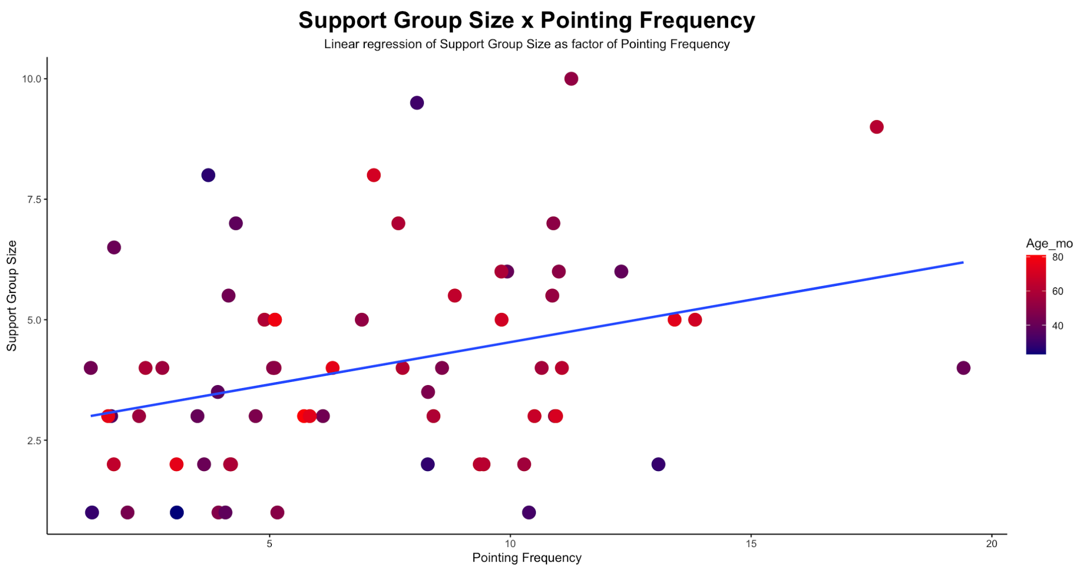


Figure 15. Linear Regression Support Group Size and Pointing Frequency. The plot displays the linear regression of Support group size as a factor of Pointing Frequency. The color indicates the age of a given individual.

The result (R^2 = 0.104, F(2, 62) = 3.725, p = .02) indicates that there is a relevant effect of pointing and age on the *support group* size (see Fig. 15).

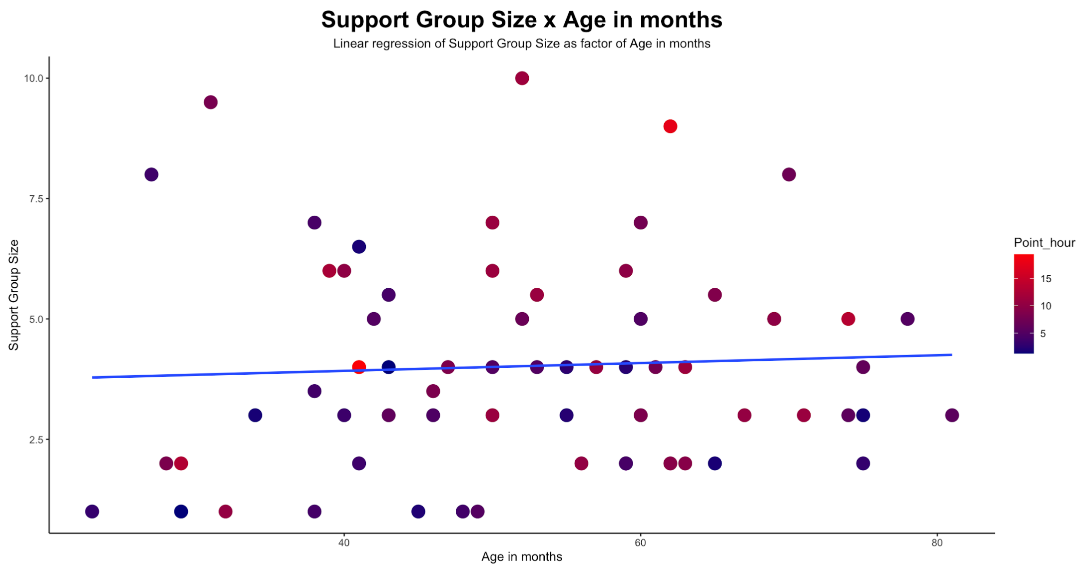


Figure 16. Linear Regression of Support Group Size as a factor of Age. The plot displays the linear regression of Support group size as a factor of Age. The color indicates the pointing frequency of a given individual.

When splitting the data by group, the sample size of each group separately was not large enough to calculate a multiple regression. Therefore, I performed a partial Spearman correlation in order to evaluate the relationship between *pointing frequency* and *support group* size and control for age within each group separately.

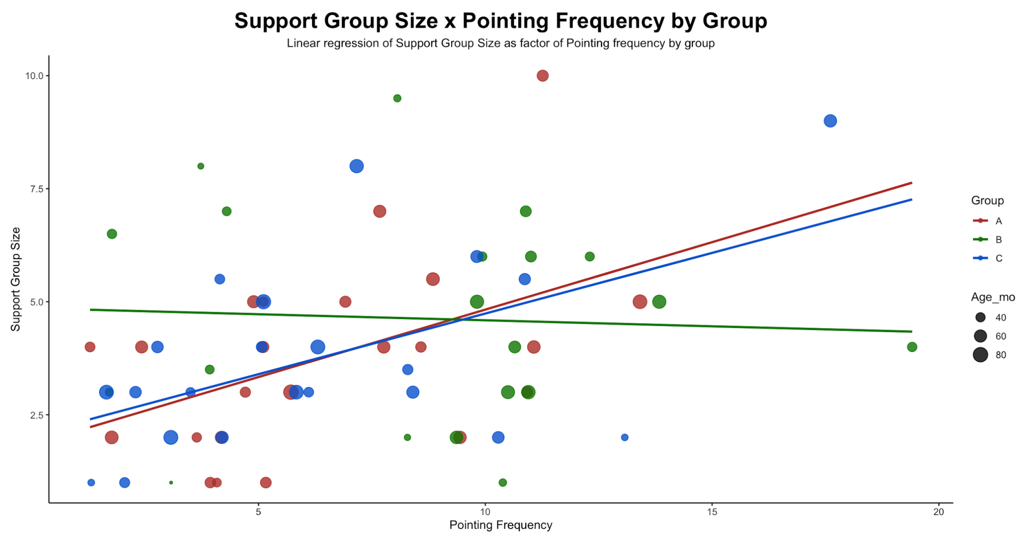


Figure 17. Linear Regression of Support Group Size as a factor of Pointing Frequency by the group. The colors indicate the respective group id in the legend. Sizes represent individual s age.

There was a marginally significant positive correlation between *Support group* size and pointing for group A and group C (i.e., children who point more often also had more friends within their *support group*). In Group B, however, there was no significant correlation between the two variables, contrastingly, this group presented a strong correlation between pointing frequency and age (Table 06).

Table 6. Summary table Partial Spearman correlation. Pointing Frequency, Age, and Support Group Size. The numbers above show r^2 values. Numbers within the brackets show p-values for correlations. (p < .05). ** (p < .1).*

Partial Correlation - Pointing Frequency, Age and Support Group Size

Group A	Sup. Group Size	Age (months)	Pointing Freq.
Sup. Group Size	-		
Age (months)	.09552 [.67238]	-	
Pointing Freq.	.40386 [.06232]**	.34422 [.11671]	-
Group B			
Sup. Group Size	-		
Age (months)	-.03290 [.89362]	-	
Pointing Freq.	.03536 [.88571]	.59534 [.00716]*	-
Group C			
Sup. Group Size			
Age (months)	.28947 [.20310]		
Pointing Freq.	.42306 [.05602]**	-.04785 [.83678]	

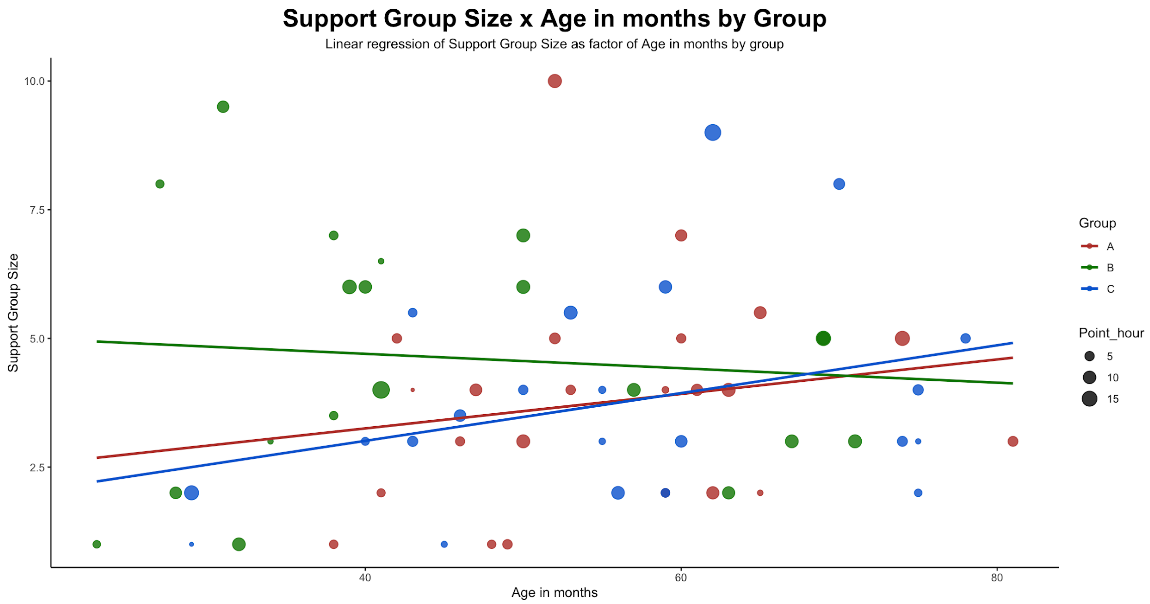


Figure 18. Linear Regression of Support Group Size as a factor of Age by the group. The colors indicate the respective group id in the legend. Sizes represent individual s pointing frequency.

4 Discussion

In the exploratory part of this study, I could detect friendship clusters among 2-6-year-old peers by observing their proximity patterns during a naturalistic preschool setting (i.e., free play). Using the kneedle algorithm, I could identify each child's number of closest friends (i.e., most frequent in proximity), this number was considered in this study as a given child's *support group size*. The support group size found in this study was compared to the number of individuals for this affiliation layer proposed by Robin Dunbar (i.e., 5; Dunbar, 2021), the comparison, however, indicates for the overall sample the support group size found does not yield a statically significant similarity with Dunbar's number. In the second, confirmatory part of my investigation, I found that preschoolers' use of pointing gestures predicted the size of their support group within their peer group. Age means were significantly different between groups, and it was found to have a different effect in one of the group's pointing frequencies (i.e., Group B). All of the groups had more males than females, but no significant difference was found between the groups' gender distribution, likewise, gender did not have an effect on any other variable. The results obtained in this project do indicate the existence of a consistent number of closest friends between groups, this number was identified in this investigation as the *support group*. Moreover, the statistical analyses also corroborate the prediction of the positive relationship between joint attention requests and *support group* size. Namely, children who point more often have a more significant number of affiliative ties within the *support group* in the overall sample.

This conclusion relates to Dunbar's claims on the competence of individuals in mentalization mechanisms as a predictor of the number of affiliative relationships within the *support group* (Stiller & Dunbar, 2007). Nevertheless, it is still important to outline the differences between Dunbar's conceptual constructs (i.e., *support group*, friendship, socio-cognitive competence), sample population, methodology, and the current study, before drawing any parallels between the results obtained in this project and Dunbar's experiment (Dunbar. 1998; Dunbar, 2022; Hill & Dunbar, 2003; Stiller & Dunbar, 2007).

One of these conceptual differences concerns the *support group* as defined by Dunbar. The size of the *support group* in the three preschoolers' peer groups studied in this project for the overall data (4.02) seems similar to Dunbar's prediction for the *support group* size (5). However, the statical comparison between the value for *support group size* found in this study and Dunbar's proposed value, indicates that the overall sample support group size is not statically significantly similar to Dunbar's number.

Foremost, the first intuitive conclusion is that preschoolers' social network sizes may naturally differ from adults given obvious distinctions between the social scope of both populations. Furthermore, it can be easily claimed that the peer group in which the children interact in kindergarten does not represent the whole child *support group* (cf. Dunbar's experiment *support group*). Children's family is undoubtedly more likely to represent the qualitative features on which Dunbar describe a *support group* (e.g., providers of emotional support) (Coplan & Arbeau, 2009; Fabes et al., 2009; Hay et al., 2009; Howes, 2009.; Linda & Denham, 2009). Nevertheless, within a peer group, it is unproblematic to assume that affiliative relations may also imply some kind of support (as in Dunbar's definition) between individuals involved in a dyadic relationship. Children tend to bond through and reciprocate prosocial behavior (including the voluntary or indirect provision of emotional support) (Coplan & Arbeau, 2009; Fabes et al., 2009; Hay et al., 2009; Howes, 2009.; Linda & Denham, 2009). Therefore, even though, implicit differences between the expected affiliative interactions between adults' *support group*s and preschoolers' peer groups, it is still possible to argue in favor of an age-equivalent *support group size* within the specific context of this project.

One of the critical points to be taken into consideration regards the use of pointing as a proxy for mentalization. As already exposed in the introduction, the theoretical and empirical bases for the use of pointing can be taken into the discussion (Carpenter et al., 1998; Tomasello, 1995; Tomasello et al., 2007; Desrochers & Morissette, 1995; Cochet et al., 2017; Sodian & Kristen-Antonow, 2015). However, it would be still necessary that a clear relationship between *ToM* and Joint attention be established before drawing a solid parallel comparison between the two socio-cognitive constructs. Nevertheless, the use of joint attention as a cognitive resource is granted, and the results obtained here may further the invention of the relationship between the two socio-cognitive constructs.

The last difference between Dunbar’s theoretical framework and experimental setting concerns the assessment of affiliative ties (i.e., friendship). While Dunbar usually employs sociometric methods (i.e., questionaries) to assign to individuals the number and quality of relationships, the current project's friendship assessment relied on the employment of ethological observation. Affiliative ties were attributed in this project to the frequency with which individuals were observed in proximity with a peer through an offline coding procedure. Moreover, the qualitative aspect on which Dunbar's experiment relied in order to define the *support group* was replaced in this study by a statistical tool (i.e., the *Kneedle algorithm*; Satopaa et al., 2011). This algorithm can successfully indicate the data pointing within a curve, on which the statistical significance of variation is optimal. Therefore, the parallel between Dunbar’s questionnaire and the statically significant amount of time each individual spent with a certain number of peers must not be taken directly but interpreted in its own methodological context.

In summary, besides the distinctions mentioned above, both predictions established at the beginning of this project were confirmed. Nevertheless, when looking at the relationship between pointing frequency and *support group size in* each group separately, The correlation between these variables could not be found in Group B. The average age in group B was significantly smaller than in both other groups. Although age was no significant predictor for *pointing frequency* in the overall sample, it was a significant predictor in group B (i.e., the older children pointed more frequently than the younger children in this group). While the average age in group B is 3.7 years, the overall sample and the other two groups have an average age greater than 4 years. The significant difference in age for this group was also confirmed in the post hoc test.

A possible inference can be based on the claim that more sophisticated mentalizing abilities emerge around the 4th birthday (Perner et al., 1987; Gopnik & Astington, 1988). However, the results obtained with less demanding *false belief understanding tasks* may indicate that sophisticated mentalization abilities may not be manifest in situations in which younger children do not possess adequate means of interpretation of the problem (Buttelmann et al., 2009; Southgate et al., 2007). Alternatively, it is also possible to interpret the results based on the suggestion of a gradual increase in competence (Wellman et al., 2001) or performance on the employment of mentalization abilities (Fodor, 1992). Considering any of these interpretations do not contradict the findings obtained in this investigation. Instead of contradictory, these findings seem to be aligned with most of the literature on the research in Theory of Mind and developmental psychology.

Besides the theoretical contributions aforementioned, the work here presented provides insights into the effectiveness of the proposed interdisciplinary methodological approach (i.e., combining ethological observations of peer proximity with psychologically informed constructs of joint attention). The investigation of mentalization processes as a possible relevant factor of influence on social network structures has not yet been investigated in children. Therefore, this project is expected to spark researchers' interest in further investigations on the topic. It is further expected that the current project will improve future coding processes (e.g., distinct proximity criteria) for ethological observation of preschoolers for social network analysis purposes and to provide ecologically sensitive methods as an alternative for the research of cognition.

4.1 Limitations and outlook

Even though the current project has successfully provided closure for the aims and predictions proposed in its onsetting, further work on the topic should be pursued. The limitations of the work presented here may be addressed in their methodological and theoretical aspects.

Further work could investigate the valence of the interaction between peers to identify instances of emotional support within a *support group*. In the current project, I argue that this (i.e., emotional support) may be implicit in the case of frequent proximity between peers. However, a detailed description of the character of these interactions may provide a better comparison between Dunbar's concept of a *support group* and the concept employed here.

Moreover, a larger sample size, and group age homogeneity, in addition to a direct comparison between age-specific group compositions, may be able to address the specific results obtained in the group composed of younger children (Group B). A study on which age can be employed as a concisely controlled variable could be pursued with this aim.

Furthermore, there are challenges in measuring sociocognitive capabilities within a socio-ecological sensitive context. However, new studies could prospect the inclusion of a controlled assessment of *ToM* and/or Joint Attention competencies in conjunction with the methodology applied in this project (i.e., ethologic observation) for assessing social network clusters.

Concerning the theoretical limitations within this project, a precise elaboration on the connection between Joint attention and *ToM* may be the most essential missing feature. Researchers have already been pursuing the exact nature of a possible developmental and cognitive relationship between these two sociocognitive constructs. It is, however, also necessary for a conclusive theoretical argument, which can be able to encompass the distinct developmental and cognitive implications involved in these two sociocognitive competencies.

4.2 Conclusion

The analysis of peer interaction based on offline observation of sixty-five preschool children provided the data from which the structure and strength of affiliative ties for each individual were obtained. The same method provided data on the frequency of the employment of joint attention requests (i.e., pointing) within each group. The statistical analyses applied to this data indicate that, although within a large variance between individuals, (1) I was able to find clusters of affiliative ties based on the average size of these clusters which were consistent between the groups. These clusters were identified as preschoolers' support group sizes. However, (2) the overall sample mean value for the size of the overall sample support group (n = 4.02) was not statically significantly similar to Dunbar's predictions for an average size of *support group* (n=5).

Nevertheless, the linear regression model indicated that the hypothesis (i.e., does the employment of joint attention request predict the size of the *support group* in children?) was confirmed for the overall sample and at least two groups separately. The only group in which this relationship was not found was also the group with the lowest mean age (the youngest group). This result is in accordance with the current research on Theory of Mind and the literature on developmental psychology. Therefore, it is possible to conclude that age-specific developmental stages of socio-cognitive constructs have an effect on preschoolers' social network (within peer groups) structures and size.

References

Blackburn, T. M., Lawton, J. H., & Perry, J. N. (1992). A method of estimating the slope of upper bounds of plots of body size and abundance in natural animal assemblages. Oikos, 107-112.

Bruner, J. (1995). From joint attention to the meeting of minds: An introduction. *Joint Attention: Its Origins and Role in Development*, 1–14.

Vaughn, B. E., & Santos, A. J. (2009). Structural descriptions of social transactions among young children: Affiliation and dominance in preschool groups. In K. H. Rubin, W. M. Bukowski, & B. Laursen (Eds.), *Handbook of peer interactions, relationships, and groups*, 195–214. The Guilford Press.

Buttelmann, D., Carpenter, M., & Tomasello, M. (2009). Eighteen-month-old infants show false belief and understanding in an active helping paradigm. *Cognition*, *112*(2), 337–342.

Camaioni, L., Perucchini, P., Bellagamba, F., & Colonnesi, C. (2004). The role of declarative pointing in developing a theory of mind. *Infancy: The Official Journal of the International Society on Infant Studies*, *5*(3), 291–308.

Carpenter, M., Nagell, K., & Tomasello, M. (1998). Social cognition, joint attention, and communicative competence from 9 to 15 months of age. *Monographs of the Society for Research in Child Development*, *63*(4), i–vi, 1–143.

Challman, R. C. (1932). Factors influencing friendship among preschool children. *Child development*, 3, 146–158.

Chen, X., Chung, J., & Hsiao, C. (2009). Peer interactions and relationships from a cross-cultural perspective. In K. H. Rubin, W. M. Bukowski, & B. Laursen (Eds.), *Handbook of peer interactions, relationships, and groups*, 432–451. The Guilford Press.

Clark, H. H., & Brown, K. (2006). Context and common ground. Concise encyclopedia of philosophy of language and linguistics (2006), 85-87.

Clark, H. H. (2020). Common Ground. In *The International Encyclopedia of Linguistic Anthropology*, 1–5.

Cochet, H., Jover, M., Rizzo, C., & Vauclair, J. (2017). Relationships between declarative pointing and theory of mind abilities in 3- to 4-year-olds. *The European Journal of Developmental Psychology*, *14*(3), 324–336.

Cochet, H., & Vauclair, J. (2010). Features of spontaneous pointing gestures in toddlers. Gesture, 10(1), 86-107.

Coplan, R. J., & Arbeau, K. A. (2009). Peer interactions and play in early childhood. In K. H. Rubin, W. M. Bukowski, & B. Laursen (Eds.), *Handbook of peer interactions, relationships, and groups*, 143–161. The Guilford Press.

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.

Csibra, G., & Gergely, G. (2009). Natural pedagogy. *Trends in Cognitive Sciences*, *13*(4), 148–153.

Darwin, C. (1859). *On the origin of species by means of natural selection: or the preservation of favored races in the struggle for life*. Appleton.

Desrochers, S., Morissette, P., & Ricard, M. (1995). Two perspectives on pointing in infancy. Joint attention: Its origins and role in development, 85-101.

De Waal, F. B. M. & Tyack, P. L. (eds) 2003 *Animal social complexity. Intelligence, culture, and individualized societies*. Cambridge, MA: Harvard University Press.

Dunbar, R. I. M. 1992. Neocortex size as a constraint on group-size in primates. J. Hum. Evol. 22: 469–493.

Dunbar, R. I. M. (2014). The social brain: Psychological underpinnings and implications for the structure of organizations. *Current Directions in Psychological Science*, 23(2), 109-114.

Dunbar, R. I. M. (2022). *Friends: Understanding the power of our most important relationships*. Across.

Dunbar, R. I. M. (1998). The social brain hypothesis. *Evolutionary Anthropology*, *6*(5), 178–190.

Fabes, R. A., Martin, C. L., & Hanish, L. D. (2009). Children's behaviors and interactions with peers. In K. H. Rubin, W. M. Bukowski, & B. Laursen (Eds.), *Handbook of peer interactions, relationships, and groups*, 45–62. The Guilford Press.

Fodor, J. A. (1992). A theory of the child's theory of mind. *Cognition*.

Fox, K. C. R., Muthukrishna, M., & Shultz, S. (2017). The social and cultural roots of whale and dolphin brains. *Nature Ecology & Evolution*, *1*(11), 1699–1705).

Friard, O., & Gamba, M. (2016). BORIS: a free, versatile open-source event-logging software for video/audio coding and live observations. *Methods in Ecology and Evolution / British Ecological Society*, *7*(11), 1325–1330.

Fuentes, A. (2017). *The Creative Spark: How Imagination Made Humans Exceptional*. Penguin.

Gopnik, A., & Astington, J. W. (1988). Children's understanding of representational change and its relation to the understanding of false belief and the appearance-reality distinction. Child development, 26-37.

Hagman, E. P. (1933). The companionships of preschool children. University of Iowa Studies in Child Welfare, 7, 4.

Hay, D. F., Caplan, M., & Nash, A. (2018). The beginnings of peer relations. *Handbook of Peer Interactions, Relationships, and Groups., 2nd Ed.*, *2*, 200–221.

Herrmann, E., Call, J., Hernàndez-Lloreda, M. V., Hare, B., & Tomasello, M. (2007). Humans have evolved specialized skills of social cognition: the cultural intelligence hypothesis. *Science*, *317*(5843), 1360–1366.

Heyes, C. (2012). What's social about social learning? *Journal of Comparative Psychology*, *126*(2), 193–202.

Heyes, C. M., & Galef Jr, B. G. (Eds.). (1996). Social learning in animals: the roots of culture. Elsevier.

Hill, R. A., & Dunbar, R. I. M. (2003). Social network size in humans. *Human Nature*, *14*(1), 53–72.

Holekamp, K. E. (2007). Questioning the social intelligence hypothesis. *Trends in Cognitive Sciences*, *11*(2), 65–69.

Howes C. (2009). Friendship in early childhood. Peer interactions and relationships from a cross-cultural perspective. In K. H. Rubin, W. M. Bukowski, & B. Laursen (Eds.), *Handbook of peer interactions, relationships, and groups*, 180-195. The Guilford Press.

Humphrey. (1976). The social function of intellect. *Growing Points in Ethology*.

Ihaka, R., & Gentleman, R. (1996). R: A Language for Data Analysis and Graphics. *Journal of Computational and Graphical Statistics: A Joint Publication of American Statistical Association, Institute of Mathematical Statistics, Interface Foundation of North America*, *5*(3), 299–314.

Ladd, G. W. (2009). Trends, travails, and turning points in early research on children's peer relationships. Peer interactions and relationships from a cross-cultural perspective. In K. H. Rubin, W. M. Bukowski, & B. Laursen (Eds.), *Handbook of peer interactions, relationships, and groups*, 20-41. The Guilford Press.

Lewis, S. L., & Maslin, M. A. (2015). Defining the Anthropocene. *Nature*, *519*(7542), 171–180.

Liberman, Z., & Shaw, A. (2019). Children use similarity, propinquity, and loyalty to predict which people are friends. Journal of experimental child psychology, 184, 1-17.

Linda, R. K., & Denham, S. (2011). Social-emotional competence in early childhood. Peer interactions and relationships from a cross-cultural perspective. In K. H. Rubin, W. M. Bukowski, & B. Laursen (Eds.), *Handbook of peer interactions, relationships, and groups*, 162-180. The Guilford Press.

Messinger, D. S., Prince, E. B., Zheng, M., Martin, K., Mitsven, S. G., Huang, S., Stölzel, T., Johnson, N., Rudolph, U., Perry, L. K., Laursen, B., & Song, C. (2019). Continuous measurement of dynamic classroom social interactions. *International Journal of Behavioral Development*, *43*(3), 263–270.

Moll, H., & Tomasello, M. (2007). Cooperation and human cognition: the Vygotskian intelligence hypothesis. *Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences*, *362*(1480), 639–648.

Mundy, P., Delgado, C., Block, J., Venezia, M., Hogan, A., & Seibert, J. (2003). Early social communication scales (ESCS). *Coral Gables, FL: University of Miami*.

Oláh, K., Elekes, F., & Király, I. (2019). Creating a Shared Representational Space.[preprint].

Perner, J., Leekam, S. R., & Wimmer, H. (1987). Three-year-olds' difficulty with false belief: The case for a conceptual deficit. *British journal of developmental psychology*, *5*(2), 125-137.

Pietraszewski, D., & German, T. C. (2013). Coalitional psychology on the playground: Reasoning about indirect social consequences in preschoolers and adults. Cognition, 126, 352–363.

Pust, L., Sperber, D., & Wilson, D. (1997). Relevance: Communication and Cognition. *Language*, *73*(3), 672.

Rieber, R. W. (1997). Genesis of higher mental functions. In *The Collected Works of L. S. Vygotsky*, 97–119. Springer US.

K. H. Rubin, W. M. Bukowski, & B. Laursen (Eds.), *Handbook of peer interactions, relationships, and groups*. The Guilford Press.Guilford Press.

Santini, Z. I., Jose, P. E., Koyanagi, A., Meilstrup, C., Nielsen, L., Madsen, K. R., Hinrichsen, C., Dunbar, R. I. M., & Koushede, V. (2021). The moderating role of social network size in the temporal association between formal social participation and mental health: a longitudinal analysis using two consecutive waves of the Survey of Health, Ageing and Retirement in Europe (SHARE). *Social Psychiatry and Psychiatric Epidemiology*, *56*(3), 417–428.

Satopaa, Albrecht, & Irwin. (2011). Finding a" kneedle" in a haystack: Detecting knee points in system behavior. *2011 31st International*.

Santos, A. J. (1990). Análise descritiva multivariada da estrutura afiliativa de um grupo de crianças em meio pré-escolar. Tese de Monografia em Psicologia Clínica não publicada. Lisboa: Instituto Superior de Psicologia Aplicada.

Santos, A. J. (1993). Preschool affiliative networks: A socio-structural analysis of the behavioral ecology of natural peer groups. Unpublished Ph.D. Thesis in Developmental Psychology. Université du Québec à Montréal, Montréal (Québec), Canada.

Santos, A. J., & Winegar, L. T. (1999). Child social ethology and peer relations: A developmental review of methodology and findings. Acta ethologica, 2(1), 1-11.

Santos, A. J., Vaughn, B. E., Strayer, F. F., & Daniel, J. R. (2008). Métodos de observação e análise para identificação das estruturas afiliativas de grupos de crianças em meio pré-escolar. Análise Psicológica, 447-461.

Santos, A. J., Daniel, J. R., Fernandes, C., & Vaughn, B. E. (2015). Affiliative subgroups in preschool classrooms: Integrating constructs and methods from social ethology and sociometric traditions. PloS one, 10(7).

Shultz, S., & Dunbar, R. I. M. (2007). The evolution of the social brain: anthropoid primates contrast with other vertebrates. Proceedings of the Royal Society B: Biological Sciences, 274(1624), 2429-2436..

Shultz, S. & Dunbar, R.I.M. (2010a). Social bonds in birds are associated with brain size and contingent on the correlated evolution of life history and increased parental investment. Biological Journal of the Linnean Society 100: 111-123.

Shultz, S. & Dunbar, R.I.M. (2010b). Encephalisation is not a universal macroevolutionary phenomenon in mammals but is associated with sociality. Proceedings of the National Academy of Sciences, USA, 107: 21582-21586."

Sodian, B., & Kristen-Antonow, S. (2015). Declarative joint attention as a foundation of theory of mind. *Developmental Psychology*, *51*(9), 1190–1200.

Southgate, V., Senju, A., & Csibra, G. (2007). Action anticipation through attribution of false belief by 2-year-olds. Psychological science, 18(7), 587-592.

Spence, Walton, & Miller. (1954). A thousand families in Newcastle upon Tyne. *Families in Newcastle upon …*. https://www.cabdirect.org/cabdirect/abstract/19552700671

Sperber, D., Clément, F., Heintz, C., Mascaro, O., Mercier, H., Origgi, G., & Wilson, D. (2010). Epistemic vigilance. *Mind & Language*, *25*(4), 359–393.

Stiller, J., & Dunbar, R. I. (2007). Perspective-taking and memory capacity predict social network size. Social Networks, 29(1), 93-104.

Tomasello, M. (1995). Joint attention as social cognition. Joint attention: Its origins and role in development, 103130, 103-130.

Tomasello, M. (2009). *Why We Cooperate*. MIT Press.

Tomasello, M. (2011). Human culture an evolutionary perspective. In M. J. Gelfand (Ed.), *Advances in culture and psychology, Vol* (Vol. 1, pp. 5–51). Oxford University Press, xi.

Tomasello, M., Carpenter, M., & Liszkowski, U. (2007). A new look at infant pointing. *Child Development*, *78*(3), 705–722.

Tomasello, M., Kruger, A. C., & Ratner, H. H. (1993). Cultural learning. *The Behavioral and Brain Sciences*, *16*(3), 495–511.

Tomasello, M., & Vaish, A. (2013). Origins of human cooperation and morality. *Annual Review of Psychology*, *64*, 231–255.

Vygotsky, L. (1986). *Thought and Language* (A. Kozulin, Ed.; 2nd ed.). MIT Press. (Original work published 1962)

Wellman, H. M., D. Cross, and J. Watson. (2001). "Meta-Analysis of Theory-of-Mind Development: The Truth about False Belief." *Child Development* 72 (3): 655–84.

Wellman, H. M., & Liu, D. (2004). Scaling of theory-of-mind tasks. Child development, 75(2), 523-541.

Whiten, A. (2000). Social complexity and social intelligence. *Novartis Foundation Symposium*, *233*, 185–196; discussion 196-201.

Whiten, Andrew, Hinde, R. A., Laland, K. N., & Stringer, C. B. (2011). Culture evolves. *Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences*, *366*(1567), 938–948.

Wilson, D., & Sperber, D. (2002). *Relevance theory*. Blackwell.

Wimmer, H., & Perner, J. (1983). Beliefs about beliefs: Representing and constraining function of wrong beliefs in young children's understanding of deception. Cognition, 13, 103–128.

Appendices

Appendix 01. Abstract

Effective management of social relationships demands from individuals the employment of certain cognitive processes in order to, for example, recognize faces, remember past social interactions, and understand another's individual mental representations (e.g., beliefs and intentions). Robin Dunbar claims that social complexity drives individuals to the selective use of cognitive resources, which in turn, leads to constraints in social network size and the emergence of sequential, hierarchical clustering of relationships or "layers of interaction partners". The investigation of these constraints by Robin Dunbar and James Stiller (2007, Soc. Netw. 29) has found that (in adults) an individual's competence to infer another individual's state of mind (i.e., mentalization) can predict the number of friends a person can have within the first layer of the social network (i.e., support group). Due to the developmental process through which these socio-cognitive abilities emerge, it would be important to understand how early in life (if at all) these constraints are manifested. Up to now, however, the relationship between mentalization competence and the number of closest friends has not yet been investigated within a developmental framework. Therefore, I employed behavioral observation of peer proximity and interactions within an ecologically relevant setting (i.e., free play) to (1) investigate if Dunbar and Stiller's proposed network structures can be found in preschool children's social networks and (2) if the number of children's affiliative relationships (within the support group) is predicted by an individual's successful employment of socio-cognitive resources (i.e., joint attention requests via pointing). The findings of this investigation indicate that in the three groups analyzed there was an average number of peers with whom a preschooler spends most time in proximity. Moreover, this number was correlated with the frequency with a given individual employed joint attention requests (i.e., pointing gestures) in groups composed of older children. In summary, these results are in alignment with both Dunbar and Stiller's findings (2007, Soc. Netw. 29) and with the current literature on developmental cognition. Moreover, it should be expected that the work presented in this thesis may foster the further investigation of children's cognitive competencies and peer group structure and size.

Appendix 02. Abstract (German)

Damit zwischenmenschliche Interaktionen erfolgreich stattfinden können, bedarf es den Einsatz verschiedener kognitiver Prozesse, beispielsweise das Erkennen individueller Gesichter, die Erinnerung an frühere soziale Ereignisse und das Verstehen der mentalen Repräsentationen von anderen Personen (z. B. Überzeugungen und Absichten). Robin Dunbar postuliert, dass soziale Komplexität Individuen dazu antreibt, kognitive Ressourcen selektiv zu nutzen. Das wiederum führt zu einer Beschränkung der Größe sozialer Netzwerke und zur Entstehung einer sequentiellen, hierarchischen Clusterbildung von Beziehungen. Dunbar spricht hier von „Ebenen von Interaktionspartnern". Die Untersuchung dieser Beschränkungen durch Robin Dunbar und James Stiller (2007, Soc.Netw. 29) hat ergeben, dass bei Erwachsenen die Fähigkeit einer Person, auf den Geisteszustand einer anderen Person zu schließen (genannt Mentalisierung), die Anzahl der Freunde vorhersagen kann, die eine Person in der ersten Schicht des sozialen Netzwerkes, der Schicht der engsten Freunde (nach Dunbar „support group"), hat. Gerade mit Blick auf die frühe soziale Entwicklung im Kindesalter wäre es wichtig zu verstehen, wie früh im Leben (wenn überhaupt) sich diese Beschränkungen manifestieren. Bisher wurde der Zusammenhang zwischen der Fähigkeit der Mentalisierung und der Anzahl der engsten Freunde jedoch noch nicht in einem entwicklungsbezogenen Rahmen untersucht. Daher habe ich in dieser Masterarbeit Verhaltensbeobachtungen der Nähe zu Gleichaltrigen und Interaktionen innerhalb eines ökologisch relevanten Umfelds (z.B. freies Spiel) eingesetzt, um (1) zu untersuchen, ob die von Dunbar und Stiller vorgeschlagenen Netzwerkstrukturen in den sozialen Netzwerken von Vorschulkindern zu finden sind und (2) ob die Anzahl der Beziehungen von Kindern (innerhalb der Schicht der engsten Freunde) durch den erfolgreichen Einsatz soziokognitiver Ressourcen, in diesem Fall Aufforderungen zur Gemeinsamen Aufmerksamkeit durch Zeigegesten vorhergesagt werden können. Die Ergebnisse dieser Untersuchung deuten darauf hin, dass es für Vorschulkinder eine mittlere Anzahl von engsten Freunden gibt. Diese Anzahl korreliert mit der Frequenz der Fälle, in denen ein Kind durch Zeigegesten andere Kinder zur Gemeinsamen Aufmerksamkeit auffordert Gruppen bestehend aus älteren Kindern. Zusammenfassend stimmen diese Ergebnisse sowohl mit den Ergebnissen von Dunbar und Stiller (2007, Soc. Netw. 29) als auch mit der aktuellen Literatur zur Entwicklungskognition überein. Darüber hinaus ist zu erwarten, dass durch diese Arbeit die weitere Untersuchung der kognitiven Kompetenzen von Kindern und der Struktur und Größe von Peer-Gruppen gefördert werden kann.

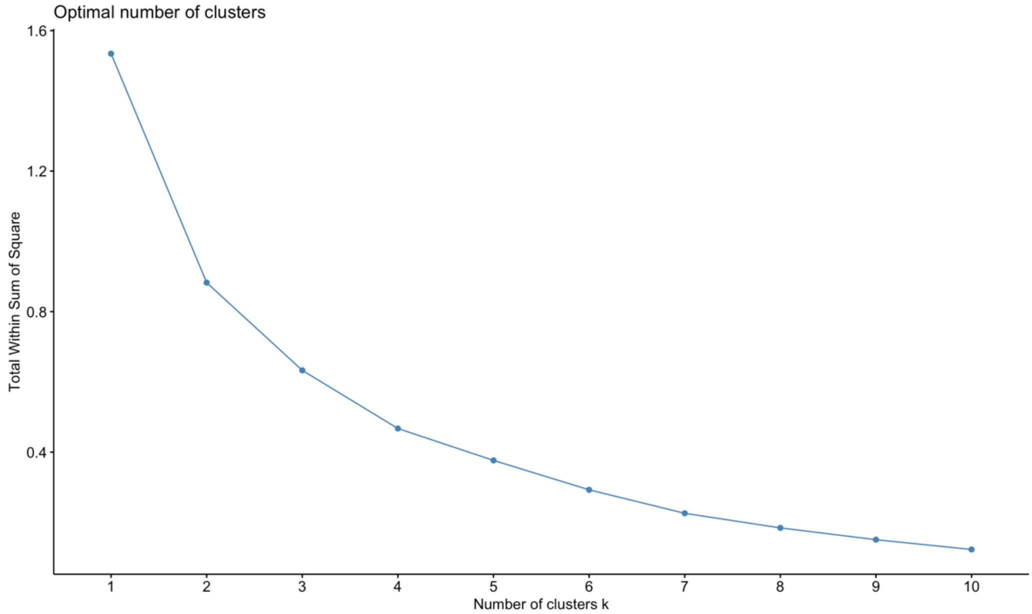
Appendix 03. Ethogram

Behavior	Code	Description	Example	Modifiers
Proximity				
Proximity	prox	An individual within arm's reach (1m) from the observation target. If two or more children are equally nearby to the focal child, both subjects must be coded as proximity. If the observation target is interacting verbally or physically with a child, the respective modifier must be added to the coded event.	Observation target playing in proximity, stationary in proximity, moving in proximity with another child and/or teacher. Individuals interacting across a table or physically separated by some material should not be coded as proximity.	+ partID
Joint Attention				
Point	point	Gesture (visually accessible to a communication partner) towards some feature of the environment (e.g., object, situation, other individuals). Usually performed by displaying an extended index finger (with contracted or extended respective arm). It can also be performed by using one's body extremity or object (e.g., head, pencil, etc.). It is always performed in the context of social interactions where the pointing individual demonstrates the intention to drive a communication partner's attention towards some aspect of the environment (i.e., Declarative) or elicit change in the partner's behavior (i.e., Imperative).	The observation target uses an extended index finger to direct another individual's attention towards another child (including the observation target him/herself), objects/places (e.g., toys, books, chairs, etc.), and events.	+ partID

		The communication partner may or may not respond to the gesture (i.e., look towards the pointing direction) and may not demonstrate awareness of the gesture displayed. It can be accompanied by some form of attention monitoring by the gesturing individual (e.g., gaze alternation between partner face and pointing direction) (Tomasello et al., 2007). It can also be accompanied by physical contact and/or verbal exchange.		
Out of Sight				
Out of Sight Proximity	outp	It is not possible to visually infer the degree of proximity between the target subject and any other individual.	The observation target and other individuals are not visually accessible to the coder in the video image, not being possible to infer the spatial proximity between these (i.e., if the observation target is alone and out of sight, it is not necessary to infer proximity with other individuals).	
Modifiers				
PartnerID	id	Individuals with whom the observation target is in proximity. Individual to whom pointing and/or show is intended.	Another child's respective ID	

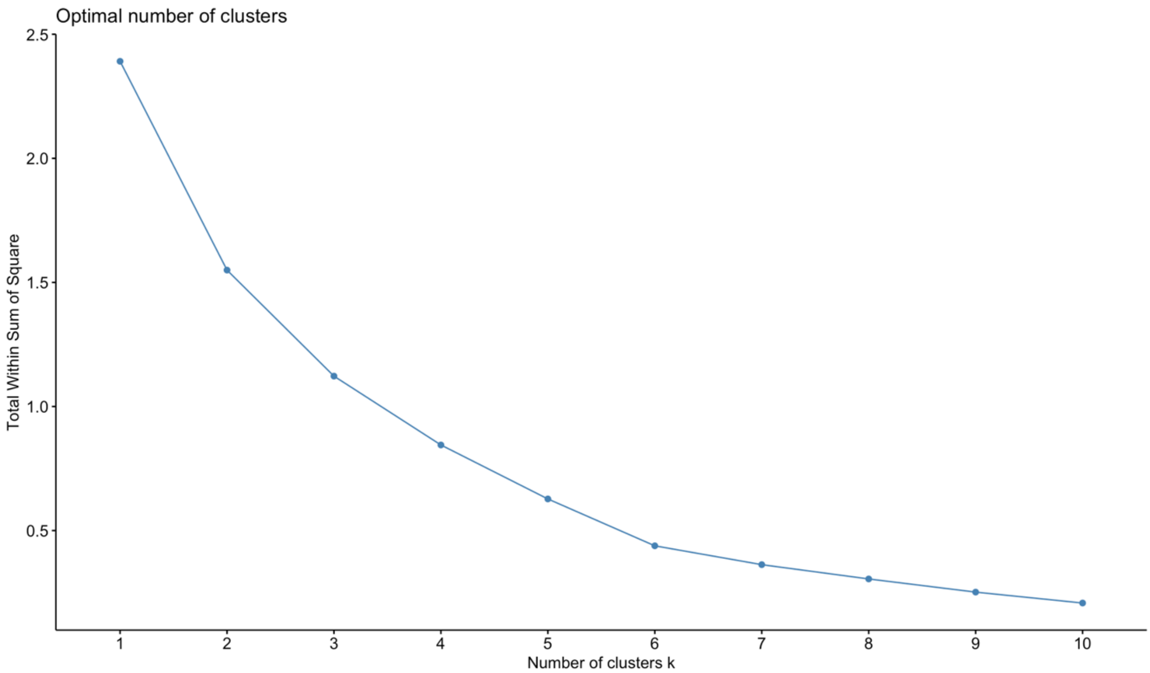
Appendix 04. Scree plot cluster analyses Group A

X



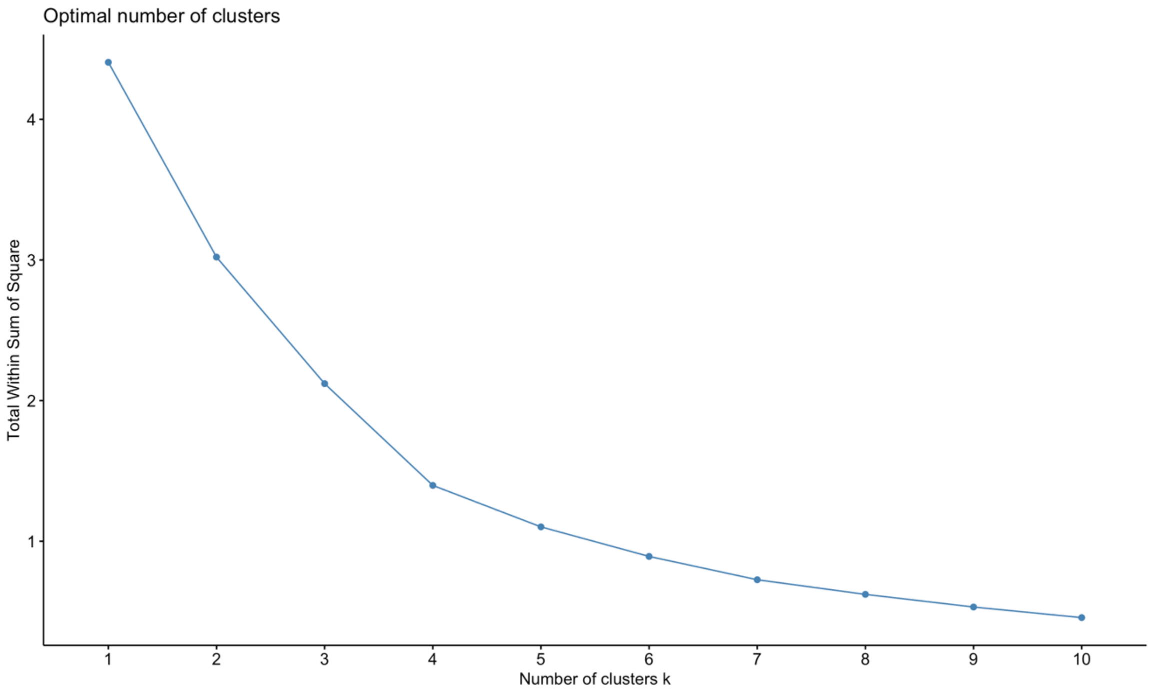
The figure displays the total within sum of squares in relation to the number of clusters.

Appendix 05. Scree plot cluster analyses Group B



The figure displays the total within sum of squares in relation to the number of clusters.

Appendix 06. Scree plot Cluster analyses Group C



The figure displays the total within sum of squares in relation to the number of clusters.

.