The Rise and Fall of Repetitive Behaviours in a Community Sample of Infants and Toddlers

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Dedication

For their courage, inspiration and love…

I would like to dedicate this thesis to my parents, Malcolm and Gillian Fyfield

Thank you.

Acknowledgements

First and foremost, I would like to extend my deepest gratitude to my supervisors, Professors Dale Hay and Sue Leekam. Dale, for your unfailing support throughout the duration of my PhD. Thank you also for your constant words of encouragement, your patience and for inspiring intellectual curiosity. Sue, for your wisdom and encouragement throughout.

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Summary

This thesis examines motor stereotypies and repetitive actions with objects. These repetitive behaviours are an early diagnostic feature of autism. To date, no studies have systematically examined repetitive behaviours in a community sample of children aged 6 to 36 months, when behavioural signs of autism begin to emerge and the age at which motor and socio-communication skills are achieved. In this thesis, repetitive behaviours were assessed within the context of two studies, the First Friends and the Cardiff Child Development Study.

Firstly, the Repetitive Behaviours Coding Scheme was developed; it is the first scheme developed from narrative records of behaviours that accurately represent the range of repetitive behaviours commonly seen in infants and toddlers (Chapter 2).

Repetitive behaviours were measured during 6- and 12-month-olds' object exploration (Chapter 4); they were ubiquitous at 12 months and there was a significant increase in the use of the repetition from early to late infancy. The investigation extended to examining the association between repetition and developmental milestones. Frequent use of motor stereotypies but not repetitive actions with objects characterised infants who were more immature in their locomotor development (Chapter 5). Infants who engaged in more repetition were no worse at nonverbal communication, as measured by joint attention.

I examined the decline in repetitive behaviours by conducting longitudinal assessments and found a significant decrease in the frequency of repetition from infancy to toddlerhood (Chapter 6). I found that toddlers who still engage in repetitive behaviours in their third year did not have poorer inhibitory control nor have higher ratings of ADHD symptoms but had better socio-communicative skills (Chapter 7).

These findings offer a developmental framework to assess the function of repetitive behaviours; repetitive behaviours characterise children who are less motorically mature but they are not associated with a deficit in communicative abilities or social competence.

Roles and responsibilities within the Cardiff Child Development Study

The vast majority of the data within this thesis is based on the analyses of the children within the Cardiff Child Development Study (CCDS). The CCDS is a prospective longitudinal study of 332 first time mothers and their children which started recruitment in 2006. The study is currently in the sixth stage of assessment. Within this section I will describe my contribution to the CCDS, focusing on my roles and responsibilities since I joined the study in 2008. Chapter 3 explains the overall structure of the CCDS. I have been involved in various aspects of data collection, coding and analysis.

In terms of data collection I assisted with the testing of some participants at the late infancy (Wave 3) and early toddler (Wave 4) assessments. This involved helping research assistants administer the protocol in Welsh. At the late toddler assessment (Wave 5) I conducted a substantial amount of the assessments on participants. This involved administering a battery of socio-cognitive tasks to toddlers, conducting parent-child cooperation tasks, collecting physiology data (heart rate, movement and cortisol samples), filming a 20 minute free play session between peers, and administering a range of socio-emotional challenges during a teddy bear's picnic scenario. During the teddy bear's picnic scenario I acted as both birthday lady and teddy bear in order to act out a scripted teddy bear's picnic with the participants. At the middle childhood assessments (Wave 6, currently taking place), I have contributed to a significant portion of the family assessments. I am trained in and have administered interview protocols, child assessment, parent-child interaction tasks, and I have administered questionnaires and collected physiology data from the children. The interview involves psychiatric assessments of the children (by interviewing the primary caregiver) and psychiatric assessment of the primary caregiver. The child assessment involves a battery of tasks assessing children's vocabulary, socio-cognitive skills as well as various other developmentally appropriate assessments of children's ability.

Furthermore, I have contributed substantially to the observational coding of the data and assisted with entering, cleaning and checking questionnaire data from the late infancy and late toddler assessments of the CCDS. At the middle childhood assessment I also downloaded and entered data from questionnaires that derive from Adobe Acrobat forms.

In terms of the observation data, I devised an observation coding scheme for repetitive behaviours which has been applied to various tasks within the CCDS. I also adapted a coding scheme for parent-child interaction applied to the late toddler assessment. In terms of the observation coding I have coded the majority of the tasks administered during the late infancy and toddler assessment of the CCDS. Specifically, at the early infancy assessment I completed 60% of the transcribing of parent speech during a parent-child interaction task (used for publication), all of the repetitive behaviour coding during the object exploration task (Chapter 4). At the late infancy assessment I coded 60% of the joint attention task (see Chapter 5), 70% of the imitation task (used for publication), 50% of the A-not-B task, 70% of the turn taking task, all of the object exploration task (repetitive behaviour, Chapter 4), all of the conflict provocation task, 10% of the reliability of the Peer Interaction Coding Scheme applied to the free play session and all of the repetitive behaviours during the peer interaction (Chapters 4, 5 and 6). At the late toddler assessment I coded 30% of the Tower of Cardiff planning task, 75% of the imitation tasks, 75% of the behavioural regulation tasks (chapter 7), 75% of the cognitive flexibility tasks (Chapter 7), 30% of the peer interaction during the free play (Chapter 7) and all of the repetitive behaviours during the peer interaction (Chapter 6 & 7).

I have further contributed to the CCDS by auditing the early and late infancy and late toddler tasks. I have also trained numerous volunteers and summer bursary students to part-code the tasks listed above. I contributed to the coding of maternal and paternal psychiatric interviews that had been conducted in Welsh at the first wave of the study. I helped with cleaning and checking questionnaire data from the late infancy, early toddler and late toddler assessment. Finally, I make DVDs from the observation videos available from the assessments undertaken at different waves. The DVDs represent highlights of each child through the waves of assessments. These are given to the families as a memento.

CHAPTER 1.

Introduction

Section 1: The Issue and Importance of the Topic Area

1.1 Focus of the Thesis

As part of their development, young children often show repetitive behaviours. As such, the overarching aim of this thesis is to take a developmental approach to track repetitive behaviours between 9 and 36 months of age, with reference to their relation to other dimensions of motor, cognitive and social development. Repetitive behaviours are significant for the early diagnosis of the Autism Spectrum Disorders (ASD); however, any consideration of their pathological nature must also take into account the ubiquity of repetitive behaviours in early development (Arnott, McConachie, Meins, Fernyhough, Le Couteur, Turner, Parker…et al., 2010; Leekam, Tandos, McConachie, Meins, Parkinson, Wright & Turner, 2007; Evans, Leckman, Carter, Reznick, Henshaw, King et al., 1997; Thelen 1979; 1981). Repetitive behaviours are common in early childhood and are found in many childhood games (Zohar & Bruno 1997); clapping games and skipping rope for example. Elaborate rules in playground games that involve taking turns, or rhythmic nursery rhymes are found in a variety of cultures. Repetition also characterizes many adult-infant games such as peek-a-boo (e.g., Ross & Goldman, 1977). There is however, a relative paucity of empirical information available regarding the normative developmental pattern of these behaviours over the first years of life. The work presented within this thesis will provide much needed description of the phenomenon of repetitive behaviours in the first years. As such, the findings presented within this thesis will allow us to place repetitive behaviours in the context of early normative development and will also provide developmental data that can then be used in comparison with other measures of repetitive behaviours in the clinical setting.

Specifically, the primary aim of the thesis is to extend Thelen's (1979; 1981) and Piaget's (1952) developmental perspectives on repetitive behaviour by examining two different types of repetitive behaviour (motor stereotypies and repetitive operations on objects) in the age range from 6 to 36 months. This is the age range in which several developmental milestones are typically achieved, milestones which have been previously associated with repetitive behaviours, for example locomotion (Thelen 1979, 1980), language (Iverson & Fagan, 2004; Iverson & Wozniack, 2007), and the acquisition of knowledge about the environment (Piaget, 1952). This is also the developmental period in which, according to diagnostic criteria, the onset of autism is frequently identified. The information presented within this thesis will therefore contribute towards understanding motor stereotypies and repetitive operations with objects in the context of development, with reference to their relationship with early communication, socialisation and motor development.

This chapter consists of two sections. I will first explain the title of the thesis and explain the importance of the work by considering the implication of studying this topic from a developmental perspective, before considering the contribution that the work makes to research into developmental disorder. The second section of this chapter will review the research that has been conducted on the topic area and will consequently highlight the need for the work presented within this thesis.

1.2 The Importance of Studying the Rise and fall of Repetitive Behaviours

Motor stereotypies and repetitive actions with objects are very common in infancy (Thelen, 1979; Arnott et al., 2010), are notable during the toddler years (Leekam et al., 2007) and have also been documented (albeit less frequently) amongst older children (Sallustro & Atwell, 1978). Thelen (1979) showed, for example, that infants engaged in a wide variety of repetitive, rhythmical behaviours that peaked in frequency at 24 months of age and consumed approximately 40% of infants' time. In the first year of life, when motor action is less under voluntary control, stereotypies are high in frequency and are sensitive to being released by many triggers.

Cross-sectional studies suggest that younger children (less than 12 months of age) and older children (usually above 48 months) exhibit fewer repetitive behaviours than older infants and toddlers (Evans et al., 1997). Both observation and questionnaire studies suggest that repetitive motor movements are highly common in the first year and still present in a substantial minority of infants in the second year. This is at the point in development when screening checklists are used: the Modified Checklist for Autism in Toddlers questionnaire (M-CHAT; Robins, Fein, Barton & Green, 2001) and the Early Screening of Autistic Traits questionnaire (Dietz, Swinkels, van Daalen, Kerkhof van Engeland & Buitelaar, 2006). However, no single study has addressed the developmental sequence of these behaviours. Understanding exactly how common these behaviours are during the early years is imperative; we need to further our knowledge regarding the proposed normative decline too. The rise and fall in the use of repetitive behaviours may provide valuable information regarding the early phenotypic expression of ASD but may further allow us to understand motor development and alternative modes of pre-verbal communication.

1.3 The Important of Studying Repetitive Behaviours in a Developmental Context

The application of knowledge about developmental trends can enhance our understanding of psychopathological conditions (Cicchetti, 1990). Cicchetti states that "before developmental psychopathology could become a distinct discipline, the science of normal development needed to mature" (p. 330) and further noted that "the proliferation of knowledge about psychological and biological development….has enabled developmental psychopathologists to make compelling progress in unravelling the aetiology, course and sequelae of mental disorders" (Cicchetti, 1990, p.330). Research conducted with community samples of infants and children has resulted in major advances in our comprehension of behaviours in children diagnosed with an ASD (Dawson & Lewy, 1989; Frith, 1989). Specifically, much of the progress in the understanding of cognitive, socio-emotional and socio-cognitive deficits in the ASDs is attributable to concomitant progress related to describing the development of these domains (Baron-Cohen, Leslie & Frith, 1985; Mundy & Sigman, 1989). It is thus imperative to further our understanding and knowledge regarding the early presentation of repetitive behaviours.

Furthermore, it is important to understand the role of repetitive behaviours within the context of infants' and toddlers' early development. The timing of their onset in early infancy and the predictable pattern of increase within the first years suggests that the repetitive behaviours assessed within this thesis are associated with elements of infants' development. The predictable pattern of development warrants the systematic study of repetition and its existence within the context of normative development, independent of its contribution to atypical development.

1.4 Operationalising the Definition of Repetitive Behaviours for the Thesis

Repetitive behaviour is a broad term used to describe behaviours that are characterized by sameness, rigidity and repetition (Honey, Leekam, Turner & McConachie, 2007; Turner, 1999). Such behaviours include motor mannerisms, compulsions, sensory interests, an insistence on sameness and circumscribed interests (Lewis & Bodfish, 2009; Turner, 1999). Whilst it is widely accepted that repetitive behaviours are broad ranging in type, there is as yet no universally accepted categorisation system used to group types of behaviours together.

In the context of ASD four subtypes of repetitive behaviours are identified by the international classification systems DSM-IV (APA, 2000) and DSM-V (APA, 2013). Preoccupation with restricted interests and non-functional routines or rituals has previously been described as higher-level repetitive behaviours. Higher level repetitive and restricted behaviours are those exemplified by attachment to objects, maintenance of sameness, repetitive language and circumscribed interests. Within this higher-order category, routines and rituals represent insistence on sameness (IS; e.g., Szatmari et al., 2006). In contrast, lower level repetitive behaviours are motor repetitions and stereotyped behaviours including repetitive manipulations of objects, repetitive forms of self-injury and stereotyped movements (Prior & Macmillan, 1973; Turner, 1999).

These two forms emerge reliably from factor analytic studies (see Turner, 1999; Leekam, Prior & Uljarevic, 2011 for reviews). In recent years there has been considerable empirical support for the two factor model of restricted and repetitive behaviour (Bishop, Richler & Lord, 2006; Cuccaro, Shao, Grubber, Slifer, Wolpert, Donnelly et al., 2003).

Several studies provide useful insight into the nature of repetitive behaviours. Cuccaro and colleagues (2003) studied 292 children aged 3 to 21 who were diagnosed with an ASD; Bishop and colleagues (2006) studied 830 children with varying forms of ASD with a mean age of 4.8 years. Most notably, the two factors were also identified in a factor analysis of a community sample of 2-year-old children, where repetitive behaviours were rated by caregivers using the Repetitive Behaviours Questionnaire (RBQ-2; Leekam et al., 2007).

The distinction between the higher and lower level repetitive behaviours is useful to conceptualise and categorise repetitive behaviours, especially for empirical purposes. However, there are permeable boundaries between these categories. Leekam and colleagues (2009) state that the phenotypic complexity of repetition is a dimension that runs across all categories of repetitive behaviours. There are overlaps between the behaviours within each group and thus, whilst the sub-types are useful, the terms must be used and interpreted cautiously.

In this PhD thesis the focus is on what is referred to as the lower-level repetitive behaviours, specifically motor stereotypies and repetitive actions with objects. I decided to focus on these because they are considered to be characteristic of younger children and they are relatively simple to observe (Harrop et al., 2014). Motor stereotypies will be defined throughout the thesis as movements that include recurrent, raising and lowering of the arms, internal and external twisting of the upper or lower extremities, flapping, waving, rocking motion and bouncing. Movements are considered stereotypic when their form, amplitude and location are predictable (Jankovic, 1994). Many types of repetitive behaviours do not use objects (e.g. hand and finger mannerisms, clapping, bouncing, rocking); however, there is a second category of repetitive actions that are repeated actions on objects, e.g. tapping, banging objects against one another or against other objects and flapping with an object

(Watt, Wetherby, Barber & Morgan, 2008; Loh, Soman, Brian, Bryson, Roberts, Szatmari, Smith, Zwaigenbaum, 2007).

This thesis will focus on both forms of early-occurring repetitive behaviours, motor stereotypies and repetitive actions with objects. Previous studies have largely focused on questionnaire and interview measures of repetitive behaviours, and thus to supplement the knowledge gained from these studies I decided to use an observation measure. Thus, a further aim of the thesis is to study the prevalence and developmental course of these two types of repetitive behaviour in the first three years of life. This will be apparent in the specific questions and in the introduction to each of the empirical chapters included within this thesis.

1.5 Repetitive Behaviours in the Context of Developmental Disorders

1.5.1 Repetitive Behaviours in relation to the Autism Spectrum Disorders

Recent research has seen significant advances in our knowledge of the early manifestation of the Autism Spectrum Disorders (ASDs) (Leekam, Prior & Uljarevic, 2011; Wetherby & Woods, 2002). Subsequent knowledge about the early ASD phenotype has encouraged the prospective identification, screening for and diagnosis of an ASD at an increasingly younger age. Despite the fact that the DSM-5 (American Psychological Association, 2013) states that symptoms must be present in early childhood, a large proportion of children who are later diagnosed with ASD manifest developmental problems between 12 and 24 months (Barbaro & Dissanayake, 2009), with some showing behavioural abnormalities before 12 months (Baranek, 1999; Osterling & Dawson, 1994).

Impairments in social interaction and communication are the traditional hallmarks of early identification of ASDs and subsequently less attention has been focused on repetitive behaviour as an early diagnostic marker. Consequently many aspects of repetitive behaviours remain relatively unexplored and this paucity of empirical information leaves fundamental questions regarding the phenomenology of repetitive behaviours unanswered (Leekam et al., 2011). Due to the clinical significance of repetitive behaviours for ASD diagnosis, a more comprehensive understanding is required.

From the first and original descriptions of the ASDs to the current diagnostic criteria, repetitive behaviours are defining features of these developmental neuropsychiatric conditions (Kanner, 1943; APA, 2013). A diagnosis of an ASD (APA, 2013) or childhood autism (International Classification of Disorders-10, World Health Organisation [WHO], 1993) is given when an individual has clinical impairments in social interaction, communication and presents with restrictive and repetitive behaviours. The diagnostic criteria have recently been changed but much of the existing research focused on the DSM-IV-TR. Subsequently I shall outline the clinical significance of repetitive behaviours in relation to the DSM-IV criteria for autism before describing the changes made to the DSM-5.

To warrant a DSM-IV-TR diagnosis of an ASD an individual must exhibit six symptoms within the three key domains. The socialization impairments are (1) impairment in the use of multiple nonverbal behaviours, (2) failure to develop peer relationships, (3) a lack of spontaneous seeking to share enjoyment, or (4) a lack of social emotional reciprocity. Communication impairments are described as (1) delay in spoken language, (2) impairment to initiate or sustain a conversation, (3) stereotyped and repetitive use of language, or (4) lack of varied, spontaneous make believe play. Repetitive and/or restricted behaviour is operationalized as (1) encompassing preoccupation with one or more stereotypies and restricted patterns of interest that is abnormal in intensity or focus, (2) apparently inflexible adherence to specific, non-functional routines or rituals, (3) stereotyped and repetitive motor mannerisms or (4) persistent preoccupation with part of objects (APA, 2000, p.75). Repetitive behaviours thus play a crucial role in obtaining a DSM diagnosis of an ASD.

With the recent publication of the DSM-5 (APA, 2013) and the accompanying re-categorization of the ASDs, repetitive behaviours have recently become even more critical for diagnosis. They now constitute over half the diagnostic criteria. Furthermore, to warrant a diagnosis, individuals must exhibit two impairments within the repetitive behaviour symptom cluster. Whilst the DSM-IV-TR outlines five different disorders, the new DSM-5 (APA, 2013) contains one disorder called Autism Spectrum Disorder with two symptom categories: (1) impairment in social communication and social interaction and (2) restricted, repetitive pattern of behaviours, interests or activities. In the first symptom cluster, individuals will need to exhibit all three of the symptoms outlined in the social communication domain. These behaviours are (1) impairment in social-emotional reciprocity, (2) deficits in nonverbal communicative behaviours used for social interaction and (3) problems with developing and maintaining relationships, appropriate to developmental level. The collapse of nonverbal communication and social interaction into a single cluster is based on findings in the literature that have suggested that there is a large overlap between these areas that leads to difficulty distinguishing if behavioural difficulties are related to communication solely, socialization solely, or an interaction between the two areas (Carpenter et al ., 1998).

For the DSM-5 second symptom cluster, two of the following four behaviours need to present in order to obtain a diagnosis: (1) stereotyped or repetitive speech, motor movements or use of objects, (2) excessive adherence to routines, ritualized patterns of verbal or non-verbal behaviour or excessive resistance to change, (3) highly restricted fixated interests that are abnormal in intensity or focus, (4) hyper- or hypo-reactivity to sensory input or unusual interests in sensory aspects of the environment. The new criteria in this domain (i.e. requiring two of the four symptoms) place a heavier emphasis on repetitive behaviours than in the past. Children who do not exhibit repetitive behaviours will no longer meet the diagnostic criteria for ASD, but will be more likely to receive the new DSM-5 diagnosis of Social Communication Disorder (Happé, 2011). The transition to the new criteria suggests that repetitive behaviours are critical for an ASD diagnosis, thus emphasizing the importance of gaining a comprehensive understanding of the repetitive behaviours now.

It is evident that simple repetitive behaviours (as opposed to more complex rituals or routines) play a critical role in ASD. Children diagnosed with an ASD commonly demonstrate motor stereotypies and repetitive actions using objects. They are likely to engage in body rocking, finger flicking and hand flapping (Turner, 1997). Different methods have been used to study the occurrence of repetitive behaviour in children who are diagnosed with ASDs. Wetherby and colleagues (2004) observed behaviour whilst children completed the Communication and Symbolic Behaviour Scales Developmental Profile (CSBS; Wetherby & Prizant, 2002). They developed the Systematic Observation of Red Flags of ASD (SORF) to rate 29 behaviours that might be early indicators of ASD. They studied a sample of children (the FIRST WORDS Project) by screening a general population sample, collecting videotapes of systematic observations during a communication evaluation in the second year, and later diagnosing ASD in a small subset of children screened. Repetitive movements of the body and repetitive movements with objects distinguished 18 children with ASD between 12 and 24 months of age from 18 children that did not have an ASD. Children diagnosed with autism have previously demonstrated higher frequency and longer duration of repetitive behaviours, specifically repetitive motor behaviours, repetitive behaviours with objects and sensory behaviours (Watt et al., 2008). Within their longitudinal observation study comparing children with an ASD, children identified as developmentally delayed and ‘no problem’ children, Watt and colleagues (2008) noted that the motor stereotypies and repetitive actions with objects were related to concurrent measures of symbolic capacity and social competence in the second year. These specific repetitive behaviours also predicted developmental outcomes as well as severity of autism symptoms at three years. Subsequently, motor stereotypies and repetitive actions with objects, specifically, are important for early identification and prediction of developmental outcomes (Watt et al., 2008).

1.5.2 Repetitive Behaviours in the Context of Other Developmental Disorders

Furthermore, repetitive behaviours are common features of a number of other developmental disorders. In some cases (e.g., fragile X), these disorders include expression of autistic traits and behaviours (Lewis & Kim, 2009). Furthermore repetitive behaviours are part of the phenotypic expression of other disorders including Tourette syndrome and schizophrenia (Lewis & Kim, 2009). Other conditions such as blindness (Fazzi, Lanners, Danova, Ferrarri-Ginevra, Gheza, Luparia et al., 2002) are also associated with repetitive behaviours. Repetitive behaviours are also seen in neurological disorders. Motor stereotypies are seen in patients with frontal lobe lesions, Luria (1973) argued that lesions of the posterior areas of the frontal lobes would result in motor stereotypies. In the context of OCD, repetitive behaviours play a key role in the maintenance of the perseverant actions. Finally, motor stereotypies are commonly noted in patients with Parkinson’s disease (Ridley, 1994). This demonstrates the dependence of repetitive behaviour on specific neural circuits (Ridley, 1994).

1.5.3 Repetitive behaviours in Relation to Genetic Mutations and Animal Models

Autism has been recognized as the neuropsychiatric disorder with the greatest genetic component. This is due to greater than 90% heritability estimated by twin studies and a sibling recurrence rate of 5 to 6% (Persico & Napolioni, 2013). The phenotypic heterogeneity of ASD had delayed the identification of autism susceptibility genes. In the context of ASD, the repetitive behaviour phenotype also shows a tendency to run in families. Repetitive behaviours may be influenced by genes that are largely independent of those that make up social and communication impairments, the remaining diagnostic criteria of autism (Mandy & Skuse, 2008; Ronald, Happé, Bolton, Butcher, Price, Wheelwright et al, 2006). In families with individuals with autism, reports of biased transmission of both alleles (short, long) at the serotonin transporter gene promoter polymorphism (5-HTTLPR) locus of SLC6A4 now exist. Brune, Kim, Salt, Leventhal, Lord & Cook (2006) explored whether variants of two functional polymorphisms of SLC6A4 (5-HTTLPR, intron 2 variable number tandem repeat [2 VNTR]) were related to behavioural characteristics measured by the Autism Diagnostic Interview-Revised and Autism Diagnostic Observation Schedule. They found evidence of genotype-phenotype interactions on the Autism Diagnostic Interview-Revised with the 5-HTTLPR short group of HTTLPR (S/L or S/S genotypes) being rated as severe on the subdomain failure to use nonverbal communication to regulate social interaction, and the long group (L/L genotype) being more severe on the subdomain stereotyped and repetitive motor mannerisms. These findings provide initial support for genotype-specific phenotypes for 5-HTTLPR in repetitive behaviours.

Recent research involving animal models of repetitive behaviours generally fall into three classes: repetitive behaviours associated with (1) targeted insults to the CNS; (2) administration of specific pharmacological agents and (3) exposure to restricted environment and experience (Lewis & Kim, 2009). Motor stereotypies have been observed in several mutant mouse models. For example, mice expressing truncated MCCP2 protein exhibit repetitive forelimb movements resembling the distinctive stereotypies seen in children. Furthermore, a reduced activity of the indirect basal ganglia was associated with high levels of the lower level repetitive behaviours in deer mice (Lewis & Kim, 2009). Specific genetic alterations appear to be important risk factors to isolate as there are findings from both clinical and animal models studies linking repetitive behaviour to genetic mutations. Repetitive behaviours have been linked to mutations at several different chromosomal locations. This can be attributed to the heterogeneity of the behaviours that exist within the symptom domain of autism. Whilst I have highlighted some genetic links with the lower level repetitive behaviours, it is important to note that repetitive behaviours are mediated by complex circuitry involving a large number of genes. Mutations of even a few such genes could result in significant disruption to this circuitry and full expression of the behavioural phenotype (Lewis & Kim, 2009).

The circuitry hypothesized to mediate the expression of repetitive behaviours includes pathways that link selected areas of the cortex and the basal ganglia. Several studies have implicated the basal ganglia, particularly structures within the striatal level, to repetitive behaviours in developmental disorders (Cromwell & King, 2004). The disruption of coordinated functions within the basal ganglia, or between striatal and forebrain structures, result in changes in behaviour and often induce repetitive behaviours, specifically stereotypies. Dysfunctional feedback to the front cortical areas causes an inability to switch to other behaviours and also facilitates inappropriate behavioural sets (Langen et al., 2010). Structural differences are found in the basal ganglia of those with an ASD when compared to control groups (Hollander et al., 2007; Langen, Durston, Staal, Palmen & England, 2007).

Due to the role that the basal ganglia plays with regard to planning and memory, it seems reasonable to conclude that children who engage in repetitive behaviours most frequently will not perform as well on tasks that draw on these skills. I will address this possibility in Chapters 5 and 7 of this thesis.

1.5.4. Repetitive Behaviours and Neuropsychological Theories

Theories relating to the functions of the frontal lobe propose a connection between executive functioning and the control of repetitive behaviours. Executive function (EF) impairments of poor regulation and poor control of behaviour have been linked to elevated use of repetitive behaviours. Executive dysfunction encompasses problems with inhibition of inappropriate behaviours, impaired generation of adaptive goal-directed behaviour, failure to learn from feedback in the environment and a lack of flexibility (e.g. Evans, Lewis & Iobst, 2004; Lopez, Lincoln, Ozonoff & Lai, 2005). Executive dysfunction has been identified in individuals at a variety of ages with ASD (Ozonoff, South & Provencal, 2005), and in that context, a deficit in EF is a major contender as an explanation of repetitive behaviours.

Turner (1997; 1999) proposed a two-step hypothesis for the relationship between EF and repetitive behaviours, one relating to an inability to inhibit ongoing behaviour and another related to an inability to generate novel behaviours. In Turner's view, those two deficits would thus result in higher rates of motor stereotypies and repetitive actions with objects, as children with executive dysfunction would revert to well-learned behavioural responses. A link between EF and repetitive behaviour has been found in adults with ASD (Lopez, Lincoln, Ozonoff & Lai, 2005) (n=17) compared to adult controls (n=17). Three dimensions of EF (cognitive flexibility, working memory and response inhibition) were associated with repetitive behaviours. These results did not support a single executive process that could account solely for repetitive behaviours. Rather, their results suggested that EF contributed to the presentation of repetitive behaviours. However, these results could be attributed to the choice of measure of repetitive behaviours. The authors used a composite score of repetitive behaviour by drawing from repetitive behaviour items from the ADOS-G, ADI-R, Gilliam Autism Rating Scale and the Aberrant Behavior Checklist-Community (Aman & Singh, 1994; Lord, Rutter & Le Couteur, 1994; Lord et al., 2000). The composite score is reflective of several types of repetitive behaviour and thus requires clarification. The link between EF and repetitive behaviour has been clarified in research with a community sample of children (Tregay et al., 2009). Children aged between 37- and 107-months were assessed on three aspects of the executive system; cognitive flexibility, response inhibition and generativity. Seventy-eight children completed a card sorting task, the Luria hand game and a category fluency task (measuring semantic verbal fluency). Simultaneously, the parents completed the Childhood Routines Inventory (CRI). Children's cognitive flexibility was associated with repetitive behaviours, where poorer performance on the card sorting tasks was associated with parental reports of elevated repetitive behaviours. Furthermore, the number of errors during the card sorting task predicted to elevated frequency on the repetitive behaviours factor (or the CRI) in the younger children (aged < 67.5 months). Participants' generativity was unrelated to repetitive behaviours, thus suggesting that the association between EF and repetitive behaviours are driven by the inhibitory component rather than the generative aspect of thinking in a new way (Tregay et al., 2009).

Over a decade of research has not been able to fully substantiate either of Turner's (1997, 1999) hypotheses and overall findings regarding executive dysfunction are very mixed. Arguably, this could be attributed to the broad phenotypic expression of the different types of repetitive behaviours. In this thesis, I will specifically examine the relationship between toddlers' inhibitory control and lower-level repetitive behaviour (motor stereotypies and repetitive actions on objects; see Chapter 7).

Section 2: Literature review

How common are repetitive behaviours in the early years and do they relate to other domains of development?

The developmental approach to repetitive behaviour proposes that the pathological repetitive behaviours seen in children with developmental disorders are "immature behavioural responses that are a normal part of early development but have been maintained beyond the typical period" (Leekam et al., 2011, p.581).

The subsequent sections of this chapter will therefore focus on the developmental approach to the study and understanding of motor stereotypies and repetitive actions with objects in infants and very young children. The subsequent sections highlight questions that remain unanswered and an area of research in which clarification is required. To this end, the remaining sections of Chapter 1 will review literature bearing on the developmental research questions addressed within this PhD thesis. The questions are exploratory because the nature of the studies conducted within this thesis are novel and designed to provide a platform from which future research can be conducted. Due to the novel nature of the research conducted within this thesis, the literature review presented below takes a narrative approach. Studies were included in Table 1.1 if they had assessed repetitive behaviours in community samples of infants, toddlers and children. Studies were also included if authors had reported instances of repetition (even when the primary purpose of the study was to assess other behaviours).

The literature discussed in this chapter was derived from my review of journal articles and book chapters dating from October 2010 – June 2014. I did not apply any exclusion criteria and thus included all relevant studies of infant and toddler repetitive behaviours that I could find. I did not exclude any studies in which repetition was assessed in community samples. First I performed computerized searches of MEDLINE, PsychINFO, PubMed and Web of Science databases. During the final three months of writing this thesis I performed another thorough search in order to ensure recently published studies were also included. The search terms included infant, toddler, child, community, stereotypies, rhythmic, motor movement, motor development, repetitive actions, object repetition, lower level repetitive behaviours, play, interaction, communication, language, executive function and development. I did additional manual searching of the relevant journals: Journal of Developmental & Behavioural Paediatrics, Child Development, Journal of Autism and Developmental Disorders, Developmental Psychology, Journal of Child Psychology and Psychiatry, Infancy. I also searched the reference lists of review articles and list of publications of researchers working in these fields. I read the method sections of papers involving children's social and/ or motor development in order to extract those studies including repetition as a theme.

Table 1.1. Methods and measures used in previous research examining motor stereotypies and repetitive actions on objects in infants and toddlers.

Author	N	Age	RB measure	Design	Prevalence	Onset	Other Details	Results
Arnott et al., (2010)	123	15 months	Questionnaire (RBQ-2)	Cross-sectional	Yes	No	-	High frequency of repetitive motor movements in 15 month olds. Motor stereotypies and repetitive actions with objects were commonly recorded. Some of the items of the RBQ-2, such as 'repetitive fiddles with toys' were endorsed by 60% of the sample. Implication for the early detection of disorders such as ASDs.
De Lissovoy (1962)	33	10 to 49 months	Observation (unstandardized – observer kept a continuous narrative)	Prospective, longitudinal	No	Yes	Weekly observations Assessed head banging & positions in which the banging occurred.	All children banged their heads. Most likely to bang head when on hands and knees or when sitting. 37% of the children engaged in more than one rhythmic behaviour at a time (i.e. head banging and rocking).

Author	N	Age	RB measure	Design	Prevalence	Onset	Other Details	Results
Evans et al., (1997)	1492	8 to 72 months	Questionnaire (CRI)	Cross-sectional	Yes	Yes	The study explored the sub-constructs of the CRI. Two factors - items relating to a 'Just Right' phenomenon and items relating to repetitive behaviours.	Children engaged in a wide range of different types of repetitive behaviour that are also found in children with autism. Children younger than 12 months engaged in fewer repetitive behaviours than children who were between 12 and 47-months. Children older than 47 months showed less repetitive behaviours than younger children.
Field et al (1979)	20	Not stated	Interview	Group comparison, prospective.	No	Yes	Assessed two groups of high risk infants (preterm respiratory distress syndrome and post-term post-mature group). Also assessed with the Bayley Scale 12 months.	All infants engaged in rhythmic behaviours. Onset was earlier for the post-term post-mature group than for the preterm group. Group difference in onset not exist after correcting for gestational age. Stereotypies onset at the same time regardless of earlier life experiences. Significant group differences in the Bayley motor assessment - the development of motor skills affected by perinatal complications.

Author	N	Age	RB measure	Design	Prevalence	Onset	Other Details	Results
Foster et al., (1998)	100	36 to 80 months	Interview unstandardized	Cross-sectional	Yes	No	Assessed situations in which the stereotypies occurred. Excluded those with developmental disorders.	Older children engaged in fewer motor stereotypies but the behaviours were still prevalent in a community sample. 55 children engaged in motor stereotypy. ***Parents and teachers should consider the function of the behaviour before they try to force a child to stop engage in them.***
Goldfield (1989)	15	Mean 193 days at start and 271.5 days at the end	Observation (unstandardized measure used to transcribe all motor movements made by infants [including rocking])	Prospective, longitudinal	Yes	Yes	Observed weekly until individual crawled.	73% of the infants rocked. Mean age of onset = 228 days. Rocking was always observed before crawling. Rocking facilitated the coordinated pattern of arms and legs, useful for locomotion because of the release of the constraint for supporting the body with both hands.
Iverson & Fagan (2004)	47	6-9 months old	Observation (standardized assessment of stereotypy)	Cross-sectional	No	No	Observed babble onset	Stereotypy use increased prior to babble onset, vocal-motor coordination is a robust feature of infant behaviour.
Kahrs et al, (2012)	14	7-14 months	Observation - unstandardized	Cross-sectional	No	No	Assessed the role of banging in the development of tool use	All banged, older infants banged less frequently. Banging facilitates transition in behaviour to manual controlled behaviour suitable for tool use.

Author	N	Age	RB measure	Design	Prevalence	Onset	Other Details	Results
Kravitz & Boehm (1971)	140	0-12 months	Observation & questionnaire (unstandardized)	Prospective, longitudinal	Yes	Yes	Multiple observations of infants from birth to onset of hand sucking. Questionnaire follow up assessed onset of other rhythmic behaviours.	Variety of rhythmic behaviours were observed. Hand sucking emerged first (median onset = 54 minutes), then foot kicking (median onset 2.7 months), rocking (median onset 6.1 months) and head rolling (median onset >12 months). Therefore considered normal.
Leekam et al., (2007)	679	2 years old	Questionnaire (RBQ-2)	Cross-sectional	Yes	No	Assessed the psychometric properties of the RBQ-2 (PCA) N.B participants drawn from same study as Arnott et al., 2010.	Found a four-factor model provided a best fit for the data. These closely resembled ICD-10 criteria for autism. Every item of the RBQ-2 endorsed by 18 to 30% of the sample. Each repetitive behaviour were frequently reported by parents.
MacLean et al., (1991)	10	Mean 5.8 months	Direct observation (unstandardized)	Prospective, group comparison	No	Yes	-	Children exhibited repetitive motor behaviours between 3 and 18 months, children with developmental delay/disability exhibited repetitive motor behaviours between 6 and 36 months.

Author	N	Age	RB measure	Design	Prevalence	Onset	Other Details	Results
Mahone et al., (2004)	40	9 months to 17 years	Review of medical records	Cross-sectional	Yes	No	Noteworthy is that the authors assessed non autistic clinical stereotypies	The onset of stereotypies was before 3 years in 90% of the sample. Movements stopped when cued in 98%.
Palmer (1989)	20	6, 9 and 12 months	-	Cross-sectional	No	No	The author examined infants' exploratory actions	P's waved and banged objects whilst exploring. Older infants more likely to wave/ bang, the banging and waving preceded goal-directed manipulation of objects.
Piek et al., (1994)	50	0-12 months	Observation, unstandardized	Cross-sectional	No	No	Home observation	Single leg kicks and arm waves most common types of spontaneous movements.
Sallustro et al (1979)	525	3 months to 6 years	Parent questionnaire (unstandardized)	Retrospective	Yes	Yes	Also collected data on socioeconomic status and developmental milestones.	Persistent display of the repetitive behaviours (rocking, head banging and head rolling) was not uncommon. 19.1% engaged in rocking, 5.1% in head banging and 6.3% in head rolling. Onset of rocking was first, head banging and rolling had similar onset. SES had no impact on development of repetitive behaviours. Developmental milestones were predicted by frequency of rocking and head banging but not head rolling.

Author	N	Age	RB measure	Design	Prevalence	Onset	Other Details	Results
Schwartz et al (1986)	12	Mean 4 months	Direct observation (unstandardized)	Group comparison.	No	No	Groups defined as typical developing and children with severe intellectual disability	Topographical differences between children with and without intellectual disabilities for duration of the repetitive behaviours. Children with severe intellectual disability spent more time hand gazing and rocking. Typically developing children engaged in repetitive behaviours.
Soussignan & Koch (1985)	12		Direct observation (unstandardized)	Cross-sectional	No	No	The authors measured heart rate in school aged children	Heart rate decreased when they engaged in repetitive actions (specifically leg-swinging). This suggests functional interpretations of the behaviours.
Tan et al (1997)	10	2 to 7 years	Direct observation (unstandardized)	Cross-sectional	No	Yes	Sample was drawn from reviewing children's' medical records. 7 children were delayed at attaining developmental milestones.	Median onset of the repetitive behaviours (flap, rock and neck extension) =23 months. All children engaged in stereotypies and at the follow up, only 2 children had stopped.

Author	N	Age	RB measure	Design	Prevalence	Onset	Other Details	Results
Thelen (1979)	20	0-12 months	Direct observation (unstandardized)	Prospective, longitudinal	No	Yes	-	Repetitive movements extremely common in the first year of life. Overall frequency reduced towards the end of the first year they still remain relatively high.
Troster (1994)	57	10 to 60 months	Direct observation, unstandardized	Cross sectional	Yes	No	Assessed 15 different stereotypies in children in residential care.	All children engaged in a stereotypy. Thumb sucking and body rocking most frequent in younger children, and nail chewing in school aged children. Boys engaged in more and children with a suspected history of abuse engaged in more. Stereotypies observed when concentrating, aroused, bored or frustrated.
Werry et al (1983)	156	3 to 59 months	Survey & questionnaire (unstandardized)	Group comparison	Yes	Yes	A community sample was used	Motor stereotypies are common aspects of infants and toddlers motor movements. During the toddler years, 5% of children still engaged in stereotypies such as rocking.

1.6 Repetitive Behaviour in relation to Developmental Theories of Development

As outlined in section 1.1, this thesis concentrates on two forms of the repetitive behaviours: motor stereotypies and repetitive actions with objects. The reasons are two-fold. From a practical perspective these repetitive behaviours are easy to observe and are most likely to be seen by direct observation; whereas the insistence on sameness and adherence to routines and rituals are better suited for interview measures. Furthermore, the motor stereotypies and repetitive actions with objects have previously been described as predictive to future developmental level (Watt et al., 2008), they are very common in infancy (Thelen, 1979) and have been associated with the developmental of motor and vocal systems (Iverson & Fagan, 2004). I will discuss the conclusions drawn from research with community samples of children in relation to theories of motor and cognitive development, respectively. This is the research presented in Table 1.1. Two categories of repetitive behaviour will be considered individually.

1.6.1 Motor Stereotypies

Repetitive behaviours are normal concomitants of motor development during infancy (Thelen, 1979, 1980, 1981). Infants typically exhibit large amounts of rhythmical behaviours, such as kicking, rocking, waving, banging, bouncing, swaying, scratching and twirling (Thelen, 1979). Such behaviours were originally recorded and observed during individual assessments and observations of infants at home, or in laboratories. These repetitive behaviours were first noted in systematic empirical investigations of infant behaviours, beginning with the work of Gesell & Ilg (1948) describing the normative timetables for infant motor achievements and that of McGraw (1941, 1943) examining the determinants of these patterns. More recent research suggested that repetitive behaviour could be identified even earlier, during foetal life. Spontaneous motor activity that demonstrate cyclic fluctuations emerge at the gestational age of 12 weeks. Pre-natal rhythmical sucking and swallowing are important in the regulation of amniotic fluid (Piek, 2006). These repetitive behaviours continue once the infant is born but are irregular in the first few months (Piek, 2006).

The early studies of normative motor development showed that rhythmical behaviours (what are referred to in this thesis as motor stereotypies) were common in healthy, well-adjusted infants. Such behaviours were described as transient, developmental events (Gesell & Armatruda, 1941). Referred to as ‘rituals of the ritualist’ (Gesell, Ames & Ilg, 1974), behavioural repetition were claimed to be a crucial feature of human experiences that characterise automatic and well-practiced activity (Ridley, 1994).

At about the same time as Gesell and McGraw’s works were published, neuroanatomists were identifying the particular structural changes of the brain that occurred during the infancy period (e.g. Tilney & Casamajor, 1924). These observations of predominant postures in the acquisition of crawling led Gesell to conclude that motor development was a reflection of an underlying neurological maturational process. Similarly, McGraw (1941; 1943) interpreted her observations as being consistent with progressive myelination of the cerebral cortex and concluded that the development of crawling reflected progressive control by cortical structures over subcortical ones.

Repetitive behaviours were therefore thought to be evidence for developing neuromuscular control and progressive organisation of the central nervous system; they represent a period of motor development that is more mature than spontaneous movement but less mature than voluntary, goal-directed behaviour (Gesell and Ilg, 1948; Gesell and Armatruda, 1941). For example, hand-and-knee rocking has been interpreted as one of the steps in prone progression, occurring after the infant assumes the creeping posture but before it can make forward progress (McGraw, 1943). Rocking is an example of the reciprocal interweaving of motor development, a process that is the balancing of flexor and extensor influences and has been interpreted as one of the steps in prone progression, occurring after the infant assumes the creeping posture but before it can make forward progress (McGraw, 1943; Gesell and Ilg, 1948). Rhythmical patterns appeared in transition stages of motor development, as in a child who can sit but cannot stand or walk (Lourie, 1949). It seems sensible to thus suggest that the repetitive behaviours are commonly exhibited and are a normal part of their behavioural repertoire.

Motor stereotypies develop in a predictable format. Hand sucking tends to develop first, followed by foot kicking, rocking and then head movements (Kravitz & Boehm, 1971; Sallustro et al., 1978). By drawing the results of these studies together we can draw on different methods of data collection, both observation and questionnaire to further our knowledge about the early development of motor stereotypies. Gesell (1946) makes an interesting proposal for how the infant's postural asymmetry might contribute to the transition from rocking to crawling. He proposed that, because the muscles are arranged in bilateral pairs, asymmetries in posture might serve the compensatory function of shifting posture from symmetry to an eccentric position. Gesell considered the position of the limbs as postural ends only but did not consider how the infant used the limbs for locomotion; he did not explain how asymmetry may be involved in the transition from rocking to crawling. Goldfield (1989) therefore observed 15 infants aged 6- to 9-months in their homes on a weekly basis and recorded infant activity from prone position on the floor. A toy was placed either 30 or 60 seconds from the infants' hands as a lure. Each observation session lasted for four minutes. Goldfield (1989) found that orienting the eye-head system to objects and persons in the environment motivated the infant to locomote in order to approach or avoid particular affordances.

Both postural and muscular constraints on head orientation, reaching, and kicking create a particular opportunity for locomotor approach that is not evident earlier. According to the dynamic systems approach, each developmental capability assumes a specific function for locomotion (Thelen, 1979; 1980). These behaviours come together to produce crawling. The data suggested that co-ordinated leg/ head orienting/ reach action is seen long before mature crawling. The essential link was repetitive rocking, where infants can push symmetrically with their hands whilst prone. This counteracts the forces of kicking and reduces weight on the hands during the tripod stance.

Careful analysis of motor movements has also been undertaken in the context of a clinical population. Mahone and colleagues (2004) characterized the clinical features, onset, course and outcome of 40 children and adolescence with complex stereotypies involving the upper extremities. Forty-three participants were recruited. The inclusion criteria were individuals with movements involving the upper extremities that were involuntary, bilateral, patterned, coordinated, repetitive, rhythmic, non-reflexive, seemingly purposeful and suppressible. These movement patterns were characterized as complex motor stereotypies if they were present for at least 4 weeks. Children were included if there was no evidence of pathologic movement abnormality. The participants' mean age was 7.9 (range 9-17 years). Eighteen percent were younger than 5 years of age. Ten children met the clinical criteria for ADHD (measures using the Conner's Parent Rating Scale) and two had OCD (as diagnosed by a psychiatrist). Mahone and colleagues (2004) concluded that the physiologic stereotypies can be divided into one of three major categories on the basis of type of movement observed: (1) common, which are circumscribed and smooth, (2) head nodding and (3) complex.

Mahone and colleagues (2004) state that the complex category differs from the other categories on the basis of its primary involvement of the arms and hands bilaterally, use of multiple muscle groups, irregular movements and similarity to movements seen in the autistic population. The members of their sample of 40 children with non-autistic complex stereotypies were similar in several aspects. Most children had an onset of stereotyped movements by age 2 years. Mahone and colleagues (2004) therefore concluded that it was important that physicians recognize that repetitive, fixed, complex movements of the arms and hands can exist in otherwise normal children. These movements are often associated with comorbid developmental and neuropsychiatric conditions and are likely to persist for many years. These authors suggested that further studies are required to characterize more precisely the clinical features, prevalence, pathophysiology and therapy.

This raises questions regarding individual differences in the presentation of repetitive behaviours. In their study, Watt and colleagues (2008) observed repetitive behaviours with objects, with body and sensory behaviours in three groups of children. The participants were recruited prospectively through the First Words project. Fifty of the participants met the clinical criteria for autism, 25 had developmental delays and 50 had no developmental problems and were considered as the typically developing group. All participants were assessed using the CSBS (Wetherby et al., 2012). The CSBS is a measure of social-competence administered during individual testing with an experimenter, which is designed to encourage spontaneous communication and provide opportunities for symbolic and constructive play. Aside from the significant group differences, the authors found that repetitive behaviours with objects correlated negatively with the participants' social competencies. Similarly, Harrop and colleagues (2014) examined children's nonverbal IQ and their language ability in relation to their repetitive motor actions. They also found a negative correlation between the frequency of repetitive behaviours and the participants' scores on the social-communication measures. Noteworthy however is the fact that the participants within this study, unlike Watt and colleagues (2008), were assessed in the context of free play. Harrop and colleagues (2014) and Watt and colleagues (2008) assessed participants aged between 24 and 48 months. Arguably, the early communication and developmental milestones such as learning to walk and learning to communicate through pointing, gesturing and babbling come into the behavioural repertoire before this age. These empirical examples do not assess the earlier origins of these individual differences.

Harris, Mahone and Singer (2007) aimed to expand our knowledge of otherwise normal non-autistic children with motor stereotypies by obtaining additional longitudinal data. They conducted both cross-sectional and longitudinal analyses. One hundred children and young adults aged between 8 months and 27 years (mean age 8.5 years) were observed. Nearly all children demonstrated an onset of stereotypic movements by age 3 years. Such movement could last for minutes, could occur multiple times throughout the day and tended to be associated with periods of excitement, stress/ anxiety, fatigue, or when the child was engrossed. These repetitive movements were absent during sleep. Longitudinal follow-ups confirmed that most motor stereotypies were persistent. The outcomes for the participants varied based on the type of movement. However, the underlying pathophysiologic mechanism of motor stereotypies in typically developing children remains unknown.

One of the major theorists about motor stereotypies was Esther Thelen (Thelen & Fogel, 1989, Thelen, Kelso & Fogel, 1987), who took a dynamical systems approach to the study of developmentally normative, lower-level repetitive behaviours. In this view, novel behavioural functions emerge from unique combinations of interacting capabilities, each with its own rate of development. Rather than reflecting a separate neuromuscular mechanism (as

Gesell and McGraw suggested), crawling may be one functional possibility for infant locomotion, given a unique combination of other developing capabilities. Consistent with the earlier work of Lourie (1949), Gesell (Gesell and Ilg, 1948; Gesell and Armatruda, 1941) and McGraw (1941, 1943), Thelen (1979, 1981) noted that repetitive behaviours represent a period of development that is more mature than spontaneous movement but less mature than voluntary, goal-directed behaviour. She postulated that repetitive motor behaviours tend to show great uniformity in form and regularity in the developmental course. They are symptomatic of developing neuromuscular control and progressive organisation of the central nervous system. Thelen's (1979) dynamic systems approach postulated that repetitive behaviours can enhance motor development as they are likely to be one source of a rhythmical timing mechanism that facilitate development of gross motor behaviour. The intrinsic rhythmical motor patterns specify spatial and temporal patterns. They are an essential form of movement coordination and postural stability.

In Thelen's view, repetitive behaviours are adaptive and functional before full voluntary control develops (i.e. the non-reflexive, spontaneous stereotypic leg kicking of infants reflects an endogenous motor program that specifies the spatial and temporal pattern of leg movement). Motor stereotypies amongst typically developing children symbolise periods where neuromuscular co-ordinations (such as the flexions, extensions or rotations) are most apparent (Thelen, 1981). Thelen (1979) attributed spontaneous activity to the dynamic control of muscle synergies or coordinative structures. Although Thelen did not operationally define these terms, flexions can be seen as bending or the condition of being bent or a part of the body whereas extensions refer to the action of moving a limb from a bent to a straight position. Using 3D limb kinematics, Thelen and her colleagues made an extensive examination of the different contributions of muscular, passive and gravitational torques on the ankle, knee and hip joints when infants are producing spontaneous leg kicks. Comparison of ankle, knee and hip joints by Thelen and Fisher (1983) in 2- and 4-week old infants suggested that the leg acts synergistically during a leg kick as a result of the self-organisation of active and passive forces. They argued that the flexion phase is well developed virtually from birth compared with the extension phase which appeared to be quite slow in comparison. The relative invariance of the timing of flexion and extension in infant kicking was pointed out by Thelen and Fisher (1983). Changes in the frequency and vigour of kicking were associated with changes in the level of arousal and context of the kicking. However, neither the timing of the leg flexion nor of the leg extension appeared to differ when the context was varied. For example, no differences were found for those measures when infants were in an active, moving state compared with a state of crying, nor was the timing affected when infant kicking was reinforced by attaching the leg to a mobile.

In her seminal paper, Thelen carried out a comprehensive longitudinal study to classify rhythmical stereotypies in infants up to 12 months of age. Her definition of such a movement was quite specific in that the movement had to be repeated at least three times in sequence before it was recorded. Thelen approached the study of infant repetitive behaviour from an ethological perspective and described the occurrence of over 16,000 bouts of repetitive behaviours amongst 20 infants (observed on a bi-weekly basis during the first year of life). Her infant sample was Caucasian, full-term, and raised by two parents. Forty-seven different motor stereotypies were identified. On average 5% of infant time was spent engaged in repetitive behaviour with some infants engaging in the motor stereotypies over 40% of the time (Thelen, 1981). Such repetitive behaviours (e.g., rocking, flapping hands, finger flexing, banging and bouncing) tended to arise at an early age of 24 to 32 weeks in development.

In Thelen's research, repetitive behaviours were frequently observed in the first year of life and they demonstrated a clear period of onset, peak and decline. Thelen considered the onset of different repetitive behaviours in terms of body location, using a morphological framework. When the 47 distinct movements were grouped together by body part and posture a number of development profiles emerged. Stereotypic actions and repetitive behaviours were most prevalent at seven to eight months with leg stereotypies peaking at three to seven months and arm/ torso stereotypies at six to twelve months. Furthermore, Thelen observed a significant correlation between the mean age of onset of repetitive behaviour for each infant and the mean Bayley Motor Scale score. She concluded that repetitive behaviours and motor stereotypies peak in frequency at transition points of motor growth such that the behaviours represent a transitional phase in motor development (Thelen, 1979, 1980).

Thelen's detailed observation of repetitive behaviour has not been replicated. However, informants' reports also draw attention to the occurrence of repetitive behaviour in the first years of life. One such questionnaire study used the Childhood Rituals Inventory (CRI; Evans et al., 1997) in a large cross-sectional assessment of 1492 children. Items in the CRI relate to both lower-level and higher-order repetitive behaviours. The questions within the CRI load onto two factors, with items loading onto a 'Just Right' factor or a 'repetitive behaviour' factor. Within the repetitive behaviour factor Evans and colleagues found that infants younger than 12 months engaged in repetitive behaviours less frequently than infants aged between 12 and 48 months. Infants who were older than 48 months engaged in fewer repetitive behaviours than their younger peers. Another questionnaire measure was conducted with parents of typically developing children; parents completed the Repetitive Behaviour Questionniare-2 (RBQ-2, Leekam et al., 2007) at 15 and 20 months of age. According to the parents, approximately half the sample showed repetitive motor actions at 15 months, with

48% of infants rocking back and forth and 51% flapping their hands at least once a day (Arnott et al, 2010). Repetitive behaviour was less common but still present at 20 months, with 17.8% rocking back and forth and 22.4% flapping their hands at least once a day. This work supports Evans and colleagues (1997).

1.6.2 Repetitive Actions with Objects

Infants' repetitive actions on objects are of special interest for theories of cognitive development. It has long been argued that repetitive actions on physical objects facilitate cognitive development (Flavell, 1963, Piaget, 1952) as well as the development of fine motor skills (Palmer, 1989). Infants increasingly engage in self-directed exploration of their own environment as their growing motor competence allows. Self-directed exploratory activities and the multi-modal perceptual opportunities they create provide infants with important additional information about the world within their reach. For example, 5-month-old infants often engage in repetitive exploratory behaviours with objects. The repetitive inspection appears to facilitate the infants' ability to compare visual and tactile information and develop cross-modal links between sensory experiences (Rochat, 1989). This suggests that infants' repetitive use of objects, during individual observations facilitates the infants understanding of the object. Noteworthy is the fact that repetitive actions with objects cannot occur before the infant can grasp.

Furthermore, Piaget's theory drew attention to kicking, banging and rubbing movements as secondary circular reactions, a necessary stage in cognitive development in which the infant repeats behaviours that have had an interesting effect on the environment (Piaget, 1952). Piaget's theory was further developed with the view that during the first two years of life, infants coordinate single reflex behaviours into a system of sensory-motor movements. This occurs gradually in a succession of six sensory-motor sub-stages (Cowan, 1978). In his description of the six sub-stages, Piaget encompassed five major domains of behaviour (adaptive, gross motor, fine motor, language and social) identified by Gesell & Ilg (1948) as being developmentally significant. A theme of repetition begins to arise across motor and socio-cognitive domains (see Table 1.2).

Table 1.2. Motor Repetition in the context of Piaget's Theory of Stages of Sensory-motor Development

Sub-stage	**Age (in months)**	**The role of repetition**
1	0 - 1	Emergence of directed behaviour, repetitive exercise of the reflex becomes evident.
2	1 - 4	Scheme-coordination and early-goal direction: achieved via circular reactions (i.e. functional pleasure, the pleasurable effort involved in repeating actions for their own sake.
3	4 - 8	Infants repeat actions to prolong interesting events (secondary circular reactions).
4	8 - 12	Repeated activity of play increases the infants' mastery of symbolic representation thus providing knowledge about the objects.
5 }	12 - 18	Less emphasis on motor repetitions.
6 }	18 - 24	

Note *Adapted from text, Piaget with Feeling. Cognitive, Social + Emotional Dimensions, Cowan, 1978.*

Empirical studies have shown that at about 3 to 4 months of age, infants begin to attend to, grasp, manipulate and inspect distant objects (Trevarthen, 1979, 1988). At first, few actions such as mouthing, waving and banging are employed as means of sensory-motor exploration. From 6 to 12 months of age, there is an increase of fine object manipulation such as fingering, rotating, and banging behaviours (Ruff, 1984). The more frequent and varied motor behaviours an infant can perform, the more knowledge the infant possesses and the faster the infant develops new knowledge (MacLead, 1984). This suggests that the repetitive actions with objects can facilitate the acquisition of knowledge about the physical environment.

Arguably, the repetitive actions with objects could be used during a transition phase. Repetitive waving of an object, flapping with an object or banging an object could bridge the gap between younger infants' immature behavioural exploration of objects to older infants' goal-directed actions. In her series of experiments, Palmer (1989) examined the discriminating nature of infants exploring actions. In one of her studies utilising an individual testing paradigm she presented infants with several different objects on a testing table. The testing table was covered in a variety of materials, thus allowing the infant to see the table as another play object. Palmer found that the infants' actions varied greatly with the nature of the object. Furthermore, she found that, compared to 6-month-olds, the 9-month-olds were more likely to bang and wave the objects. Palmer's study of object exploration teaches us how infants learn what the environment affords for their actions. Furthermore, the cross-sectional comparison showed that 6-month-old infants explored objects by mouthing them, 9-month-olds waved or banged objects and 12-month-olds explore the objects using their fine motor skills (e.g., fingering and squeezing). Palmer's study suggests that motor stereotypies can facilitate the development from one stage of locomotor development to another;

repetitive actions with objects can facilitate infants' learning to explore and their fine motor skills. This further suggests that as infants acquire more advanced motor abilities they will engage in fewer repetitive actions with object.

Further work by Kahrs & Jung (2012) supports these findings. They suggested that banging allows infants to gain practice controlling their actions, thus enabling precise goal-directed action to be deployed. They suggested that spontaneous banging of objects were well suited for instrumental hammering and tool use in later childhood. Thus repetitive actions with objects can be used not only to facilitate cognitive development but also fine motor skills during the early months.

1.7 Repetitive Behaviour in the Context of Social Interaction and Play

Infants' repetitive behaviour has also been studied in the context of the development of the ability to engage in social interaction. Infants' interactions with their parents and other people rely initially on the use of repetition of facial gestures (e.g. repeatedly smiling or tongue movements) and subsequently on repetitive operations on objects.

By three months of age, infants' growing capacity to sustain eye contact, to smile, and to coo enables them to take an active role in face-to-face play with a parent or other caregiver. Such interactions are characterized by complex, reciprocal patterns of engagement, where parents exaggerate their expressions and insert their vocalizations in between those of their infant, as well as imitating the child's facial expressions and motor movements, giving rise to the earliest form of turn-taking (Stern, 1974). In these proto-conversations parents scaffold their infants' participation as a social partner in a conversational exchange (Bateson, 1975). Repetition of actions may therefore carry an important role in interaction.

From around 9 to 12 months, parent-infant interactions undergo a significant qualitative change. Turn-taking, games and toy-mediated play dominate (Crawley and Sherrod, 1984; Lamb, 1977). The repetition of traditionally defined motor patterns with a clear role structure characterizes conventional social games such as peek-a-boo (Bruner and Sherwood, 1976; Crawley and Sherrod, 1984; Ratner and Bruner, 1979). In the case of peek-a-boo, for example, the basic rules of initial mutual attention, followed by hiding, then reappearance and the re-establishment of contact can be varied (Bruner and Sherwood, 1976), thus demonstrating repetition with variation.

Repetitive actions with objects in the context of social interaction contribute to the infants' social development, facilitating the advancement of socio-cognitive skills. Traditional studies of repetition (see previous review of Thelen, 1979, 1980, 1981, Piaget, 1952 and Gesell, 1943) suggests that repetition is common in the context of individual observation and assessment, however infants predominantly exist within a social and interactive world. It is therefore imperative to determine whether the repetitive behaviours previously recorded are also seen in the context of interaction.

Conventional turn-taking games and social interactions around objects, which both rely on key communication skills such as joint attention, typically emerge in the first year of life and facilitate the acquisition of early communicative and linguistic skills in infants (Bakeman and Adamson, 1984; Bruner, 1975; McArthur and Adamson, 1996; Tomasello and Farrar, 1986). According to Bruner (1975; 1982) the predictable communicative formats, which emerge between the infant and caregiver in reciprocal back-and-forth games, structurally underpin many features of language. Empirical evidence suggests that the comprehension of referential language, lexical learning, and the appropriation by the infant of the social rules governing conversational pragmatics are all facilitated by joint object engagement (Ninio and Bruner, 1978; Tomasello and Farrar, 1986; Tomasello and Todd, 1983). Early repetitive interactions around objects have also been associated with the development of some of the abilities required for relating successfully to other people, including the regulation of affect and the recognition that other people have minds distinct from one's own (Adamson and Bakeman, 1985; Hobson, 1993). In the context of children's early communicative speech, does the use of repetitive behaviour relate to more or less advanced communicative abilities? The early repetitive nature of toddlers' speech suggests that the repetition plays a crucial role in the development of speech.

As well as providing a foundation for the development of cognitive, social, affective and communicative abilities, such repetitive motor behaviour with objects and play involving circular reactions therefore contributes to infants' subsequent development. Murdoch (1997) claims that repetitive behaviour can be used to encourage development through Vygotsky's Zone of Proximal Development (ZPD) where skills, activities or concepts that the child has not yet mastered independently can be achieved with the help of another more competent person (Vygotsky, 1978). In working with motor stereotypies, the repetitive behaviours can be interpreted in the ZPD framework as follows; the child brings his or her skill in performing the behaviour and an interest in it, the adult encourages the development and redefinition of the behaviour, possibly as a compensatory strategy. The repetitive behaviour is used to provide the shared experience needed for the adult and child to communicate and work together. Murdoch (1997) suggests that repetitive behaviours, specifically motor stereotypies, can be used to encourage development in this way.

Thus, despite the fact that in the context of ASD, repetitive behaviour is associated with social and communicative impairments (Wing & Gould, 1979), typically developing infants who show repetitive behaviours also possess age-appropriate social and communication skills and their repetitive behaviour supports their social and communicative development. This, along with the fact that a substantial minority of toddlers still show motor stereotypies and repetitive operations on objects, has implications for attempts to identify autism in the first two years of life.

1.8 When do the Repetitive Behaviours Shown by Children with ASD and other Developmental Disorders Differ from those seen in Other Children?

Are there qualitative differences between the repetitive behaviours shown in the general population of infants versus those who are subsequently going to be diagnosed with ASD or other developmental disorders? Or is there simply a quantitative difference with atypically developing children performing these behaviours more frequently? In order to answer these questions the discussion draws upon research that has compared groups of children; those who are diagnosed with an ASD/ who have a sibling diagnosed with an ASD and groups of otherwise 'typically' developing children. This research is not in Table 1.1 as it addressed a different question and thus new research is now considered.

Evidence suggests that it is possible to identify differences between the repetitive behaviours of children with and without ASDs at an early age (Loh et al., 2007; Wolff et al., 2014). Berkson & Tupa (2000) claim that although motor stereotypies are an aspect of typical development, abnormalities in these behaviours can already be detected in the first three years. This suggests a qualitative difference.

Several small studies attempted to compare stereotypic movements of children in the general population to those in autistic children. MacDonald, Green, Mansfield and colleagues (2007) scored the number and types of repetitive movement in videotaped play sessions and found that children with autism or pervasive developmental disorder - not otherwise specified had somewhat elevated levels of stereotypic behaviour than their typically developing peers at 2-, 3- and 4-years old. However, individual assessment of the children's stereotypies showed that some typically developing 2- and 3-year-old children engaged in more stereotypies that those in the PDD-NOS group. Consequently it seems that great individual differences exist in the presentation of repetitive behaviours and thus analysis incorporating the distribution of data seems necessary, as opposed to considering group means.

Recent research suggests that elevated levels of stereotypies are evident in infants and toddlers who later have a subsequent diagnosis of an ASD (Wolff et al., 2014). In their research Wolff and colleagues asked informants to complete the Repetitive Behaviours Scale-Revised (a 43 item caregiver report) to assess restricted and repetitive behaviours in 12- and 24-month-old children who were either infant siblings of older children with autism or were infant siblings of children with no diagnosis? The RBS-R is an informant report measure that contains six sub-scales, one of which is stereotypies. The 250 participants were also observed using the ADOS and thus the infant siblings of children with autism were further divided to high-risk no diagnosis and high-risk-ASD group. The authors focused on the number of items endorsed, as opposed to the severity rating of each item within the RBS-R (because the severity was highly influenced by parents' perception of a problem). At 12 months, the high risk-ASD group endorsed more items of the stereotypies scale of the RBS-R than the high risk-negative and the low risk groups. These results suggest that the parent measure can predict risk by identifying disorder-specific behaviours at 12 months and further suggest a quantitative difference. However, the results of this study must be interpreted with some caution because the correlation between the parental report of repetitive behaviour and the ADOS observation algorithm score was modest (Wolff et al., 2014). Furthermore, the authors quoted the estimated marginal means and the standard error and thus we are unable to interpret the range of behaviours exhibited by the infants' within each group. It is possible that some infants within the high-risk negative group and the low risk groups engaged in equal levels of stereotypies but this natural variation was not discussed.

The results reported by Wolff and colleagues were supported by recent observations of toddler repetitive behaviours by Harrop and colleagues (2014). In their short-term longitudinal study the group comparison design allowed the authors to compare the frequencies of repetitive behaviours exhibited by a group of children diagnosed with an ASD (N= 49, mean age 45 months) with the frequencies exhibited by their typically developing group (matched on non-verbal developmental abilities; N=44, mean age 24-months). All infants were observed at three time points: at their entry to the study, 7 months post-entry and 13 months post-entry. In addition to the ADOS and ADI-R, the participants completed the Preschool Language Scales. Noteworthy was the fact that the testing environment was confounded with group membership; children in the typically developing group were observed at home and those in the ASD group were observed in a laboratory setting. All observations took place in the context of a free-play setting. The authors note that this is a setting that provides a valuable opportunity to observe repetition within a naturalistic setting. The ASD group was observed to engage in more repetitive behaviours at all three time points and as such indicate that the difference is quantitative. Interestingly there was no significant effect of time on the frequency of the repetition in either group; however more frequent repetitive behaviours were inversely associated with language at both time points. The authors reported more frequent repetitive behaviours were not associated with the overall severity of social competence as measured by the ADOS (Harrop et al., 2014). Despite the fact that this study uses an observation method, the behaviours were not operationally defined. The authors merely presented example behaviours.

Finally, motor stereotypies are seen in the context of other developmental disorders and high risk populations of infants. The sequence of the appearance of stereotypies in infants with Down syndrome closely parallel the overall sequence of the appearance of stereotypies in normal motor development (Wolff 1967) and in those who were born prematurely (Field et al., 1979). Field et al., (1979) interviewed parents of both pre-term and post-term infants and found that, when correcting for gestational age, the onset of stereotypies was the same for both groups. This was not the case for the infants' attainment of motor skills. Even when the authors corrected for the participants' gestational age post-term infants achieved the motor milestones (as assessed by the Bayley) sooner than the pre-term infants (Field et al., 1979) This suggests that repetitive behaviours in infancy, unlike the development of other motor skills could be the manifestation of an intrinsic neural clock; thus further suggesting that the index of stereotypies could be taken relative to infants' overall motor maturity.

Differences in the frequencies of repetition can be identified relatively early in development, as identified through parent report (Wolff et al., 2014) and through observation (Harrop et al., 2014). Whilst the group comparison studies are very useful to further knowledge regarding the early identification of ASD symptoms, it is still imperative to better understand the presentation of repetitive behaviours in community samples. Great individual differences have been reported previously, and thus in this thesis I will aim to describe the repetition of younger infants and toddlers in detail.

Recent research also suggests that levels of repetitive sensorimotor behaviours can also be consistent across time (Richler et al., 2010). In their study of 192 children that had been referred for a diagnosis of an ASD at the age of 2 years, Richler and colleagues assessed the children's repetitive behaviours using the ADI-R at ages 2, 3, 5 and 9 years. The authors found evidence for a two factor model (as noted in earlier sections of this chapter). Most notably the authors also found that those children diagnosed with an ASD exhibited more repetitive behaviours at all the ages (when compared to those children who had a diagnosis of PDD-NOS or other developmental delays). This consistency specifically refers to the repetitive behaviours assessed within this thesis; whereas insistence on sameness behaviours followed a different trajectory. The authors assessed children's non-verbal and verbal social skills using the Mullen Scales of Early Learning and the Wechsler Intelligence Scale for Children. Considerable heterogeneity in patterns of change over time was found and the authors suggest that the level of children's functioning may be associated with different developmental trajectories of repetitive behaviours. Such contextual questions begin to take the developmental approach employed within this thesis and longitudinal data are required to assess such questions.

Furthermore, Honey and colleagues (2008) examined the developmental changes in repetitive behaviours in a large cohort (N=104) of young children aged between 24 and 48 months. All participants were diagnosed with an ASD or other developmental delay (speech/language delays) and were followed for 13 months. Participants were assessed using the ADI-R; the researchers interviewed parents to derive scores on 12 key items as well as the diagnostic algorithm. The main aim of this research was to follow children with autism and speech and language delays over a 1-year period in order to identify specific behavioural profiles and the way in which they change over time. This assessment of change is an important element of developmental psychology and (within the context of this thesis) is essential to understand the way in which repetitive behaviours contribute to young children's overall development (as conceptualised by consistency and change). A key finding outlined that children diagnosed with an ASD were reported to engage in more repetitive behaviours than those who had other developmental delays. This emphasised that the differences between those with an ASD and those who do not may be quantitative. The authors state that behavioural profiles need to be set within the context of children's overall developmental level in order to be indicators or markers of autism. The authors further suggest that an examination of cognitive-behavioural links is very relevant for autism research.

Arguably, from a developmental perspective this extends the questions of when and how much do repetitive behaviours differ between groups of children. It seems that the context in which the behaviours occur is an imperative area that warrants study. As such, repetitive behaviours may be considered as a normative element of children's behavioural repertoire. At times the behaviour remains part of the repertoire beyond infancy, for children who will later be diagnosed with an ASD but also for children who will never receive a diagnosis of an ASD. It may be that the continued use of repetitive behaviour becomes part of the diagnostic criteria when the context in which the behaviour occurs suggests further and additional delays in other domains of functioning; however this may not always be the case. When presented independently of any other developmental delays the repetitive behaviours assessed within this thesis may not be 'problematic' or 'symptomatic' of global delay. Such hypothesis is mere proposition and thus must be tested formally. I aim to do so in this thesis.

1.9 Summary and research Questions

Piaget's (1952) description of children's cognitive and emotional development suggests that repetitive behaviours can be normative, providing order and predictability for young children who have little control over and little understanding of the contingencies of daily life. Furthermore, researchers have observed that infants' use of repetitive motor actions increase in the period before the onset of babble and then decrease once the infant has acquired babbling abilities (Iverson & Wozniack, 2007). The repetitive motor behaviour is seemingly coordinated with the vocal system (Iverson & Fagan, 2004) and thus it seems that repetitive behaviours may be adaptive in the early years. The behaviours may constitute age-appropriate responses to the environmental challenges facing very young children. The literature reviewed within section 2 of this chapter suggests two schools of thought: Thelen (1979) and Gesell (1943)/McGraw (1942) who associated repetitive behaviours with aspects of chronological and motor development; Piaget (1952) who evaluated repetitive behaviours in terms of the contribution to socio-cognitive development. With these themes in mind, I propose five research questions (outlined below). Each of the research questions will be addressed throughout the empirical chapters of this thesis (Chapters 2, 4, 5, 6 and 7).

My first objective was to develop a relatively simple observational coding system for repetitive behaviours that could be applied across the age range of 6 to 36 months. An archival data set from a study of 9- to 12-month-old infants was used for this purpose (see Chapter 2). The coding system was then applied in a new prospective longitudinal sample. The general method for that longitudinal study is presented in Chapter 3. The following research questions were asked about the rise and fall of repetitive behaviour and its association with other aspects of development in this age range. The following research questions were asked about the rise and fall of repetitive behaviour and its association with other aspects of development in this age range:

1.9.1 Question 1: Is repetitive behaviour already evident by six months of age and does it increase over the first year (Chapter 4)? The repetitive behaviours assessed in this thesis are believed to reflect a period of development that is more mature than spontaneous movement but less mature than voluntary, goal-directed behaviour (Gesell and Ilg, 1948; Gesell and Armatruda, 1941; McGraw, 1943). Gesell and McGraw's innovative propositions and works suggest that repetitive behaviours are commonly exhibited and are a normal part of infants' behavioural repertoire before full control is developed. However, these early reports do not address the issue of frequency or prevalence of the behaviours and they do not assess individual differences. In this thesis I aim to address these issues. These early accounts of infants' repetition were based on unstructured observation during individual assessment. Similarly, this question about age of onset of repetitive behaviour and initial increase over the first year will be assessed during individual assessment. I used the coding scheme described in Chapter 2, the Repetitive Behaviour Coding Scheme (RBCS), to assess younger (6-month-olds) and older (12-month-olds) infants' motor stereotypies and repetitive actions with objects during an object exploration task. I did this in order to apply a structured scheme to formal individual assessment of the infants' behaviour to supplement the earlier accounts of repetition and to supplement questionnaire work (e.g. Leekam et al., 2010). Both cross-sectional and longitudinal analyses will be used to examine developmental change in repetitive behaviour during the first year.

1.9.2. Question 2. Are there differences in the rate of repetitive behaviour between individual assessment and social contexts (Chapter 4)? Further to the observation of the repetitive behaviours during individual assessment just described, I also assessed infants' repetitive behaviour during free play with other infants, first in the sample in which the RCBS was developed (Chapter 2) and then in the larger, longitudinal sample (Chapter 4). Humans predominantly exist within a social and interactive world and the free play context is one which provides valuable opportunity to observe the occurrence of repetitive behaviours in a semi-naturalistic context. These repetitive actions in the context of social interaction contribute to the infants' social development, facilitating the advancement of socio-cognitive skills. If, as Piaget (1952) proposed, repetitive behaviours are indeed a method used to facilitate the acquisition of information regarding the environment, and they are used as a method to exert control over the environment (Piaget, 1952), then a free play setting is one in which I expect to readily observe the stereotypies and/ or repetitive actions with objects. Recently published work by Harrop and colleagues (2014) suggests that the free play setting is ideal for the observation of repetition. I will therefore measure the rate of motor stereotypies and repetitive actions with objects which occur during infants' and toddlers' free play, in the archival data set used for the development of the coding system (Chapter 2) and in a similar free play setting in the larger longitudinal study (Chapter 4).

Furthermore, in order to examine the relative frequency of repetitive behaviour across different contexts, the analyses reported in Chapter 4 will also explore whether the repetitive behaviours occur more or less often during individual testing versus during free play with peers and caregivers. The same participants will be assessed in the both contexts at a mean of 12 months of age.

1.9.3 Question 3. When in development do individual differences in the use of repetitive behaviours first appear (Chapter 4), and are they associated with other milestones in motor and communicative development (Chapter 5)? I will seek evidence for the early manifestation of individual differences in repetitive behaviour in infancy by seeking evidence for consistency in the use of repetitive behaviour across context and over time (i.e., correlations between repetitive behaviour across the individual testing and free play situation at 12 months and longitudinal correlations from 6 to 12 months during the individual testing).

I will also test the association between the use of repetitive behaviour and motor development. In the theoretical perspective set out by Gesell and other theorists of motor development, repetitive behaviours reflect a period of development that is more mature than spontaneous movement but less mature than voluntary, goal-directed behaviour. They are thought to be symptomatic of developing neuromuscular control and progressive organisation of the central nervous system (Thelen, 1979). Repetitive behaviours can enhance motor development as they are likely to be one source of a rhythmical timing mechanism that facilitates development of gross motor behaviour (Thelen, 1980, 1981).

Finally, I will examine correlations between repetitive behaviour in infancy and communicative development. In previous studies motor stereotypies and repetitive actions with objects have been found to be associated with different dimensions of social-communicative development, e.g., children's social-competence, communication and play (Watt et al., 2008); their language and nonverbal IQ (Harrop et al., 2014); and children's early language acquisition (Iverson & Fagan, 2004). However, not one study has looked at all of these developmental indicators in a single sample and no one has assessed the association in a community sample. To this end, I will examine the association between infants' motor stereotypies and repetitive actions with objects and developmental indicators (such as chronological age, locomotor development or early socio-cognitive abilities).

1.9.4 Question 4. Is there a normative decline in the use of repetitive behaviour from 12 months onward? (Chapter 6). The cross-sectional studies reviewed within this chapter suggest a developmental sequence in which repetitive behaviour declines over time. Motor stereotypies and repetitive actions with objects are very common in infancy (Thelen, 1979; Arnott et al., 2010), are notable during the toddler years (Leekam et al., 2007) and have also been documented (albeit less frequently) amongst older children (Sallustro & Atwell, 1978). However, none of these studies analysed the longitudinal change in behaviours from infancy to toddler to childhood years in the same participants. Harrop and colleagues (2014) did assess change in the same participants over a period of 13 months. This short-term longitudinal assessment did not find a significant effect of time which suggests that, in order to detect change, the time between assessments must be long enough for development to occur to allow change to be detected. The question regarding the degree of change that is possible from infancy to toddler years remains unknown. Subsequently, within this thesis I explore whether there is a significant decline in the rate of motor stereotypies and repetitive actions on objects from 12 to 33 months.

1.9.5 Question 5. Does the use of repetitive behaviour at 33 months relate to children's inhibitory control, activity levels or social and communicative skills? (Chapter 7). The claim that high rates of repetitive behaviour are related to problems with executive function (Turner; 1999) and to problems in inhibitory control in particular (Evans & Iobst, 2004) would imply that toddlers who continue to show repetitive behaviour as they approach the third birthday might have problems inhibiting their behaviour. Consequently in Chapter 6 I examined the relationship between repetitive behaviour and toddlers' performance on inhibitory control tasks (Kochanska, 1996).

Failure of inhibitory control is sometimes linked to higher activity levels, particularly in the context of Attention Deficit Hyperactivity Disorder (ADHD) (e.g. Barkley, 1997, 2001, 2006; Von Stauffenberg, & Campbell, 2007). Activity level is a dimension of temperament that varies across individuals, even those who are not showing any ADHD symptoms. It is possible that a higher rate of repetitive behaviour simply reflects higher levels of activity in general.

Theorists have also claimed that early repetitive interactions using objects have been associated with the development of some of the abilities required for relating successfully to other people, including the regulation of affect and the recognition that other people have minds distinct from one's own (Adamson and Bakeman, 1985; Hobson, 1993). Empirical evidence suggests that the comprehension of referential language, lexical learning, and the appropriation by the infant of the social rules governing conversational pragmatics can be related to the repetitive nature of interactions (Ninio and Bruner, 1978; Tomasello and Farrar, 1986; Tomasello and Todd, 1983). However, it is not clear whether repetitive behaviour still facilitates social interaction at 33 months. In the context of children's early communicative speech at that point in development, does the use of repetitive behaviour relate to more or less advanced communicative abilities? I will therefore examine whether there is an association between toddlers' use of motor stereotypies and repetitive action with objects and their social competencies (specifically, their communication skills and ability to engage in cooperative play).

Finally, the findings that address each research question will be discussed in the context of developmental theory and the theoretical and clinical issues relating to the early diagnosis of ASD (Chapter 8).

CHAPTER 2.

The Development of an Observational Coding System for the Analysis of Infants' Repetitive Behaviour

2.1 Introduction

The literature reviewed in the previous chapter presented information repetitive behaviour in the context of early development. Specifically, I drew a distinction between two sub-types of repetitive behaviours (motor stereotypies and repetitive actions with objects). I drew upon different thoughts in the literature in order to describe the different behaviours. Motor stereotypies were linked with literature postulating that the progressive development of the motor system is related to the initial increase and subsequent decline of motor stereotypies (Gesell, 1943) and were also the dynamic systems perspective which postulates that behavioural functions (such as stereotypies) emerge from the unique combination of interacting capabilities, each with its own rate of development (Thelen 1979; 1980). Conversely repetitive actions with objects were associated with a Piagetian perspective which postulates that repetitive actions with objects are performed to prolong interesting activities (circular reactions) which subsequently facilitates the understanding of objects. Further, this may facilitate cross-modal development (Piaget, 1952; 1963). As such, in chapter 1 I reviewed evidence that suggests the repetitive behaviours may contribute to the development of locomotor movement and playful social interactions.

The studies reviewed in Table 1.2 contribute towards our understanding of the repetitive behaviours in the early years. Despite their contribution to our knowledge, these empirical examples highlight the varying methods used to collect data and further highlight the lack of a standardised coding scheme to observe the repetitive behaviours in community samples. Subsequently, there has been very little systematic observation of the motor stereotypies or repetitive actions on objects. Consequently, the primary aim of this chapter was to extend Thelen's (1979) and Iverson & Fagan's (2004) observational work on a small sample of 100 infants in order to develop a simpler observational coding system that could be used in longitudinal research with larger, more representative samples. In doing so, I would create a new standardised method for studying motor stereotypies and repetitive action with objects. I will assess the motor stereotypies and repetitive actions with objects separately as the literature reviewed in chapter 1 suggests that the presentation of these behaviour may differ.

The new coding system was applied to an archive of video records of 9- to 12-month-old infants observed in a semi-naturalistic setting with their parents and familiar peers. The infants' natural use of repetitive movements was not restricted by the confines of an experimental task. Recent research by Harrop and colleagues (2014) also used a play paradigm in order to assess children's repetitive behaviours and found that repetition was prevalent during young toddlers' play.

2.1.1 How Might we Measure Repetitive Behaviours More Effectively in Larger, More Representative Samples?

Current understanding of motor stereotypies and repetitive actions on objects has been largely influenced by the type of measurement tool used (Leekam et al., 2011). Different methods highlight different types and qualities of repetitive behaviours. Furthermore, studies that focus on large community samples as opposed to small selected samples have different requirements. In existing samples, a large range of methods has been used to study repetitive behaviours, including interviews, questionnaires (completed concurrently or retrospectively), unstructured observations and review of medical records. These were summarised in Table 1.2.

Previous research in community samples has largely used informants' reports to collect information about the repetitive behaviours. These consist of either interview or questionnaire methods. Using interview or questionnaire tools allows researchers to collect information about all types of repetitive behaviours from a source close to the participants, such as a caregiver or teacher. Informants' reports are therefore likely to elicit a complete picture of the repetitive behaviours profile of an individual. Furthermore, using such measures it is possible to gain information about possible causes or triggers of behaviours, coping strategies and changes over time. However, results from informant report studies must be interpreted with caution. The informants' subjective interpretation of questionnaire or interview items coupled with the informants' memory abilities and personal experiences may in some cases decrease the reliability or accuracy of such findings.

The use of observational methods in the study of repetitive behaviours allows the researcher to apply the same standard coding criteria to the observations of each participant. Moreover, repetitive behaviours such as motor stereotypies can be observed relatively easily. In small samples, very fine details of motor actions can be recorded (e.g. Thelen, 1981). However, the time allocated for observational coding must be streamlined if it is to be feasibly carried out in large, representative community samples. Thus a major aim of this thesis is to develop a feasible observation coding system for repetitive behaviours that will supplement the pre-existing questionnaire approach used in other community samples (e.g.

Arnott et al., 2010; Leekam et al., 2007). Before describing the coding system that has been developed, I will review existing methods for assessment of repetitive behaviour.

2.1.2 What Methods are Currently Available?

There are several measures of repetitive behaviours available to researchers. These vary with regards to the type of repetitive behaviour they measure, the level of detailed information that they elicit and the population to which they are applicable. The type of measure preferred depends on whether or not the aim is to make a clinical diagnosis of ASD or study repetitive behaviour as a dimension of development in non-clinical samples.

2.1.2.1 Assessing repetitive behaviours with diagnostic interviews and observation schedules. The Gilliam Autism Rating Scale (GARS; Gilliam, 1992), for example, is a 42 item interview measure that is composed of four subscales: stereotyped behaviours, communication, social interaction and developmental disturbances. The Autism Diagnostic Interview-Revised (LeCouteur et al., 2003; Lord et al., 1994) is a standardised semi-structured parent interview, in which parents rate behaviours for their degree of abnormality. The ADI-R contains 14 items that target repetitive behaviours. By using a selection of items from the interview algorithm scores for repetitive behaviours can be created. The algorithms are compatible with the DSM-IV and ICD-10 diagnostic criteria for autism. The Diagnostic Interview for Social and Communication Disorders - 10 (DISCO; Wing, Leekam, Libby, Gould & Larcombe, 2002) provides an assessment of the individual's profile of behaviours and abilities rather than to provide a categorical diagnosis. The repetitive behaviour items in the DISCO focus on specific behaviours rather than categories of behaviours. There are over 50 items that assess repetitive behaviours, they can be classified as follows: limited interests, routines and rituals, motor stereotypies and interests in part objects. However, these are informant based measures and therefore will not be used within this thesis.

It is important to consider an observation-based diagnostic tool separately. The Autism Diagnostic Observation Schedule-Generic (ADOS-G; Lord et al., 1996; 2000) is a semi-structured play based measure of ASD, used in clinical practice to aid with the diagnosis of ASD and within research to confirm the diagnosis of individuals and to attain information about characteristic features of autism. Five domains of behaviour are assessed during the ADOS-G: reciprocal social interaction, communication, imagination, stereotyped behaviours and restricted interests and other abnormal behaviours. The ADOS-G is made up of four modules, only one module is administered to an individual and this is selected according to their expressive language ability. For the ADOS-G there are algorithm scores for social interaction, communication, imagination, and repetitive behaviours and also for social interaction and communication combined.

The purpose of the measure can influence the conceptualisation of repetitive behaviour. The use of the diagnostic tools and their algorithms for instance, in the assessment of behaviours characteristic to a population poses an issue of circularity. The group of participants would have been identified on the basis of specific behaviours, which then become the focus of the research. Furthermore, items included in the diagnostic instruments assess the repetitive behaviours within a set of symptoms and impairments, as opposed to a more general developmental construct. Such diagnostic tools are used to collect data on a range of behaviours (e.g. social interaction, imagination), not just repetitive behaviours. A more focused measure is needed for work in large, community samples.

2.1.2.2 Questionnaire measures of repetitive behaviours. In addition to the more encompassing diagnostic tools reviewed in the previous section, measurement tools specifically designed to assess repetitive behaviours are also available. These primarily rely on informants' reports and tend to collect information on a broad range of restricted and repetitive behaviours, rather than focusing on the repetitive motor behaviours that feature in early development (Thelen, 1981). Caregiver informant measures are most frequently used within research, presumably because they allow the researched to obtain a large quantity or rich data regarding several types of repetitive behaviours. Table 2.1 shows that there are a number of specific measures available for research with repetitive behaviours. Most of the investigators have elected to use a closed response format, specifically using questionnaire or structured interview formats. Within this section I have focused on the questionnaire measures designed to assess repetitive behaviours in community samples. The purpose of this is two-fold: the children assessed within this thesis are drawn from community samples; such are unlikely to measure the repetitive behaviours as 'problematic' and are more likely to examine the behaviours in relation to developmental milestones (as is the aim of this thesis). Indeed, tools designed primarily for the use with children with ASD or amongst clinical samples may not be applicable to my study.

Findings from studies using questionnaires designed specifically for the study of repetitive behaviours, the Childhood Routines Inventory (CRI) and the Repetitive Behaviours Questionnaire (RBQ-2), were discussed in Chapter 1. The CRI (Evans et al., 1997) is a parent report questionnaire that extracts valid and reliable data about age-related compulsive behaviours in community samples of children (Evans et al, 1997; Evans et al, 2001; Evans & Gray, 2000) as well as clinical samples of those diagnosed with Down Syndrome (Evans & Gray, 2000) and autism (Greaves et al., 2006). The measure was designed on a community sample of 679 children aged 0-7 and may thus represent the behaviours seen in their repertoire. Despite this, the measure does lack items relating to motor stereotypies and repetitive actions with objects specifically. The CRI is therefore unlikely to present a comprehensive picture of the repetitive behaviours shown by infants and toddlers.

The RBQ-2 (Leekam et al., 2007) is another informant measure of repetitive behaviours that was developed using a community sample of children. The RBQ provides a comprehensive measurement of all the repetitive behaviours. There is however no distinction between 'Never' and 'Rarely' in any of the items; this may create floor effects when in some cases a behaviour is in fact present though not shown often.

The RBS-R (Bodfish, Symons & Lewis, 1999) is an example of a well-rounded instrument that collects information about a range of repetitive behaviours. It is a 43-item questionnaire rating a range of behaviours on a 4-point Likert scale from 0 (the behaviour does not occur) to 3 (it occurs and is a severe problem). The RBS-R records the number of defferent repetitive behaviours present and their intensity. This yields 6 subscales: stereotyped, self-injurious, compulsive, ritualistic, sameness, and restricted behaviours. The RBS-R has been used to examine RRB in children and adults with ASD, developmental delay and typically developing children.

Questionnaire items designed for use with community samples are very few in number. This emphasises earlier discussion regarding the paucity of studies that have addressed repetitive behaviours in community samples. The studies that have used these questionnaire measures have contributed significantly to our understanding of repetitive behaviours. However, the overarching aim of this thesis is to supplement the questionnaire data and the observations made on small samples (e.g. Thelen, 1979) by using a standardized set of observation categories that have been operationally defined. The aim of this thesis is to develop such a reliable, easily applied observational measure suitable for the study of low-level repetitive behaviour in infants and toddlers. If reliable and easily administered, such an observational measure could be used to validate informants' reports in future studies.

Table 2.1 Summary of measures specific to repetitive behaviours

Measure	Method	Used with community sample?	Description	Frequency/intensity measured?	Duration measured?
Repetitive Behaviour questionnaire (RBQ-2)	Parent report questionnaire	Yes	20 item questionnaire assessing sensory, motor and ritualistic behaviours.	Yes	No
Childhood routines Inventory (CRI)	Parent report questionnaire	Yes	19 item assessment of motor stereotypies, ritualistic behaviours and restricted interests.	Yes	No
Repetitive Behaviours Scale - revised	Informant questionnaire	Yes	42 item assessment of stereotypies, self-injurious, compulsive, ritualistic and sameness behaviours and restricted interests.	Yes	No

2.1.2.3. Observational measures of repetitive behaviours. In addition to informants' reports, some observation coding schemes have been developed to record repetitive behaviours in children. The vast majority of the coding schemes are designed to address repetitive behaviours in samples of children diagnosed with an ASD. As noted in the previous section such tools may not be applicable or suitable for my study of children derived from a community sample. As such, within this section I will review standardised coding schemes that have been designed for use in community samples, only.

The *Repetitive and Stereotyped Movement Scales: Companion to the CSBS* was developed by Wetherby and Morgan (2007). They categorised a movement as repetitive when it happened three or more times and when the behaviour was not communicative or imitative. Noteworthy is the fact that this measure is described by Morgan and colleagues (2008) as a clinical tool, one that can be applied to behavioural samples online or via videotape. I decided to include this tool in the review as this coding scheme categorises repetitive behaviours *with body* or *with object (the same distinction as I decided to draw upon).* With body repetitive behaviours were flapping, rubbing body, patting body and stiffens. The repetitive behaviour with object fell into two sub-categories; restricted interest and preoccupation (which consists of swiping an object, squeezing an object, rolling an object or rock/spin/ flick an object) and insistence on sameness (collect and order objects, moves/ line up and clutches objects). This coding scheme is comprehensive and allows the observer to extract useful information regarding the lower order and higher order repetitive behaviours. However, within the context of this thesis, this coding scheme cannot be used because the vast majority of the behavioural categories focus on the insistence on sameness and the restricted interests. Furthermore, this is a clinical tool and thus is likely to evaluate the behaviours as problematic. The behaviours are difficult to observe and not as appropriate for children in the first years of life, so they are not the focus of this thesis.

Ozonoff and colleagues (2008) studied 12 month olds infants' atypical object use. They developed a small, eight item coding scheme to assess infants' object exploration. Shaking, banging, mouthing and throwing were described as typical exploration and further they termed spinning, rolling, rotating and unusual visual exploration as a typical exploration of the toys. Whilst this coding scheme is useful to detect typical and atypical object use, it does not capture the full spectrum of repetitive behaviour commonly seen in infants.

Iverson & Fagan (2004) developed a 12 item coding scheme for rhythmic limb movements in a community sample of children. They defined repetition in the same way as Thelen (1979) as '*a movement repeated in the same format at least 3 times at regular, short intervals of approximately 1 second or less'* (p. 1057). This coding scheme organised repetitive movements into five categories, according to area of body used in the movement. Legs and feet involved kicking and rubbing, torso involves bounce and rock, arms involved swing, shake and bang, hands involved flex and twist and head involved rolling from side to side or from front to back. This coding scheme was successfully applied to 47 infants aged 6 to 9 months and was used in a semi-structured free play setting. The authors do not describe how the coding scheme was developed and thus it is unclear whether the scheme includes all repetitive behaviours seen in infants. However, noteworthy is the fact that Iverson & Fagan did assess the behaviours within a community sample and the behavioural categories seem to encompass all areas of the body. At the time I started this PhD thesis and developed my coding scheme, this scheme presented by Iverson & Fagan seemed to closely resemble the behaviours of interest in the context of my thesis. Consequently this coding scheme was influential when I was transcribing the infants' behaviour to develop my Repetitive Behaviour Coding Scheme.

Since I developed my Repetitive Behaviour Coding Scheme, Harrop and colleagues (2014) developed their 11 item observation coding scheme to assess the stereotypies in young toddlers' play. Whilst this study assessed a clinical sample, one of their participant groups were drawn from a community sample. Interestingly, the 11 items within their scheme were based on items from previously validated measures; the RBQ-2 (Leekam et al., 2007), the Repetitive Behaviour Scales-Revised (RBS-R: Bodfish et al., 1999), the Diagnostic Interview for Social and Communication Disorder (DISCO: Wing et al., 2002), and the Direct Observation of Repetitive Behaviour in Autism (DORBA; Boyd et al., 2010). Noteworthy is the fact that all but one of these tools were developed using community samples and re designed to look at the developmental context of the repetitive behaviours. Together the items captured the range of behaviours likely to be shown within a free play session. This coding scheme assesses children's arranging objects in rows, fiddling with objects, spinning/rocking, unusual finger or hand mannerisms, unusual interests in smell/ touch/sounds, sensitivity to touch, repeatedly touching part of body, looking at objects atypically, banging/tapping, mouthing and repetitive language. This coding scheme is very advantageous as it relies on previously validated items and is therefore likely to accurately represent behaviours. The coding scheme seems to capture a range of the lower level motor stereotypies and repetitive actions with objects and also speech.

Each of the coding schemes described within this section contribute towards the field in which they were developed. The RSMS companion to the CSBS (Wetherby & Morgan, 2007) is excellent for use within clinical practice, but the behavioural categories are too varied for use within this specific study of motor stereotypies and repetitive actions with objects, especially in a community sample. Ozonoff and colleagues' (2008) coding scheme is excellent when attempting to understand repetition based on object exploration, but the coding scheme does not include sufficient categories to provide a detailed examination of infants' repetition. Iverson & Fagan's (2004) coding scheme seems most suitable for use within this thesis; however I am unable to determine how accurately these behavioural categories represent infants' behaviour. It is unknown whether the categories provide a good match for infants' behavioural repertoire and thus, whilst keeping this coding scheme in mind I decided that it was most effective to develop my own coding scheme for use within this thesis. In doing so, I was able to ensure that the behavioural categories accurately represent infants' behaviour, ensure that there are sufficient categories included in order to record all types of motor movements. The behavioural categories were not too numerous thus yielding the coding scheme feasible for use with large community samples (as with the case of Thelen, 1979). The suitability, feasibility and applicability to the samples in this thesis are key when developing the coding scheme. Within this chapter I will describe exactly how my coding scheme was developed and in section 2.4 I compare my coding scheme to the ones reviewed within this section.

2.1.3 Summary and Aims of Chapter

The first objective of this thesis was to design a relatively simple observational coding system for repetitive behaviours that could be applied in home or laboratory settings for infants in the first years of life. Within the remaining sections of this chapter I will describe the development of the coding scheme used within the remaining empirical chapters of this thesis. The distinction will be drawn between motor stereotypies and repetitive actions with objects; as discussed in Chapter 1 and at the start of Chapter 2.

The remaining section of this chapter describes the development of the coding system, using video footage from a study of the developmental origins of peer relations in which infants were observed with their parents and another familiar family in a laboratory designed to look like a sitting room (Hay, Hurst, Waters & Chadwick, 2011; Hay, Nash, et al., 2011). This allows for the observation of repetitive behaviour in a naturalistic situation and simulates the kind of environment that might be present during home visits in future studies.

It is of particular importance to examine the infants' use of repetitive behaviours during interaction with other infants. Motor stereotypies and repetitive actions with objects are important activities whereby infants can coordinate their actions with those of a peer (Goldman & Ross, 1978; Eckerman, Davis and Didow, 1989), and so the peer setting is one in which a variety of repetitive behaviours are likely to be observed. The present study extends that literature by focusing on the use of repetitive behaviour in the first year of life (between 9 and 12 months of age). In developing the observation coding system, all instances of repetitive behaviours were transcribed in a narrative format to ensure that an accurate and comprehensive description of behaviours is provided (thus, an event based coding is employed). Once the coding scheme developed I will compare it with other pre-existing coding schemes (e.g. Thelen, 1979; Ozonoff, 2008).

In developing the coding system, the primary distinction was drawn between motor stereotypies and repetitive actions with objects, which may contribute differently to motor and cognitive development, respectively, as reviewed. The specific aims of this chapter are twofold

1) Develop an observation coding scheme suitable for use with infants and toddlers.
2) Provide a description of the repetitive behaviours exhibited by infants during free play in this quasi-natural setting.

2.2 Method

2.2.1 Participants

The participants assessed within this chapter had taken part in the First Friends Study (see Hay, Hurst, Waters, Chadwick, 2011). The purpose of the original study was to observe infants with familiar peers in a situation that would simulate an ordinary play occasion. A volunteer sample of families living in or near a British city was observed. The participants were recruited by contacting mothers through referrals from mother-toddler groups, the National Childbirth Trust newsletter and through health visitors at GP practices in the Cardiff area. Each mother was asked to recruit a friend who had a baby of a similar age. Fifty pairs of mothers and infants were therefore able to visit the laboratory together. Subsequently, 100 participants completed the free play session. The volunteer sample was multi-ethnic and the GP surgeries from which the participants were recruited served a mixed SES population. On average, the infants spent 11.4 hours a week being cared for with other children (range, 0 to 40 hours per week).

For the purpose of this chapter I used all of the infants for that were part of the original sample, with no exclusions. The infants were between 9 and 12 months of age (mean: 10.35 months; *SD*: 1.11 months). The majority (58.3%) were firstborns without siblings, with no infant having more than two siblings. All procedures had undergone ethical review by the School of Psychology Ethics Committee and the Local Research Ethics Committee of the National Health Service (NHS; code 03/5085). For the purpose of the analyses in this chapter I focused on all 100 infants.

2.2.2 Procedure

The infants and mothers were invited to a comfortably furnished playroom in a university building. The room was decorated to emulate a living room at home, mothers were provided with a hot or cold beverage. The first 61 families to visit the laboratory (First Friends Study 1) were asked to choose two toys from a selection of age-appropriate toys. These were: stacking rings, a shape sorter with shapes, a plastic train set, a dog pull-toy, a plastic camera, a ball, a plastic helicopter and a string of quacking ducks. The mothers were instructed to choose toys that were relatively unfamiliar to their infants.

The remaining 39 families to visit the laboratory (First Friends Study 2) were provided with a standard set of 4 toys for the infant to play with. These were a train and track, a jigsaw, a jack-in-the-box and stacking rings. For the purpose of these analyses, data from both studies are combined to create the observational data set for the present chapter of the thesis (N = 100).

In both studies, caregivers were asked to dress their infants in bibs, labeled 'A' or 'B' which contained radio microphones. All mothers were told that it was important that they behave naturally and were told to respond to their infants in any way they ordinarily would when visiting each other at one of their homes. In First Friends Study 1, no further instructions were given. In First Friends Study 2, half the mothers were instructed to sit on the floor with their babies and show them the toys, before sitting down on the sofas and behaving as they naturally would. Play was observed for 25 minutes and all observations were recorded. In one way ANOVAs, where Study1/ Study 2 was entered as the categorical variable and the motor stereotypies and repetitive actions with objects were entered as dependent variables, I found that the different experimental procedures in the two studies did not have an impact of the number of motor stereotypies exhibited (p >.10) and did not have an impact on the number of repetitive actions with objects observed (p > .10).

2.2.3 Measure – Developing the Observation Coding Scheme

The Repetitive Behaviour Coding Scheme (RBCS) was developed using the methods described below. The final version of the Repetitive Behaviour Coding Scheme is in Table 2.2.

2.2.3.1 Pre-pilot and pilot observations. I conducted pre-pilot observations on 30 hours of video records (this was 15 infants). These preliminary observations were conducted by watching one infant at a time, recording all movements made by each infant. I transcribed a continuous narrative record of all repetitive behaviours made by each infant and this narrative approach was used for the preliminary sub-sample of 15 infants. I then read over the narrative records and the behaviours that resembled the motor stereotypies and repetitive actions on objects from previous studies were extracted. Whilst focusing on Thelen's behavioural categories I read my transcripts and focused on extracting any behaviours that resembled her previous work, whilst also noting any behaviours that were not recorded by Thelen. This method resulted in a list of 8 categorical items (flap, bounce, rock, head movements, bang toy against another toy, bang toy against another object, clap and arm banging a surface [e.g. wall, sofa]). A repetition was operationally defined as *a movement of a part of the body that is repeated in the same way three times (or more) within a two second period*. Should flap, bounce, rock or head movements occur whilst the infant was holding or manipulating an object the repetition was defined as occurring *with* object. This relates to the distinction between motor stereotypies and repetitive actions with objects discussed in previous sections on the thesis

In general, the onset of the behaviour occurred at the moment the particular movement started and then the offset occurred the moment the child ceased the behaviours, engaged in a different action with the same objects of a different object, or paused between repetitive actions for a period longer than 5 seconds (e.g. if an infant flapped and then stopped flapping for five seconds and then flapped again, the second instance is a separate behavioural event). Different repetitive behaviours could be coded simultaneously (i.e. when an infant flapped and bounced at the same time).

The initial observation coding scheme was then used in pilot observations, where a different 10 participants were observed and coded by three independent observers (these 10 infants were randomly selected from the 100 in the study. The second coder was trained to use the coding scheme and the third coder was not). The 10 participants were different from the original 15 that were used to develop the scheme. Operational definitions for each item were edited to ensure clarification and ease of use of the coding scheme, these can be seen in Table 2.2. In Table 2.3 I have provided examples of behaviours occurring without object (motor stereotypies) and with object (repetitive action with objects).

2.2.3.2 Applying the RBCS to the sample. For the purpose of the formal coding, I started coding again and coded all 100 participants (including the ones used in the preliminary observations). Each video was observed two times, each viewing recorded the behaviours of one individual participant on an event-based coding. Initially observers transcribed and coded the type of behavioural repetition exhibited by the infant (e.g. flapping, bouncing or rocking). Observers were instructed to record the onset and offset time of the behavioural repetition and were also instructed to count the number of behavioural repetitions displayed per event. Subsequently, the RBCS allows measurement of the frequency of the behavioural bouts of repetition, the duration of the behaviour and the number of repeats within each behavioural event. A randomly selected transcript can be seen in Appendix II.

2.2.3.3 Establishing reliability. I coded all of the videos. Because the RBCS was a newly developed measure of repetitive behaviours, a second observer coded 33% of the videos. To measure reliability, intra-class correlation coefficients (ICC) were calculated for the total number of behavioural repetitions per participant, ICC inter-rater agreement for the total number of repetitive motor behaviour bouts per participant was .95. On the item level, for the behavioural category label provided for the bout exhibited, Kappa coefficient agreement was .91.

In order to ensure that coding had remained consistent throughout the thesis, I coded 5% of the sample (*n*=5 children) again, 36 months after the initial coding had been completed. Test-retest reliability was established with the number of behavioural bouts per participant (ICC = .98) and the type of repetitive behaviour exhibited (ICC = .99).

2.2.3.4 Creating composite variables. The total number of repetitive behaviours exhibited was calculated for each participant. The total number of repetitive actions with objects was calculated (flapping, bouncing and rocking transcribed *with* object, as well as banging toy against toy and banging toy against another object). Similarly, the total number of bouts of motor stereotypies was calculated (flapping, bouncing, rocking and head movement transcribed *without* objects as well as arm banging against surfaces and clapping). Composite variables were therefore calculated to provide a simple measure of whether or not the participant engaged in repetitive behaviour at all, whether they engaged in repetitive behaviour with an object and whether they engaged in motor stereotypies. The onset and end time of all behaviours were noted and therefore I was able to calculate the total time infants engaged in repetitive behaviour.

Participants' free play session lasted for 25 minutes. For ease of comparison with other research and in order to compare the descriptive information with those presented throughout the thesis, a rate per hour was calculated for total repetitive behaviour observed, sum of motor stereotypies observed and sum of object based repetition observed. A rate per hour was also calculated for the individual behavioural categories (flap, bounce, rock, head movements, clap and banging categories). A rate per hour therefore gives a consistent time frame over which data can be compared across the studies reported in this thesis and allows other researchers to compare their data to mine simply.

2.2.4 Data Analysis

As participants were observed in pairs, ICC was calculated for the total number of repetitive behaviour bouts exhibited by each member of the pair. The repetitive behaviour data were also checked for dependencies using SPSS linear mixed-models analysis. There was no significant effect of the pairings with particular peers in the observation session on the infants' or toddlers' engagement in repetitive behaviours. In subsequent analysis, all scores are therefore treated as independent observations. Total repetitive behaviours, total motor stereotypies and total repetitive actions with objects were not normally distributed. I therefore performed logarithmic transformations on these variables in order to improve normality. The transformations successfully transformed all variables thus enabling me to perform parametric analyses on data that did not violate the assumption of normality.

Table 2.2 The Repetitive Behaviour Coding Scheme (RBCS)

This coding system is designed to capture episodes of (motor) repetitive behaviour amongst infants and toddlers. The behaviour an event (*i.e.* the occurrence and sequence of a particular pre-defined behaviour). Event Coding: In order to be deemed as a noteworthy (*repetitive) behaviour, the movement of a part of the body must be repeated in the same form, at least three times within a 2 second period*. Initially, the observer must label the behaviour, then note the onset and end times of the behaviour. Finally the observer must quantify the number of times that the behaviour occurs within this 2 second period. Should a behavioural bout contain more than one category, they should be coded separately.	
Flap (hand, arm, legs, feet)	The infant exhibits rapid movement of either one or more of their hands, feet or finger. Elbows are pointing out at either side of the torso, amplitude of a few centimetres with movement coming from the elbow or shoulder. The movement is seemingly not-goal directed and is usually done at a quick pace. *"With object" codes for the movement occurring when object is being held.*
Bounce	The infant (either standing, sitting or kneeling) moves body in an up and down fashion, mostly from hip extension. *"With object" codes for the movement occurring when object is being held.*
Rock	The infant (either standing, sitting or kneeling) moves trunk in a back and forth or side to side fashion. *"With object" codes for the movement occurring when object is being held.*
Head movements	The infant demonstrates movement of head in an up/ down or side to side fashion. *"With object" codes for the movement occurring when object is being held.*
Clap	Infants' forearms are in mild flexion in front of the child, arms move to contact at the midline.
Bang toy/ toy	The infants' forearms are in mild flexion and therefore in front or to the side of the infant. Arms then move together to midline with an object in either hand therefore taps/ bangs one object (usually toy) against another.
Bang toy/ other	The infant holds an object (usually toy) in one hand and then arm flexes and extends from shoulder or elbow in order to bang the object against floor/ self/ sofa.
Arm bang surface	Infants' forearms are in mild flexion with flexion (from elbow) causing hand to contact a surface.

Table 2.3 Examples of the behavioural categories included in the RBCS*

Behaviour category	With object (repetitive action with object)	Without object (motor stereotypy)
Flap	The infants moves his arms up and down quickly and in succession whilst holding the jack in the box.	From her elbow the infant moves the forearm back and forth in quick succession. She does this whilst sitting on the floor.
Bounce	With shape sorter in both hands and whilst the infant is sitting on the floor she bends and straightens her back. The toy make a loud noise and the infant's body and head move up and down 5 times in quick succession.	Initially the infant is kneeling on the floor, he then stands and from the knees bends and straightens his legs 5 times. Consequently his entire body seems to move up and down in a vertical fashion.
Rock	The infants is sitting alone in the middle of the room with a shape sorted in his hands. He moves his body backwards (so he is leaning back) and then forwards (such that he is leaning forwards). He does this 14 times before stopping and then dropping the toy.	Whilst kneeling on hands and knees on the floor the infant moves the body forward and then backwards. This movement is repeated 6 times and then the infant falls on the floor.
Head	Infant pivots her head and the neck and shakes it from side to side (looking straight ahead at all times). She does this whilst holding a toy up in front of her face.	Infant simultaneously rocks his head from left to right (back and forth) and nods up and down.
Clap	N.A	Whilst standing next to the sofa the infants claps her hands together 9 times. Whilst exhibiting 'clap' the infants arms are raised as shoulder level and appear to be pivoting from the shoulder. The movement is moderately fast but does not seem to have a rhythm
Bang toy/ toy	Infant bangs one wooden block against another wooden bock. One block is in the infants hand whereas the other is on the floor (NOTE. This	N.A

	differs from the flap with object. Flapping does not involve any contact between the object being held and another object whereas banging must involve contact between the toys).	
Bang toy/ other	Whilst sitting on the floor and holding a plastic duck toy in one hand the infant raises the hand which is holding the toy and then moves the hand towards the floor thus hitting the plastic toy against the floor.	N.A
Arm bang surface	When standing next to the sofa holding a shape sorted on the sofa (in the right hand) the infant bangs the sofa with the left hand. The infant does this 5 times in quick succession with rhythm.	Whilst standing up the infants raises both arms in the air and bangs them again the room of the testing room. Both arms bang the wall at the same time and whilst doing this the infant looks down at the floor.

*Example behaviours are taken from original narrative records described in section 2.2.3.1

2.3 Results

There were no gender differences in the use of repetitive behaviours and thus, in the remaining analyses, boys and girls are analysed together.

2.3.1 The Infants' Use of Repetitive Behaviours

2.3.1.1. Overall frequency and occurrence. Ninety-five of the 100 infants exhibited at least one form of repetitive action. On average, the infants spent 4.03% of their time engaged in repetitive behaviour; one infant spent 29% of his time engaged in repetitive motor behaviour.

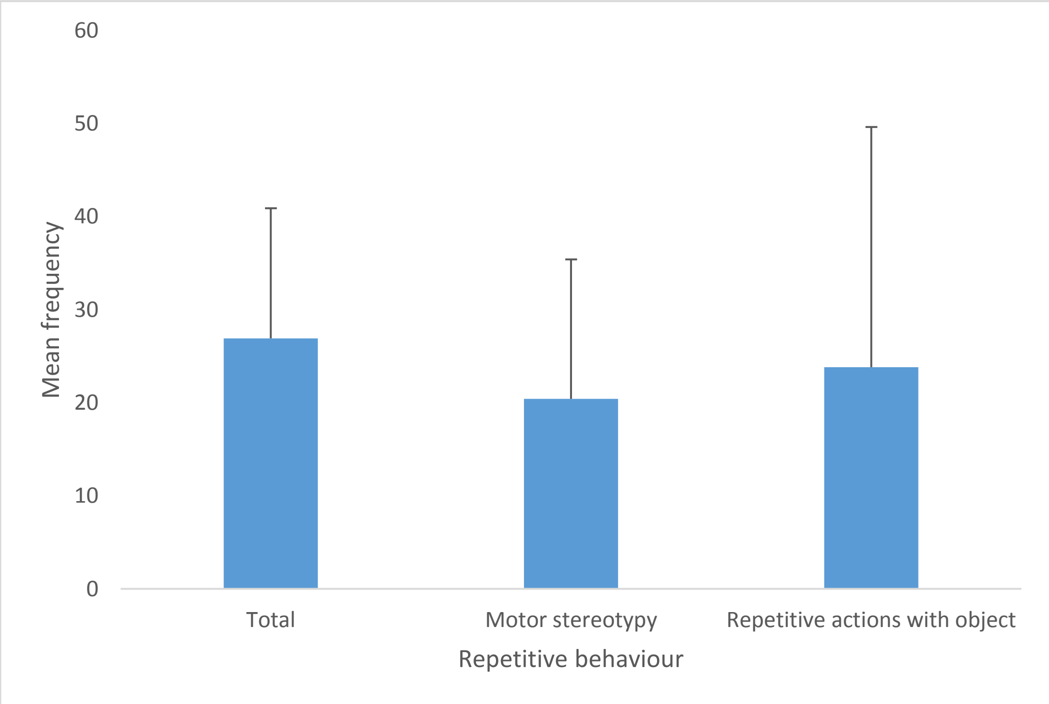

Figure 2.1 Mean frequencies of repetitive behaviours observed. Frequencies are based on the rates per hour, N=100.

2.3.1.2 Individual categories of behaviour. The frequencies and mean rates of the behaviours observed are presented in Table 2.4. Flapping was the most commonly observed behaviour. Figure 2.2 illustrates the relative frequency of each behaviour category.

Table 2.4 Frequencies, means, range and percentage of repetitive behaviour exhibited.

Behaviour Category	Frequency	Mean (SD)	% of infants exhibiting
Flap	1820	16.9 (20)	80.6
Bounce	520	4.8 (7.7)	44.4
Rock	420	39 (8.8)	30.6
Head movements	72	.7 (2.4)	10.2
Clap	116	1.1 (3.6)	14.8
Bang toy against toy	788	7.3 (12.7)	49.1
Bang toy against another object	580	5.4 (10)	43.5
Arm bang surface	536	4.9 (8.1)	49.1
Motor stereotypy	2604	20.4 (21.1)	87
Repetitive action with object	2248	23.8 (25.8)	76.1

Note Frequencies are based on rate per hour. SD indicates standard deviation

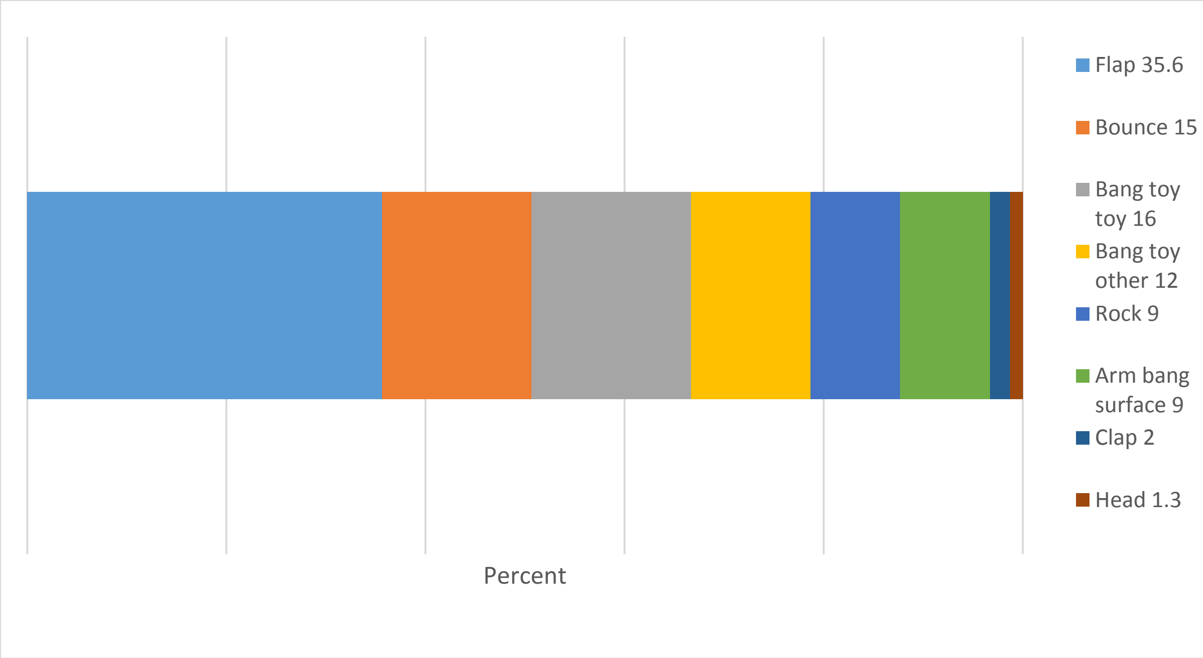

Figure 2.2 The relative frequency of the different repetitive behaviours.

2.3.2 The Age of Onset of Repetitive Behaviour

Repetitive behaviour was already present in the youngest age group, although the older infants did engage in more repetitive behaviours (Figure 2.3). In two separate one way between subjects ANOVA participant's age (in months) was entered as the predictor variable and the motor stereotypies and repetitive actions with objects as outcome variables. There was a significant effect of age on the number of motor stereotypies exhibited, $F(3, 96) = 2.98$, $p < .02$. The mean at 10 months was significantly higher (6.34) than the mean for 9-month-old infants (3.00). This difference was significant in a Bonferroni comparison, $p < .02$. In the second one way between-subjects ANOVA, the participants' age had a significant effect on the mean frequency of repetitive behaviours involving objects, $F(3, 96) = 3.10$, $p < .05$. Infants who were 10 months old exhibited significantly more repetitive behaviours with objects than 9-month-old infants (the mean at 10 months was 8.82 whereas the mean at 9 months was 3.87; this difference was significant in a Bonferroni comparison, $p < .05$).

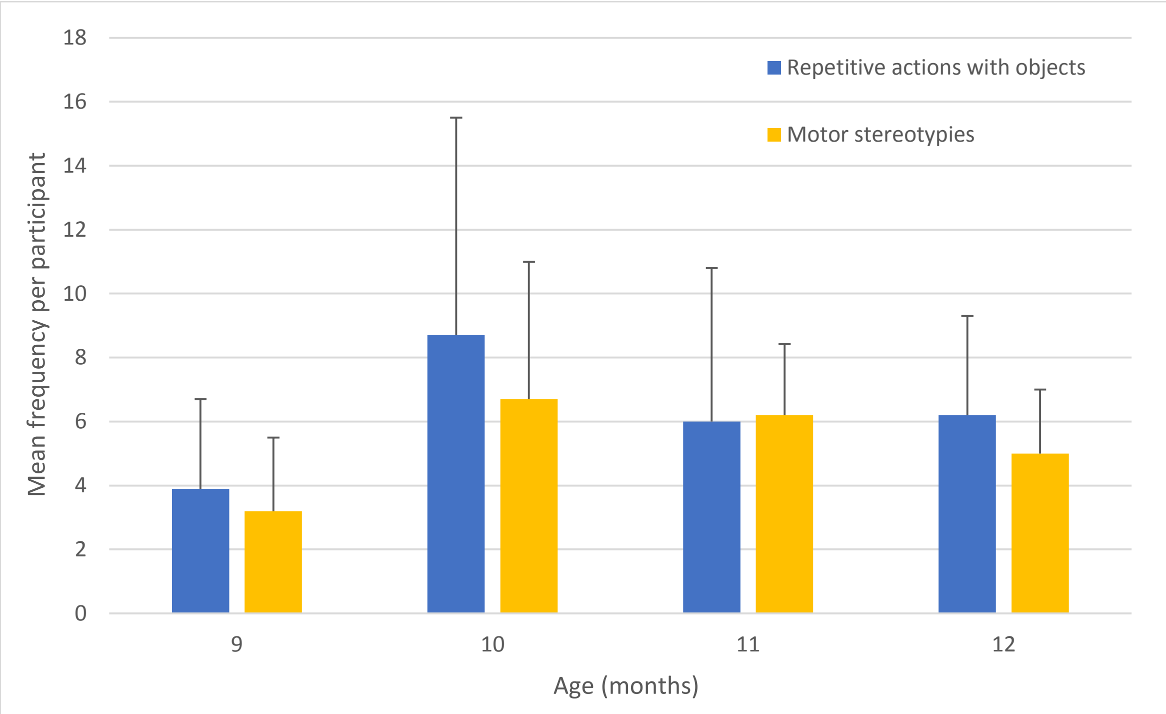

Figure 2.3. The mean frequency of repetitive behaviour in each age group

2.4 Discussion

The primary aim of this chapter was to develop a new observation coding scheme to detect motor stereotypies and repetitive actions with objects. The Repetitive Behaviour Coding Scheme (RBCS) was successfully developed and the main findings indicated that (1) excellent inter-rater and test-retest reliability was obtained when using the RBCS, indicating its simplicity and effectiveness; (2) the RBCS is a good detector of repetition in infants aged 9 to 12 months in the context of social interaction with peers.

The RBCS consists of eight behavioural categories that enables the coder to focus on observed instances of stereotypies and repetitive actions with objects. The categories draw on movements from different parts of the body, bouncing focuses on the torso, flapping focuses on legs and arms, and rocking focuses on the torso. I chose to include these eight behavioural categories for several reasons. First, the behaviours reduces Thelen's (1979) 47 behavioural categories, thus making the RBCS easier to use. Next, these behaviours were ones that were continually exhibited by the infants. The narrative records of the infants' behaviours were very detailed and described all the motor actions exhibited by the infants within this study. The behavioural categories accurately represent the movements exhibited by the infants in this unconstrained context and are therefore reflective of repetitive actions commonly exhibited by infants. Finally, the behavioural categories closely resemble those within Iverson & Fagan's (2004) coding scheme, which has been used in a previous study of a small community sample (n=47).

In Table 2.5 I compared the RBCS with other coding schemes. The information within this table shows that the coding schemes are quite similar in the definition of a repetitive action, some have been applied to community samples, some have been applied to free play session. The RBCS was designed to complement these coding schemes. The RBCS is simpler to apply than Thelen's approach (1979) but provides a broader scope than the scheme used by Ozonoff and colleagues (2008).

Table 2.5 RBCS and other coding schemes

Coding Scheme	Definition of a repetitive behaviour	Number of categories	Use within research	Reliability	Community samples?	Other
RBCS	The movement must be repeated in the same form, at least three times, in regular short intervals within a 2 second period (based on Thelen, 1979). Each behaviour category was further defined	8	25 minute free play session at university laboratory.	ICC = .95	Yes	Reliability established with trained and untrained observers
Iverson & Fagan (2004)	Repeated in the same form at least three times at regular, short intervals of approximately 1s or less (based on Thelen, 1979)	12	25 minute semi-structured play session at participant home.	88%	Yes	-
Harrop et al., (2014)	No overall definition of repetition stated. Specific definitions provided for each behaviour category only. Flapping must occur in close succession, arranging objects were defined as arranging 2 or more objects for a significant amount of time, for example.	11 (based on previously validated informant report)	Applied to 10 minute free play session at home and in the lab.	ICC = .89	Yes (and ASD)	-
Ozonoff et	No overall definition of repetition.	8 (4 typical	Applied to	Mean ICC	Infant sibs of	Observers

al., (2008)	Individual behaviours were operationalised and coders instructed to code duration of some categories and duration or others.	and 4 atypical)	object exploration task	= .91	children with an ASD or TD	trained until excellent reliability obtained
Thelen (1979)	Behaviour must be repeated in the same form 3 times.	47	1 hour free play at participant home, caregiver instructed to behave as they desire	91%	Yes	-

Note. ICC = intra-class correlation coefficient. The figure cited indicates the reliability coefficient for the frequency of observed repetitive behaviours. ASD = autism spectrum disorder, DD = developmentally delayed.TD = typically developing, as defined by the researchers.

2.4.1 Summary of Findings

The second aim of this chapter was to provide a comprehensive description of repetitive behaviour amongst infants aged 9 to 12 months. The findings indicate that most infants exhibit repetitive motor behaviour on a frequent basis during the latter half of the first year of life, although some forms of repetitive behaviour were more common than others. Repetitive behaviour was a pervasive feature of 9- to 12-month-olds behaviour in this free play setting. Flapping and banging were the most frequently observed repetitive behaviours. These findings reflect the development of prehension and the ability to control and manipulate objects, behaviours that tend to develop in the latter portion of the first year of life.

These findings extend the previous observational work reviewed in Table 1.2. The findings from the present study not only revisit those of Thelen and colleagues and also extend the findings of recent questionnaire studies. Repetitive behaviours were exhibited most frequently at the age of 10 months, with trends showing a peak of object-based repetitive behaviour and motor stereotypies at 10-months of age (see Figure 2.3). Thelen noted that repetitive behaviours and motor stereotypies peak in frequency at transition points of growth and development, such that the repetitive behaviour represents a transitional phase within development (Thelen, 1979, 1980). The current findings suggest that 9-month-old infants exhibited less repetitive behaviour than older infants. Whilst the study does not address the question of functionality of repetitive behaviour, the results support Thelen's account of motor development. Increased repetitive behaviours at 10 months may mark a transitional phase in motor development where repetitive behaviours are essential for movement coordination and postural stability (Gesell, 1941, McGraw, 1941). This may help the infant develop the ability to move around his or her environment by crawling or walking (Wade, 1986).

Furthermore, Johnson (2010) outlines the important cortical changes that occur in the first few years of life. The findings also suggest that repetitive behaviours increase in frequency at an important point in brain development. During the latter part of the first year of life, a period of cortical maturation occurs (Johnson, 2010). At around 9 months of age, the white matter associated with the frontal and parietal lobes becomes apparent. Maturation within the frontal lobes has been related to advances in voluntary movements and consequently, advances in the ability to reach for desirable objects towards the end of the first year of life. Maturation of the parietal lobes has been related to advances in the manipulation of objects (Johnson, 2010). Consequently, the brain maturation noted at this age can be said to bridge the transitional phase in development where movement is more mature than spontaneous reflexes but less mature than voluntary, goal-directed behaviour (Thelen, 1979, 1980, Johnson, 2010). One may speculate that the repetitive behaviours observed in the current study could therefore be symptomatic of the developing neuromuscular control and the progressive organisation of the central nervous system (known to occur at this phase in development, Johnson, 2010).

The significant age-related changes observed in the current study, with a significant increase in object related banging repetitive behaviours, can be linked to Piaget’s theory and sensorimotor stages of development (Cowan, 1978). Infants younger than 9 months fail to retrieve a hidden object after a short delay period if the object’s location is changed from one where it was previously successfully retrieved (Piaget, 1952). From 9 months onwards the repeated activity of play increases the infants' mastery of symbolic representation, thus providing knowledge about the objects and consequently infants tend to acquire knowledge regarding object permanence.

Subsequently, from around 9 to 12 months, parent–infant interactions undergo a significant qualitative change. Turn-taking, games and toy-mediated play begin to dominate (Bruner and Sherwood, 1976; Ratner and Bruner, 1979). These cooperative social games can be identified by their features of mutual engagement, repetition of actions and alternation of terms, often accompanied by signs of playfulness and positive affect (Hay, 1979; Ross and Goldman, 1977). Consequently, it is possible that the repetitive behaviours documented in this study may go beyond the behaviours themselves and may be related to other aspects of development such as communication, social interaction and play.

2.4.2 Limitations of Findings

Both primary and secondary aims of the current study were satisfied and consequently the study provided a comprehensive and effective description of common repetitive behaviours in 9- to 12-month-old infants. While this is useful for the study of normative development, it is important for any reader to interpret these results with a degree of caution. The study is descriptive. The causes and functions of the repetitive behaviours were not determined and therefore must not be inferred from the results. Further work is required in order to address such questions.

The RBCS provided a view of repetitive behaviours in infancy. I acknowledge that the information obtained reflected only a snapshot of time. Furthermore, I need to acknowledge the context in which the repetitive behaviours were observed. This study was based on observations of infants during a free play interaction setting. This is dissimilar to the context in which infants have been previously observed (e.g. Thelen, who observed infants at home on their own). Subsequently, I need to ascertain whether the ubiquity of the repetitive behaviours observed within this study would also be evident in a different context, e.g. during individual testing. In Chapter 4 I will assess whether the repetitive behaviours seen during free play with caregivers and peers are also apparent in during individual testing.

Finally, the volunteer sample recruited within this chapter was not representative of the UK population, the demographic data were not assessed in a way to ascertain whether nationality, ethnicity, SES or social class was representative of a population. Readers must therefore generalise the result with caution as I am unable to conclude whether the pattern of results detected accurately represent the behaviours of infants. Subsequently, the data need to be replicated for validity. For this to be most effective I will need to use a sample who is representative of mothers with infants in the UK before any firm conclusions about the ubiquity of the repetitive behaviours can be drawn.

2.4.3 Implications for Further Research

The results speak not only to an area of developmental psychology that has received little study, but also have implications for the study of neuromuscular maturation and the study of ASD. The comprehensive descriptions provided show that repetitive behaviours occur normatively and typically in the first year of life and that these behaviours are exhibited by infants on a frequent basis. The coding scheme promises to be useful in identifying age appropriate and inappropriate levels of repetitive motor behaviour in children of different ages. This normative, typical description can therefore inform the study of atypical development, specifically the study of ASDs and its related features.

The questions that do remain unanswered by the current study will be addressed in future research. The age of onset for repetitive behaviours as well as their developmental peak and decline needs to be determined. Longitudinal observations are therefore imperative to capture development itself, which in turn will inform research into atypical development. Therefore the RBCS will now be used in a prospective longitudinal study, the Cardiff Child Development Study, which has a larger and more representative sample in which to address these questions.

2.4.4 Conclusion

The study helps to provide a description of repetitive motor behaviours in typically developing community sample of infants. It is a positive step towards identifying the developmental pattern of such repetitive behaviours and therefore provides some useful and insightful information for the diagnosis of ASD. The aim of the present study was to develop an observation coding scheme and to provide a description of repetitive behaviour in 9- to 12-month old infants and subsequently extend Thelen's observational work. These aims were satisfied successfully on a small, selective sample. An observational coding scheme was developed that can now be used in future longitudinal research. Further work, as outlined above is now needed to determine the developmental significance and trajectory for repetitive behaviours. Further work will also need to establish whether these observed bouts of repetition are common in an interactive play setting only, or if they are also common during individual infants' interactions with an experimenter. Chapter 4 will address this issue. First, however, the design and procedures used in the CCDS will be explained in Chapter 3.

CHAPTER 3.

General Method; the Cardiff Child Development Study (CCDS)

The analyses contained in Chapter 2 suggested that the RBCS is a measure that is both effective at detecting behavioural bouts of repetitive behaviours and is suitable for use with infants. To obtain higher external validity, analyses of a representative community sample will be undertaken. Subsequently, the remaining chapters of this thesis will focus on the participants of the Cardiff Child Development Study (CCDS). All subsequent analyses aimed to answer the questions set out in section 1.9.2 will be based on the participants of the CCDS. This chapter outlines the overall methodology of the CCDS, describing the general design, recruitment, demographic information about the sample and the procedures used throughout the study. Detailed information about age-appropriate measurement at each wave of the longitudinal study will be provided in the subsequent chapters.

3.1 Design

The CCDS is a prospective longitudinal study of children's early social development funded by the UK Medical Research Council Programme Grant G0400086 and Project Grant MR/J013366/1 (PI: Professor Dale hay, School of Psychology, Cardiff University). A mixed method design was used. The CCDS follows first time mothers and their partners from pregnancy over the child's first seven years, with assessments at six time points (subsequently referred to as the six waves of the study). The primary focus of the study was the way infants learn to relate to other people in a social world and the social, cognitive and biological risk factors for children's later emotional and behavioural problems.

3.2 Participants

3.2.1 Recruitment

Three hundred and thirty-two primaparous women were recruited between 1st of November 2005 and 31st of July 2007 from antenatal clinics and general practice clinics in the Cardiff and Vale University Health Board and the Gwent Healthcare Trust, UK. The catchment areas that the antenatal clinics served were selected to provide a diverse sample of families. To further increase the representativeness of the sample, midwifery teams also granted access to antenatal clinics for specialist medical problems and to outreach services for vulnerably housed individuals.

During the recruitment, trained researchers approached primaparous women in the hospitals or clinics. The clinic receptionist helped to identify the primaparous women. The families were given a brief explanation of the study and what their enrolment would entail. Families who expressed an interest were provided with a leaflet and invited to watch a recruitment DVD that had previously been shown to the midwifery teams supporting the project. Families were also asked to provide contact details for the CCDS administrator to phone or write to them one to two weeks after the initial contact.

The role of the project administrator was to provide further information about the study procedures, after which, the families decided whether or not to participate. The administrator then arranged an appointment with those families who had decided to take part in the CCDS. This appointment was made for the third trimester of the pregnancy (Wave 1 of the CCDS). No exclusion criteria were used for the study, except miscarriage or infant death. Translators were employed to enable participation among those whose native language was not English or Welsh, and for those who had impaired hearing.

3.2.2 Demographic Characteristics

The demographic characteristics for each family were provided by interview or questionnaire during the prenatal/ antenatal assessment. The recruitment strategy resulted in a sample that is nationally representative of first time mother in the UK. The sociodemographic characteristics did not differ significantly from the first time mother who form part of the sample in the Millennium Cohort Study, the most recent survey of a nationally representative birth cohort in the UK (see Hay, Mundy, Roberts, Carta, Waters, Perra, Jones, Jones, Goodyer, Harold, Thapar & van Goozen, 2011). The sample characteristics are presented in Table 3.1.

Social class was categorised according to the Standard Occupational Classification 2000 (SOC 2000; Elias, McKnight & Kinshett, 1999). Each rating was based on the mothers' and fathers' highest scoring occupation of the past or present. Working-class was defined as an occupation considered as (4) administration or secretarial, (5) skilled trade, (6) personal service, (7) sales or customer service, (8) process plant or machine operative or (9) elementary occupations. Middle class was defined as an occupation of (1) manager or senior official, (2) professional, or (3) associate professional or technical position. Mother's education achievements were recorded according to the basic expected achievement of individuals in the UK. To achieve basic education qualifications, individuals must gain five or more General Certificate of Secondary Education (GCSEs) at grades A* to C. Mother's education was therefore dichotomised to fewer than basic educational qualification or basic/ more achieved (5 or more GCSEs).

The family's overall sociodemographic risk index items (described in Hay et al., 2011) were based on the female partner's information. Dichotomous variables were created for social class (0= *middle class*, 1= *working class*), educational attainment (0= *more than 5 GCSE grades A*- C or equivalent*, 1= *fewer than 5 GCSE grades A*- C*), stable partnership with the baby's father (0= *no stable partnership*, 1= *stable partnership*), marital status (0= *married*, 1= *not married*) and mother's age at entry into parenthood (0= *20 years of age or older*, 1= *19 years of age or younger*). A composite sociodemographic risk index was created by summing these five scores. The composite score showed an acceptable level of internal consistency $\alpha = .74$. Since these correlations were strong and significant the sociodemographic risk index was used as a measure of social risk.

Mother's ethnicity was self-reported during the first wave of assessment (prenatal assessment). The data were collected by questionnaire measure where mothers were asked to *tick the response that best describes you.* The data are presented in Table 3.1. 93% of the study mothers self-described as British is equivalent to the same proportions described in the Millennium Cohort study.

Table 3.1 Demographic characteristic for the participants of the CCDS

Demographic Characteristic		Full Sample (N=332)
Mean age at the child's birth	Mother	28.15 (Range 16.09-42.99)
	Father	30.68 (Range 15.62-56.67)
Relationship Status at the child's birth *(Percentage)*	Married	50.3%
	Cohabiting	33.7%
	In a relationship but not living together	6.9%
	Single	9.6%
Social Class *(Percentage)*	Middle Class	50.9%
	Working Class	49.1%
Mother's Ethnicity *(Percentage)*	Welsh/English/Scottish/Irish	88%
	Other European	3.3%
	Bangladeshi/Indian/Pakistani	1.2%
	South East Asia	.3%
	Mixed Race	.6%
	Other/Not Specified	6.1%
Mother's Highest Educational Qualifications *(Percentage)*	Fewer than 5 A*-C GCSE passes	21.7%
	Undergraduate degree	28.0%
	Postgraduate degree	24.7%
Child Gender *(Percentage)*	Male	56.7%
	Female	43.3%

3.3 Procedure

Multiple assessments were made at five different time points between the mother's pregnancy and the child's third birthday. A sixth wave of assessment is currently in progress (target age, 7.0 years). Figure 3.1 provides an overview of the data collection. The data presented in this thesis derive from Waves 2, 3, 4 and 5 of the CCDS. All procedures were approved by the NHS MultiCentre Ethics Committee, approval number 04/MRE09/36. In chapter 7 I have examined the univariate association between the toddler assessment (Wave 5) and childhood assessment (Wave 6). As such, the School of Psychology Research Ethics Committee number for the approval of CCDS follow-up at Wave 6 is EC.12.10.09.3201

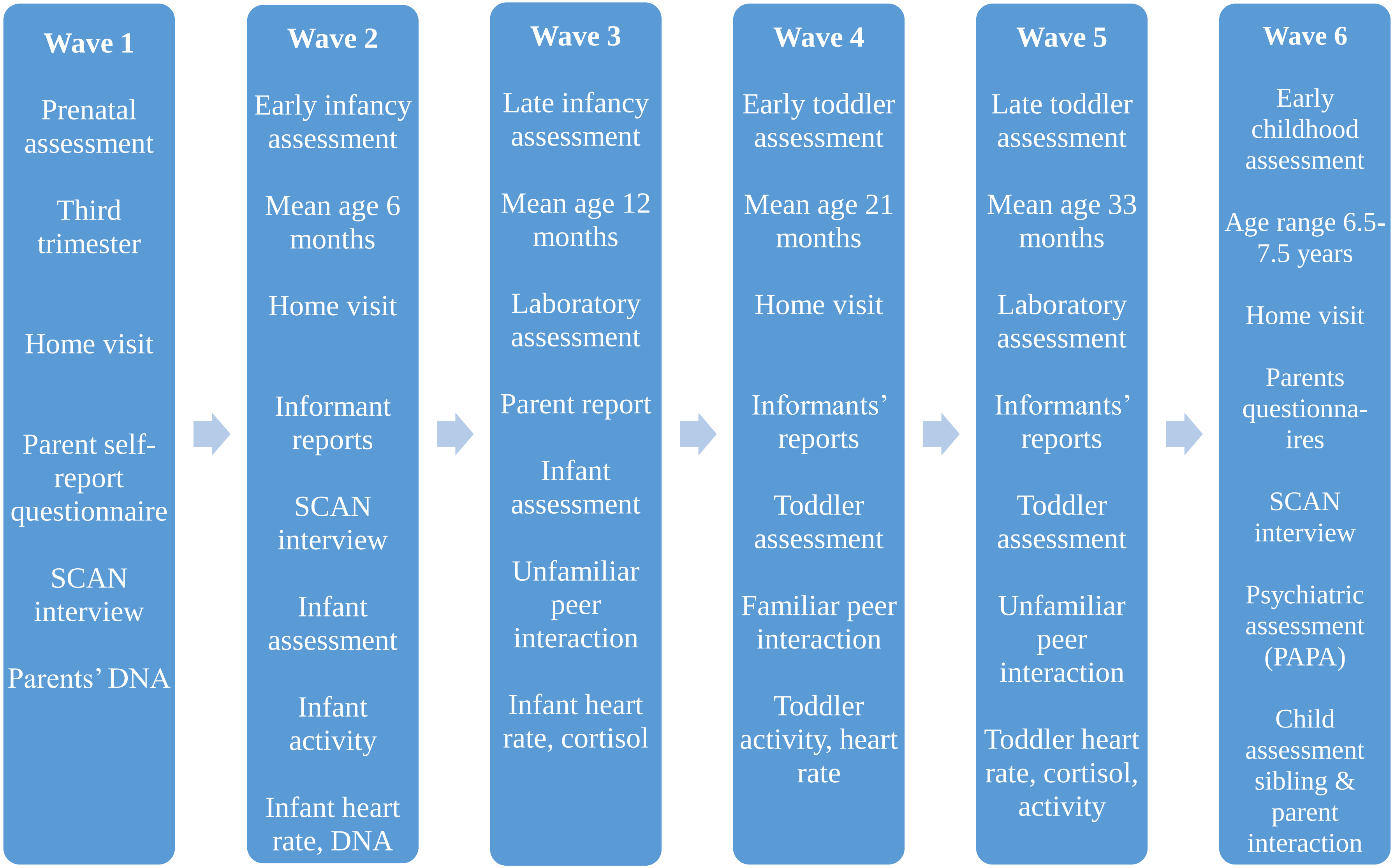

Figure 3.1 The structure of and the data collection within the Cardiff Child Development Study.

3.3.1 The Antenatal Assessment, Wave 1

Background information about the families, including their social circumstances and medical history, was taken during home visits when the mothers were pregnant. During the third trimester (*M*= 30.7 weeks gestation, *SD* = 4.5 weeks), two trained research assistants visited the family home. All interviewers underwent training in the use of the Schedules for Clinical Assessment in Neuropsychiatry, a set of instruments validated in assessing, measuring, and classifying the symptoms of major psychiatric disorders (SCAN; Wing et al, 1990). The research assistants conducted the semi-structured SCAN interview with both the mothers and fathers in separate rooms of the family home. The interviewer asked about parents' socio-demographic information, educational attainment, social-support, employment, conflict in the workplace, anti-social behaviour, family history of mental health, and parents' psychopathologies (both current and past).

On average, the interviews lasted two hours. Following the completion of the interview, parents were given questionnaires and were instructed to send the completed questionnaires to the university. The questionnaire asked parents about their general health, lifestyle, life events, relationship quality, fertility history, behavioural history and substance use. At the end of the visit, families were provided with small remuneration in the form of a £20 gift voucher for their time.

3.3.2 The Early Infancy Assessment, Wave 2

Approximately five months after the child's birth a researcher contacted the family by the phone or post to arrange the early infancy assessment (mean age 6 months). Prior to the visit, three questionnaires were sent to the family (one for the mother, one for the father and one for a third informant [a grandparent for example]). When the infants were approximately six months old (*M* = 6.55 months, *SD* = .82 months) two researchers visited the family home. Completed questionnaires were collected but in instances where the questionnaires had not been completed, self-addressed envelopes were provided to the family. One research assistant conducted the same semi-structured SCAN interview as was conducted during the antenatal assessment. Mother's clinical symptoms between the Wave 1 and Wave 2 assessment were investigated. Mothers were also asked about changes in their relationship, education, and living environment, together with their experience of labour and current social support.

During the home visit, a battery of tasks was conducted with the infants and primary caregivers (88% with the mother). Infants' reaction to novel objects, their ability to imitate, their frustration response to restraint in a car seat and interaction with the caregiver were examined. These tasks lasted for approximately 30 minutes and all of the tasks were filmed for later observation and coding. At the end of the visit, families were provided with remuneration in the form of a £20 gift voucher for their time

3.3.3 The Late Infancy Assessment, Wave 3

When infants approached their first birthdays, families were invited to attend an experimental birthday party at the School of Psychology Social Development Laboratory. Three families were scheduled for each testing session, which was approximately one and a half hours in duration. This assessment took place at approximately 12 months of age (*M* = 12.82, *SD* = 1.17). Infants were assessed individually, in the presence of their caregivers (90% mothers) for approximately 25 minutes. The battery of cognitive and social-communicative tasks was designed to assess attention, joint attention, and exploration of a novel object (V-tech Rocket ship shape sorter), causal understanding, and capacity for conflict in response to designs on their possessions or infringements of their personal space.

The three families were then observed together during a simulated birthday party, featuring a teddy bears picnic scenario, which entailed a series of socio-emotional challenges presented to the infant (Hay, et al. under review). The three families were then asked to remain in the testing room for a further 20 minutes to allow observation of free play amongst the infants. Repetitive behaviour was coded from the video records of this free play session. The accompanying parents/ guardians were asked to complete questionnaires during the afternoon of testing. Following the free play session, infants were presented with a lucky-dip task in which each child discovered a small wrapped gift (a picture book) within a box of balls. At the end of the visit, families were provided with small remuneration in the form of a £20 gift voucher for their time.

3.3.4 The Early Toddler Assessment, Wave 4

When infants were 20 months of age a researcher contacted the family by phone or post to arrange the early toddler assessment. Prior to the visit, three questionnaires were sent to the family (one for the mother, one for the father and one for a third informant [a grandparent or family friend for example]). Completed questionnaires were collected during the visit but when this was not the case, a self-addressed envelope was provided to the family. The 21 month assessment (*M* = 20.6, *SD* = 2.23) involved a two hour visit to the family's home during which a short semi-structured catch-up interview was conducted. The interview asked the parent about any new education attainments, employment information and asked about any subsequent pregnancies and siblings. Two parent-child interaction tasks were then filmed. During the latter part of the visit the parents' friend came to the home to allow the observation of the child's natural play with a familiar peer. A 45 minute session of peer interaction was filmed, followed by a gift for each child (drawing materials). At the end of the visit, families were provided with small remuneration in the form of a £20 gift voucher for their time.

3.3.5 The Late Toddler Assessment, Wave 5

When the children were approximately 30 months old a research assistant contacted the family to book the early toddler assessment. This assessment took place at approximately thirty-three months of age (*M* = 33, *SD* = 5.85 months). Three questionnaires were sent out to each family at the time of booking (one for the mother, father and a third informant [such as grandparent or a family friend]). The questionnaire contained appropriate developmental milestones and the 1½- to 5-year-old version of the Child Behaviour Check List (CBCL; Achenbach & Rescorla, 2001).

Families were invited to attend another experimental birthday party at the School of Psychology Social Development Laboratory. Three families were scheduled for each testing session, which was approximately two hours in duration. Any completed questionnaires were collected and in instances where the questionnaires had not been completed, families were provided with a stamped addressed envelope for convenience. The toddlers were assessed individually, in the presence of their caregivers. The procedure at Wave 5 was identical in design to that of the late infancy assessment (Wave 3); however, the nature of the cognitive tasks in the individual assessments was age-appropriate. The battery of individual tasks was designed to assess the toddlers' inhibitory control (both cognitive and behavioural), their capacity for conflict, their imitation abilities, and their responses to a frustrating toy. Two caregiver-infant interaction games were also included. The birthday party portion of the assessment remained identical to that at Wave 3. Following the free play, infants were given a lucky-dip in which each child received a small gift. At the end of the visit, families were provided with remuneration in the form of a £20 gift voucher for their time

3.3.6 The Early Childhood Assessment, Wave 6

The study is currently conducting the sixth wave of assessment. Between the ages of 78 and 90 months of age two or three research assistants visit the family home. The early childhood assessment takes place over two visits. The interviewer conducts two semi-structured interviews with the primary caregiver, the SCAN interview and the Preschool Age Psychiatric Assessment (PAPA). The child tester administers a battery of age appropriate socio-cognitive tasks; including deception, theory of mind, emotion recognition and further tasks of their capacity to understand conflict. The British Picture Vocabulary Scale is used to assess the children's receptive vocabulary. Some of the Amsterdam Neuropsychological Tasks are used, namely to assess children's working memory capacities, response to frustration, detection of facial emotions and inhibitory control. Parent interaction tasks and sibling interaction task are also included. The assessments also include a bespoke imaginary computer game, designed for the purpose of the CCDS. At the end of the second visit, the family is provided with gift vouchers (for both the parents and the child).

3.4 Measure

The Repetitive Behaviour Coding Scheme (RBCS) that was developed in Chapter 2 will now be applied to video records of infants and toddlers' behaviours during individual assessment with an experimenter and a free play session with peers. The free play with peer session is one that has not been used in previous assessments of repetitive behaviours. I decided to use the data available from the free play session because it is ecologically valid. Due to the novel nature of the observation I conducted additional analyses, first to determine whether assessment in the presence of peers had an impact on the infants' and toddlers' behaviours, and second to determine whether the number of peers present had an impact on the repetitive behaviour observed. The findings are in Appendix I and are also discussed within each relevant chapter. A summary of the measures used within the thesis is presented in Table 3.2

Table 3.2 Summary of research questions, chapter in which question is addressed, CCDS wave used and measures drawn from the CCDS

Question number	Research Question	Chapter	Wave	Measures used
1	Is repetitive behaviour already evident by six months of age and does it increase over the first year?	4	2 & 3	RBCS
2	Are there differences in the rate of repetitive behaviour between individual assessment and social contexts?	4	3	RBCS
3	When in development do individual differences in the use of repetitive behaviours first appear, and are they associated with other milestones in motor and communicative development?	5	3	RBCS Milestones questionnaire Joint attention
4	Is there a normative decline in the use of repetitive behaviour from 12 months onward?	6	3 & 5	RBCS
5	Does the Use of Repetitive Behaviour at 33 Months Relate to Children's Inhibitory Control, Activity Levels or Social and Communicative Skills?	7	5	RBCS Behavioural regulation Cognitive flexibility CBCL ADHD scale Activity level Peer interaction coding system

CHAPTER 4.

The Early Development of Repetitive Behaviour: Cross-sectional and Longitudinal Analyses of a Representative Community Sample during Infancy

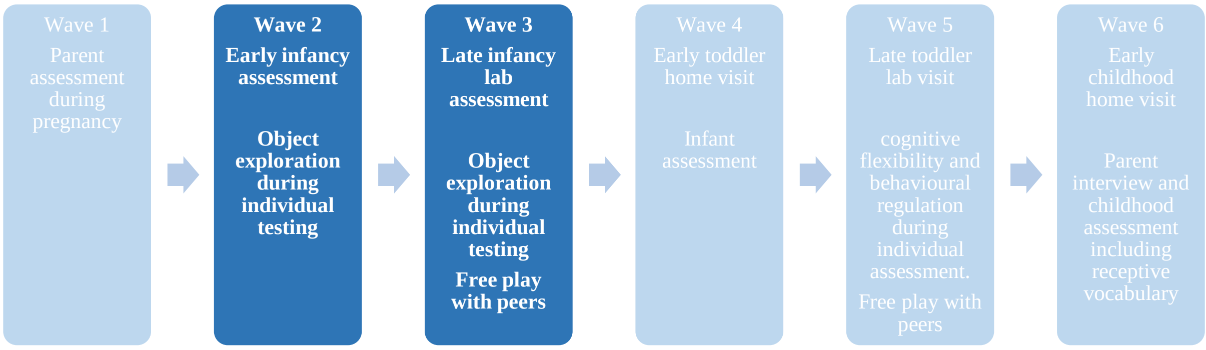

Figure 4.1 The CCDS waves included within this chapter (in dark blue).

4.1 Introduction

The analyses presented in this chapter address Research Questions 1, 2 and 3 (see section 1.9) and extend the observations of repetitive behaviour in infancy reported in Chapter 2. In the First Friends Study data set I developed the Repetitive Behaviour Coding Scheme (RCBS) and I found that repetitive behaviours were almost ubiquitous in infants aged 9 to 12 months who were observed with their caregivers and familiar peers. In the present chapter, I have applied the RCBS to a larger, more representative community sample, using formal assessments of individual infants as well as observations of a free play context, and investigated developmental change and the emergence of individual differences during the first year of life. The individual assessment paradigm closely emulates the observational settings used by earlier observers of infants' repetitive behaviour (e.g. Thelen, 1979, McGraw, 1943 and Gesell's work in the 1940s). Specifically, I assessed the infants' behaviours during object exploration tasks administered at the early and late infancy assessments (see Figure 4.1). Furthermore, in the present chapter, the RCBS, which was developed on a volunteer sample of 100 infants, is applied to members of a larger, nationally representative sample.

The assessments and analyses reported in this chapter address the first three research questions outlined in section 1.9. In the review of the literature, no empirical evidence was found regarding the associations between the repetitive behaviours in different contexts. Consequently, within this chapter I will examine whether the repetitive behaviours observed within the individual testing paradigm are related to the repetitive behaviours during the free play session. The design of the CCDS allows this to occur with the same infants, on the same day, at the late infancy assessment (Wave 3, see Figure 4.1). This allowed me to determine whether the repetitive behaviours seen in infancy transcend contexts.

4.1.1 Question 1. Is Repetitive Behaviour Already Evident by Six Months of Age and does it Increase over the First Year?

The first aim of this chapter is to seek evidence for the age of onset of the repetitive behaviours included in the RCBS and to examine developmental change in those behaviours. In the context of individual assessments of infants, theorists have posited that motor stereotypies are associated with particular stages of neuromuscular maturation. Spontaneous motor activity that demonstrate cyclic fluctuations emerge at the gestational age of 12 weeks. The prenatal rhythmical sucking and swallowing are important in the regulation of amniotic fluid (Piek, 2006). These repetitive behaviours continue once the infant is born but are irregular in the first few months (Piek, 2006).

Compared to other mammals, infants are born with relatively immature brains that are subject to a slow cortical maturation process. Consequently, infants have a long period of dependence upon their caregivers (Piek, 1994). During this stage behavioural capabilities such as reflexes emerge. For example, investigators have proposed that infants use the intrinsic patterning of both sucking and gaze alternation to enter into early social interaction (Stern 1974). Esther Thelen (1980) further suggested that rhythmical stereotypies are examples of the opportunistic infants' use of neuromuscular coordination. In this view, the rhythmical patterning is required before full voluntary control develops to serve adaptive needs later met by goal-corrected behaviour (Thelen, 1979, 1980, 1981; see chapter 1 for a full review regarding Thelen's work). The infant solves the problems of immaturity by using this phylogenetically old behaviour for which the underlying neuromuscular coordination is available at comparatively early stages of motor maturity. Thus, sucking and gaze alternations serve the function of regulating social interaction. This suggests that the repetitive behaviours studied within this thesis are present from birth.

In her seminal paper, Thelen (1979) found that developmental profiles emerged when the movements were categorised into separate body parts or postures and compared across age. Leg stereotypies, for example, increase in frequency from 1 month, they peak at 5 to 6 months and then decrease. Similarly, arm flapping increases from 1 month to 28 weeks, at which point it peaks and declines thereafter. If all of Thelen's behavioural categories were summed, the motor stereotypies would gradually increase to a peak at 6-7 months and then decrease in the last few months of their first year. On the basis of these findings she argued that these types of movements are centrally controlled and the emergence of each stage is dependent upon the maturation of the appropriate neuromuscular pathway.

Other previous research has also confirmed that stereotypies are present from a young age. Kravitz & Boehm (1971) examined the onset, sequence and frequency of stereotypies in 219 new born infants and 200 older infants (1 month to 1 year). Their results are summarised in Table 4.1. The stereotypies may represent an overflow of energy and may be characteristic of a normal infant in a state of well-being (Kravitz & Boehm, 1971).

Similarly, the repetitive actions with objects are a part of infants' behavioural repertoire (Piaget, 1952). It is however, unclear when young infants begin to use these repetitive actions. As infants are able to hold their heads up and sit they become increasingly engaged in self-directed exploration of their own environment as their growing motor competence allows. Banging objects form the basis of infants' early play. Then from 9 months the repeated activity of play increases the infants' mastery of symbolic representation. Piaget's (1950) description of children's cognitive and emotional development suggests that repetitive behaviours provide order and predictability for young children who have little control over and little understanding of the contingencies of daily life. However, little empirical information is available regarding the onset and the prevalence of such behaviours in young infants approximately 6 months old.

Arguably, the repetitive behaviours discussed in this thesis are present prenatally and continue after birth. However, further research with a representative community sample will extend previous research and describe patterns of repetitive behaviour in young infants. In particular, the present study will focus on the repetitive use of objects as well as the motor stereotypies described by earlier researchers (Kravitz & Boehm, 1971; Thelen, 1981) and examine the interrelations between these two types of repetitive behaviour.

Table 4.1 Summary of research by Kravitz & Boehm (1971)

Behaviour	Amount of infants that engaged in behaviour	Onset
Hand sucking	89%	Day 1
Kicking	99%	2.7 months
Lip sucking/ biting	93%	5.3 months
Rocking	91%	6.1 months
Toe sucking	83.4%	6.7 months
Teeth grinding	56%	10.5 months
Head rolling	10%	> 12 months
Head banging	7%	>12 months

One aim of the developmental analyses reported in this chapter was to extend the use of the RBCS beyond the observations of free play in a laboratory setting described in Chapter 2 to individual testing sessions in the home (at a mean of 6 months) and laboratory (at a mean of 12 months).The design of the study provides an opportunity at 12 months to examine infants' use of repetitive behaviour during individual assessments and in the context of social play with peers, in a similar paradigm to that described in Chapter 2. I will use both cross-sectional and longitudinal analyses to seek evidence for an increase in repetitive behaviour during infancy. Assessing infants' repetitive behaviours during the comparable object exploration tasks used at Waves 2 and 3 permits an estimate of the degree of change in the use of repetition, in the same infants, from early to later infancy. Any age-related changes in motor stereotypies and repetitive use of objects are important issues to consider in light of limited knowledge on the prevalence of normative repetitive behaviours. At 12 months, repetitive behaviours are still thought to be common in typically developing infants (Thelen, 1979); however, clinicians observing repetitive behaviour in 12- to 18- month old children are in a quandary as it is unclear whether such behaviours can be considered typical after 12 months (Loh et al., 2007). In the context of the general question about the age of onset and developmental change in repetitive behaviour, three subsidiary questions were asked:

A. How commonly do infants aged approximately 6 months engage in repetitive behaviours?

B. In a cross-sectional comparison of infants between 5 and 8 months, is there a normative increase in the frequency of repetitive behaviours? If so, is this equally true for motor stereotypies and repetitive actions on objects?

C. Does the use of repetitive behaviours during object exploration in individual assessment increase from early to later infancy?

4.1.2 Question 2. Are there Differences in the Rate of Repetitive Behaviour between Individual Assessment and Social Contexts?

It is important to test for possible differences in the rate of repetitive behaviour across different contexts. It should be noted that at the late infancy assessment the infants' mean age was 12 months (age range 11 to 14 months), a period at which early behavioural signs of ASD may begin to emerge. The present analyses thus allow us to examine how common repetitive behaviour is in this representative community sample during individual assessments (which would be used for possible diagnostic assessments for ASD) and during free play, as described in Chapter 2. It is possible that the use of the social context of Chapter 2 might not accurately represent the true frequencies motor stereotypies and repetitive actions with objects and thus further examination is required in order to clarify whether the rates of repetition observed in different context and related.

4.1.3 Question 3. When in Development do Individual Differences in the use of Repetitive Behaviours First Appear?

The design also allows for the analysis of early-emerging individual differences during the first year of life. At 12 months, it will be possible to examine consistency in the use of repetitive behaviour across the individual testing and free play contexts as well as examine the consistency over time. It will also be possible to examine evidence for longitudinal continuities in the use of repetitive behaviour during individual assessments at 6 and 12 months. In the context of this general question about the emergence of individual differences, three subsidiary questions are asked:

A. Is the rate of motor stereotypies correlated with the rate of repetitive behaviours using objects at 6 and 12 months?

B. At 12 months, do infants show consistency across the two contexts of the individual assessment and the free play setting?

C. Is there continuity in individual differences from 6 to 12 months in the use of repetitive behaviour?

4.2 Method

4.2.1 Participants

The analyses reported in this chapter derive from observations of the children of the Cardiff Child Development Study. Information regarding the study design and the sample was reported in Chapter 3.

4.2.1.1 Early infancy 6 month assessment, object exploration. The participants focused on in this chapter are the 280 infants who successfully completed the object exploration task during the early infancy assessment (Wave 2). Figure 4.2 shows the progression of the sample from recruitment in pregnancy to the 280 of the infants that were assessed in their home. The participants' mean age was 6.6 months (range 5 to 8 months). The participants' demographic characteristics did not differ significantly from the original sample.

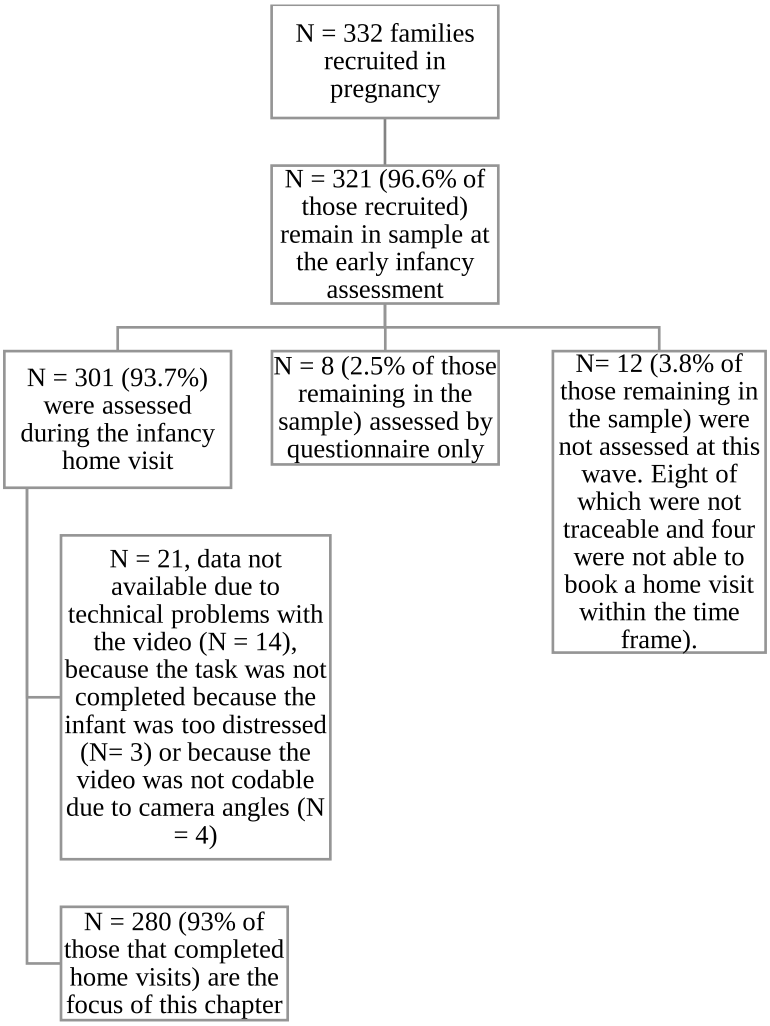

Figure 4.2. Progression of the sample from recruitment in pregnancy to the 280 participants assessed in early infancy at Wave 2 of the CCDS.

4.2.1.2 Late infancy 12 month assessment. During the late infancy assessment 253 children attended the laboratory session. The subsample doesn't differ significantly from the full sample on any demographic characteristics. Figure 4.3 shows the progression of the sample.

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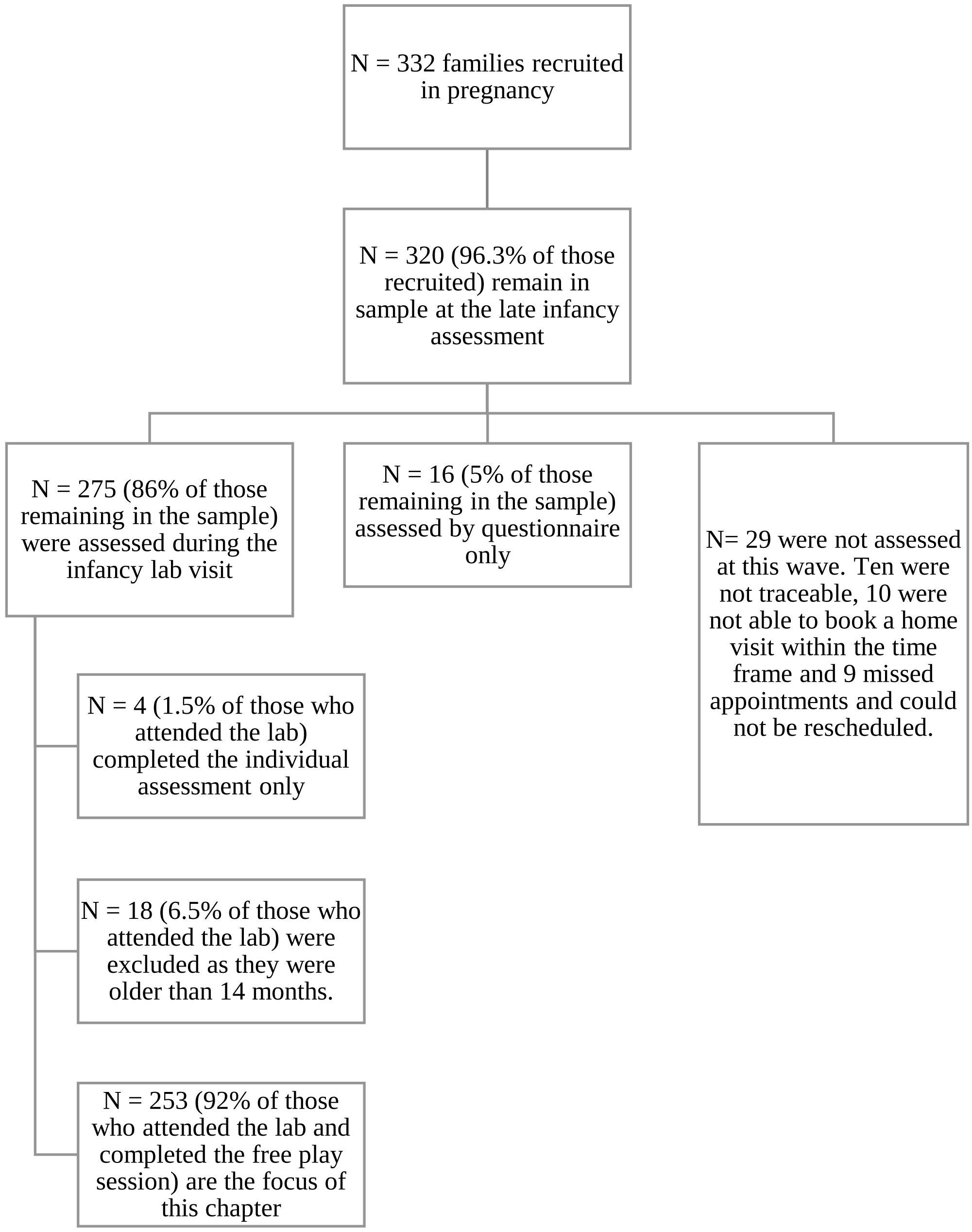

Figure 4.3. Progression of the sample from recruitment in pregnancy to the 253 participants assessed in the late infancy at Wave 3 of the CCDS.

Of the 280 participants assessed during the early infancy object exploration task, data are available on 231 participants (82%) during the late infancy free play session (one family had withdrawn, 19 were not assessed at this wave, 15 completed questionnaire data only and 14 participants were not included in the late infancy sample as they were too old [i.e. 15 months or older]) and data were available on 215 during the late infancy object exploration task (a further six cases were not scorable due to poor camera angle, four infants were too distressed to complete the task and six videos encountered technical problems)

4.2.2 Procedure

4.2.2.1 Repetitive behaviour at 6 months during the individual object exploration task. The overall procedure used at the early infancy assessment was described in Chapter 3. Of specific interest to this chapter is the object exploration task presented at the start of the infant testing session. Figure 4.4 shows the toy used for this task. Infants were presented with this toy for 3 minutes and were allowed to play and interact with the toy as desired. Parents were instructed to allow the infant to explore; they were asked not to instruct, guide or assist their infant whilst exploring this object. Infants' movements were therefore not restricted or guided by others.

Figure 4.4. Turtle toy used in the early infancy object exploration task.

4.2.2.2 Repetitive behaviour at 12 months. When the infants approached their first birthdays, infants were invited to attend an experimental birthday party at the School of Psychology Social Development Laboratory. Infants were accompanied by a caregiver; in 90% of the cases this was the mother. Three infants were scheduled for each testing session, which was approximately one and a half hours in duration. This assessment took place at approximately 12 months of age (Mean = 12.82, *SD* = 1.17).

4.2.2.2.1 Repetitive behaviours during object exploration (during individual assessment). Infants were assessed individually in the presence of their caregivers for approximately 25 minutes. The battery of cognitive and social-communicative tasks was designed to assess attention, joint attention, and exploration of a novel object, causal understanding and capacity for conflict. The focus of the present analyses was the exploration of a novel object task. The exploration of an object task was always the first task administered during the individual testing session and involved the experimenter presenting the infant with an age appropriate shape sorter (V-tech rocket; see Figure 4.5). Caregivers were instructed to allow infants to explore the object as they naturally would and asked not to direct the infants' actions. Infants were allowed to play with the rocket shape sorter for three minutes.

4.2.2.2.2 Repetitive behaviours during free play at 12 months. After the individual testing, the three infants (and accompanying caregivers) were then observed together during a simulated birthday party; featuring a teddy bears picnic scenario, which entailed a series of socio-emotional challenges presented to the infant. The three families were then asked to remain in the testing room for a further 20 minutes to allow observation of free play. The analyses of repetitive behaviour were undertaken using video records of this free play setting.

Figure 4.5. V-tech Rocket ship toy used in the late infancy object exploration task.

4.2.3 Measuring Repetitive Behaviours

All observed instances of motor stereotypies and repetitive actions on objects were coded using the Repetitive Behaviour Coding Scheme (RBCS), as described in Chapter 2, section 2.2.3 (page 72)

4.2.3.1. Six-month object exploration task. In order to establish coder reliability, for repetitive behaviours during the 6-month object exploration task, an independent observer double coded 25% of the video records for the whole sample. This second coder showed significant agreement in the number of behaviours observed, ICC = .88, number with an object, ICC = .90 and number of motor stereotypies, ICC = .89. For ease of comparison with other descriptive data presented in other chapters of this thesis, a rate per hour was calculated for total repetitive behaviour observed: sum of motor stereotypies and sum of object based repetition observed. These behaviours were not normally distributed; I attempted to transform the variables to improve normality. Normality did improve slightly but, due to the large number of infants who were not yet engaging in the repetitive behaviours, the Kolmogorov-Smirnov statistic was significant for both motor stereotypies ($p < .05$) and repetitive actions with objects ($p < .05$), subsequently, the transformations were unsuccessful. Consequently, nonparametric analyses were used for the early infancy home assessment data.

4.2.3.2 Twelve-month object exploration task. The RBCS was used to code all observed instances of repetitive behaviours during the object exploration task. In order to establish coder agreement an independent observer coded 25% of video records and showed significant agreement for the number of repetitive behaviours observed ICC = .94, number with an object, ICC = .95 and number repetitive motor actions, ICC = .93. These behaviours were not normally distributed and therefore log transformations were used in order to improve normality. The log transformations did improve normality. A rate per hour was calculated for the frequencies of motor stereotypies and repetitive actions with objects in order to facilitate ease of comparison between the social and individual contexts.

4.2.3.3 Twelve-month free play session. The RBCS was used to code instances of repetitive behaviours. Independent observers coded 25% of video records and showed significant agreement for the number of repetitive behaviours observed ICC = .91, number with an object, ICC = .94 and number repetitive motor actions, ICC = .87. Despite the fact that each interactive free-play session included two, three and occasionally four infants, each participant was coded individually to ensure high accuracy. To ensure that the parametric assumption of independence was met, the repetitive behaviour data during the free play session were checked for dependencies. I conducted a linear mixed-models analysis in SPSS and ascertained that there was no significant effect of pairings on infants' use of motor stereotypies and/ or repetitive actions with objects. No dependencies were found, all scores were independent. The repetitive behaviours during the free play session were not normally distributed and therefore log transformations were used in order to improve normality. The log transformations successfully transformed all the variables. A rate per hour was calculated for *total repetitive behaviour* observed, *sum of motor stereotypies* observed and *sum of object-based repetition* observed. Descriptive data are reported and analyses were performed on the rates per hour.

4.3 Results

Means, standard deviations, and the univariate correlations between each of the behaviours assessed across the different analyses of the CCDS sample across the chapters of this thesis are presented in Appendix III.

Descriptive properties of the data analysed for this chapter are summarised in the figures below which depict the number of participants that exhibited repetitive behaviours during (1) the 6-month object exploration task (Figure 4.6), (2) the 12-month object exploration task (Figure 4.7) and (3) the 12-month free play session (Figure 4.8).

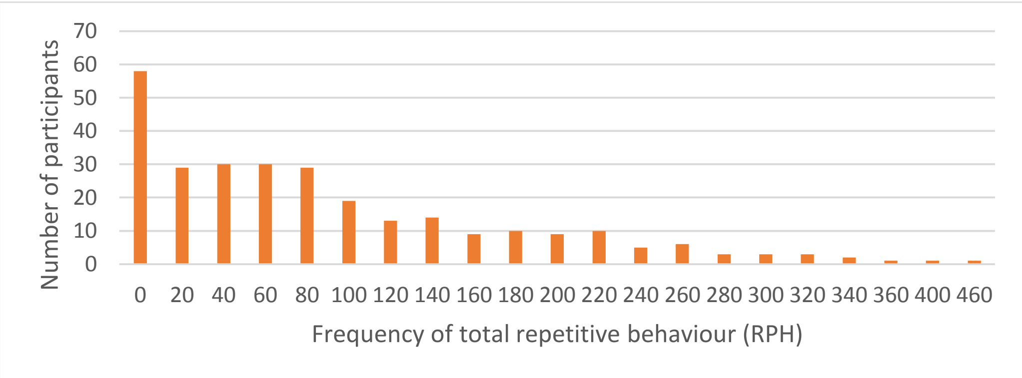

Figure 4.6 Frequency distribution of the total repetitive behaviours exhibited during 6-month object exploration

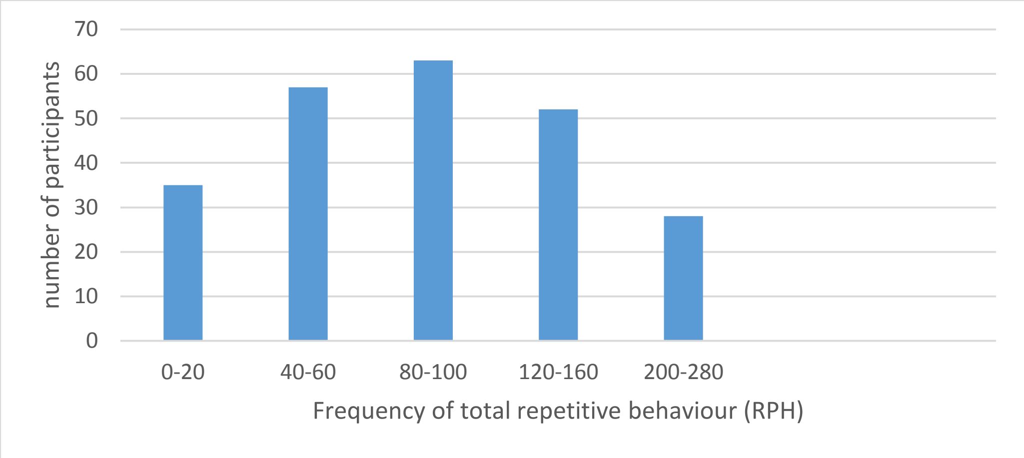

Figure 4.7 Frequency distribution of the total repetitive behaviours exhibited during 12-month object exploration task

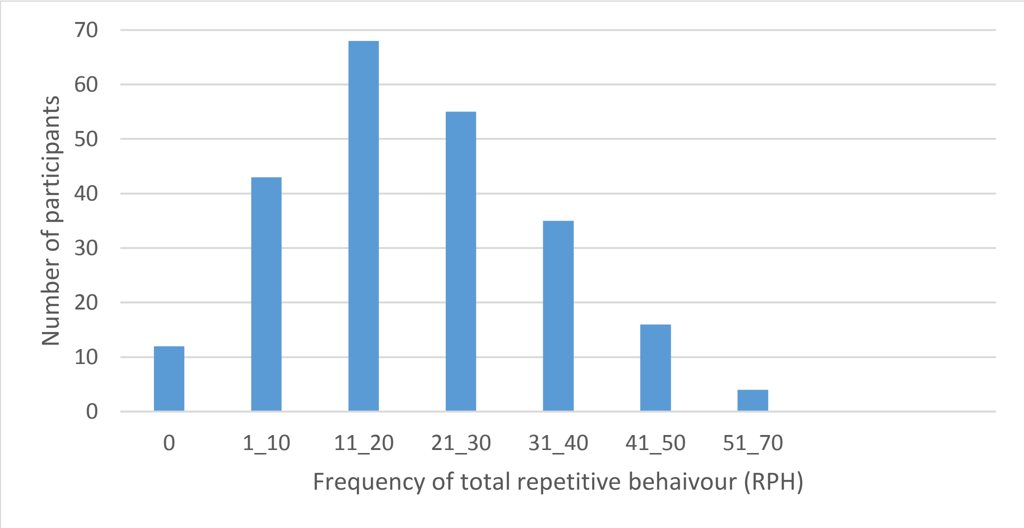

Figure 4.8 Frequency distribution of the total repetitive behaviours exhibited during 12-month free play session

4.3.1 Question 1: Age of Onset and Developmental Change

In order to address this overarching question the three questions outlined in the introduction will be examined.

4.3.1.1. Question 1A: How commonly do infants at a mean of 6 months engage in repetitive behaviours? The infants' mean age was 6.5 months (range 5 to 8 months). For the purpose of the analyses of this question, they were analysed as one group. The means and standard deviation of the number of bouts of repetitive behaviours exhibited by the infants can be seen in Table 4.2.

Table 4.2. The mean frequency per participant, the standard deviation, range and median observed bouts of motor stereotypies and repetitive actions with objects at the early infancy assessment

	Motor stereotypies	Repetitive actions with objects
Number of participants exhibiting	159 (57%)	165 (59%)
Mean frequency per participant	40.6	49.1
Standard deviation	49.1	65.7
Range	0-280	0-460
Median	20	60

Note the frequencies are based on the rate per hour.

4.3.1.2 Question 1B: In a cross-sectional comparison of infants between 5 and 8 months, do older infants show more repetitive behaviours? A clear trend emerged in a cross-sectional comparison of the infants' use of repetitive behaviours. Table 4.3 summarises the number (and percentage) of infants within each age group who engaged in the repetitive behaviours. More of the older infants engaged in the repetitive behaviours. Figure 4.9 shows the mean bouts of repetitive behaviours exhibited, as a function of age.

Table 4.3. The number (and percentage) of infants who engaged in the repetitive behaviours, as a function of their age (in months)

Age (in months)	Number of participants in each age group	Motor stereotypies N (% of infants engaged in behaviour)	Repetitive actions with objects N (% of infants engaged in behaviour)
5	40	12 (30%)	12 (30%)
6	181	109 (60%)	110 (60%)
7	48	37 (76%)	35 (73%)
8	8	7 (88%)	7 (88%)

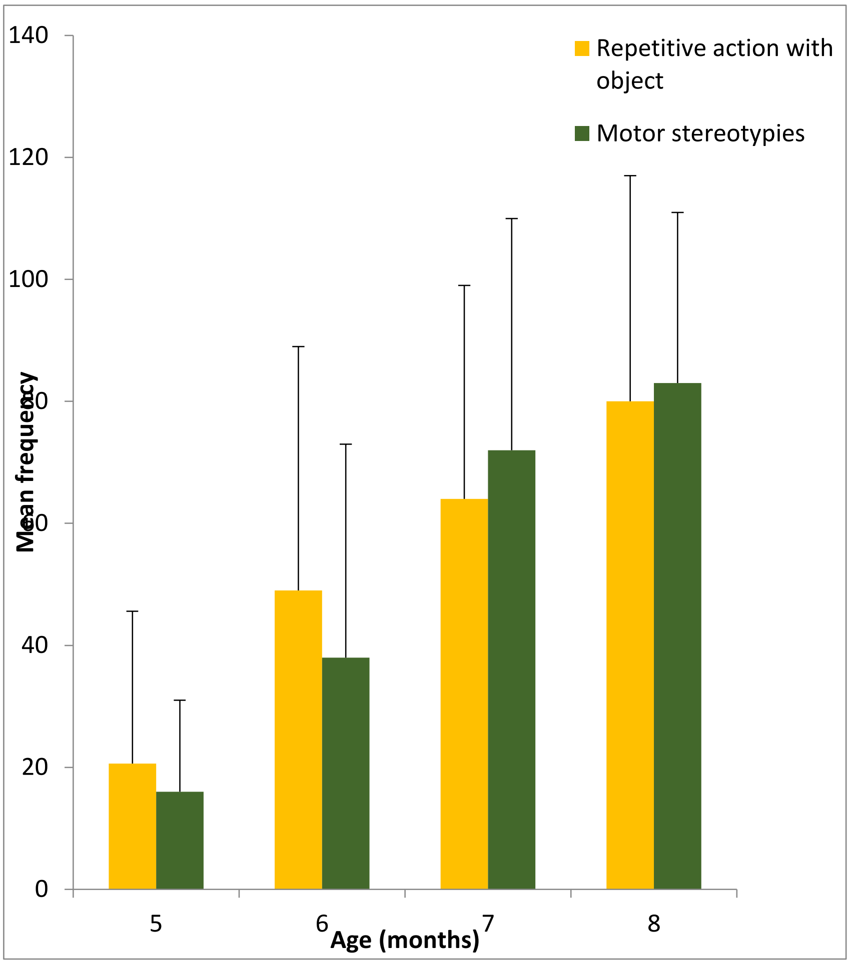

Figure 4. 9. The mean bouts of repetitive behaviours exhibited, as a function of age.

Note frequencies are based on a rate per hour.

In a Spearman correlation analysis the participant's age correlated with the frequency with which the infants engaged in motor stereotypies (r_s (280) = .27, p = .001) and the frequency with which the infants engaged in repetitive actions with objects (r_s (280) = .27, p = .001. The older infants engaged in significantly more repetitive behaviours than the younger infants.

4.3.1.3 Question 1C: Does the use of repetitive behaviour (during object exploration) increase significantly from early to later infancy? A Wilcoxon signed-rank test was used to compare the motor stereotypies and repetitive actions with objects that the infants exhibited during the individual testing session at the early (Wave 2) and late (Wave 3) infancy assessments. The infants engaged in significantly more motor stereotypies at the older age (median = 40) than when they were younger (Wave 2, early infancy assessment; median = 20), $T = 8{,}486$, $p = .018$. Consequently there is an increased use of repetition at 12 months. Despite the fact that the older infants also engaged in more repetitive actions with objects than the younger infants, this difference was not significant in the Wilcoxon signed-rank test.

4.3.2 Question 2. Are there Differences in the Rate of Repetitive Behaviour between Individual Assessment and Social Contexts?

The motor stereotypies and repetitive actions with objects exhibited during the 12- month individual assessment and during the free play context all responded to log transformations and were normally distributed. Consequently, parametric data are used to test for differences across context.

The mean number of bouts of repetitive behaviours per participant in both the individual assessment and free play contexts are presented in Figure 4.10. Two hundred and twenty-six (89.3%) of the 253 infants exhibited repetitive behaviour during the free play session. Of the 253 infants who had completed the free play session, data are available on the 243 participants for the object exploration task data. Two infants were too distressed for the task to be administered and eight videos had technical issues. During the object exploration task 71% of the infants engaged in repetitive behaviours, this is not significantly different from the 226 that exhibited repetitive behaviour during the free play.

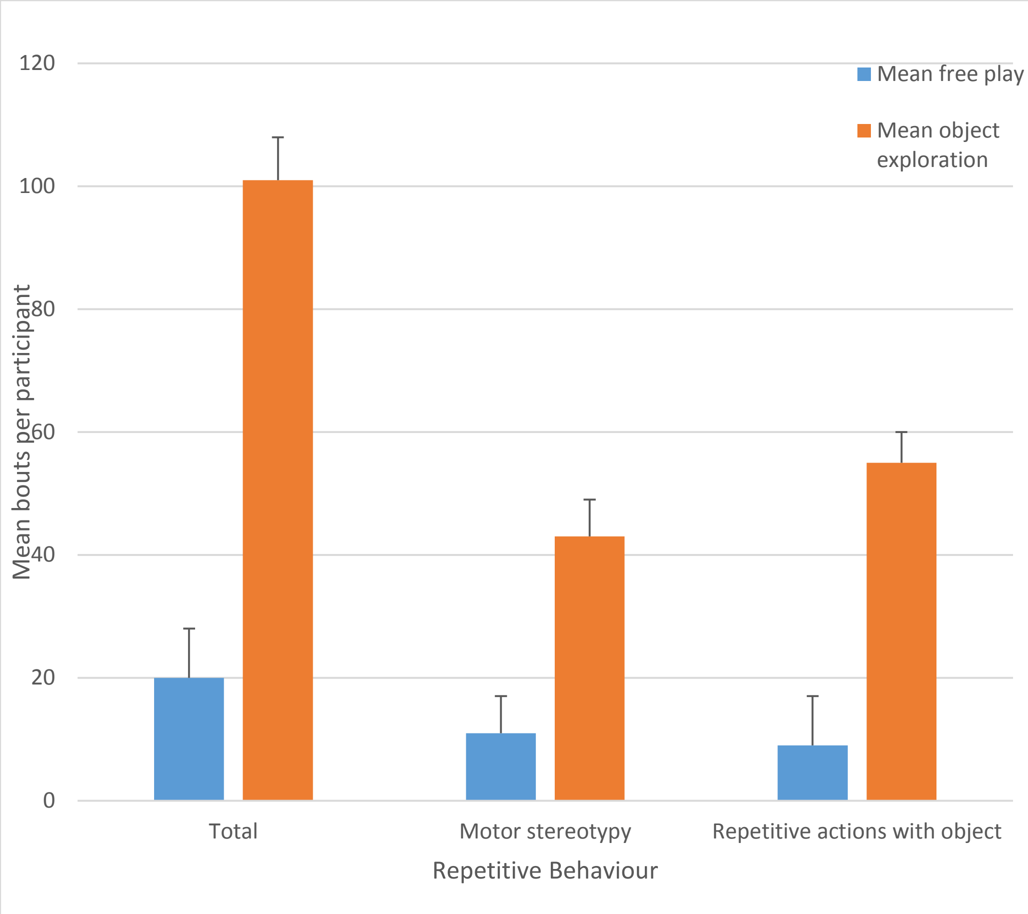

Figure 4.10. Mean bouts of repetition exhibited in older infants' free play and object exploration at the late infancy (ages 11-14 months, mean = 12 months) assessment.

Figure 4.11 shows the relative rate of each of the individual behavioural categories that are included in the RBCS. Figure 4.11a focuses on the relative rate during the free play session and Figure 4.11b focuses on the relative rate during the individual testing session. Flapping is the dominant behaviour in both contexts.

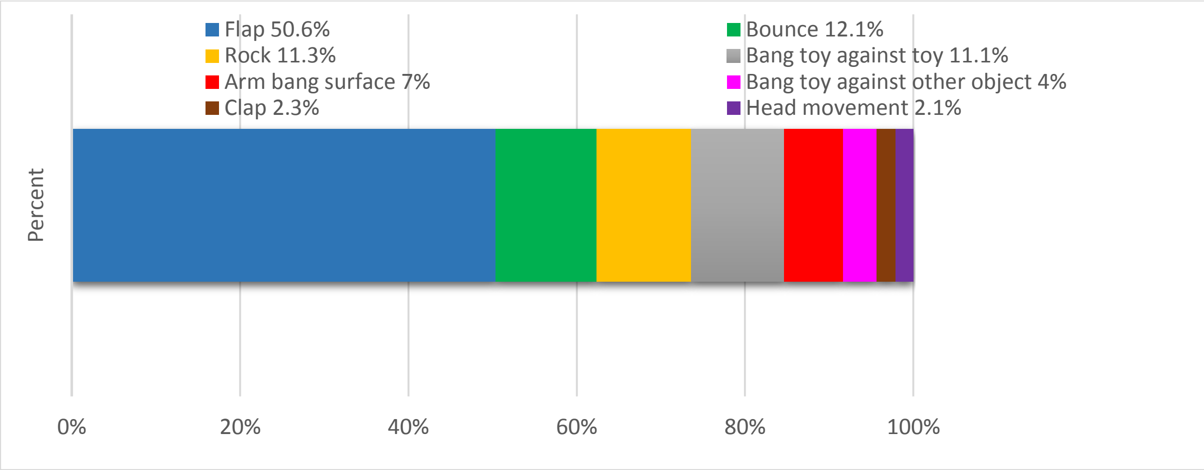

Figure 4.11a The relative rate of each behaviour category, presented as the percentage of the total repetitive behaviour. Behaviours observed during the late infancy free play session

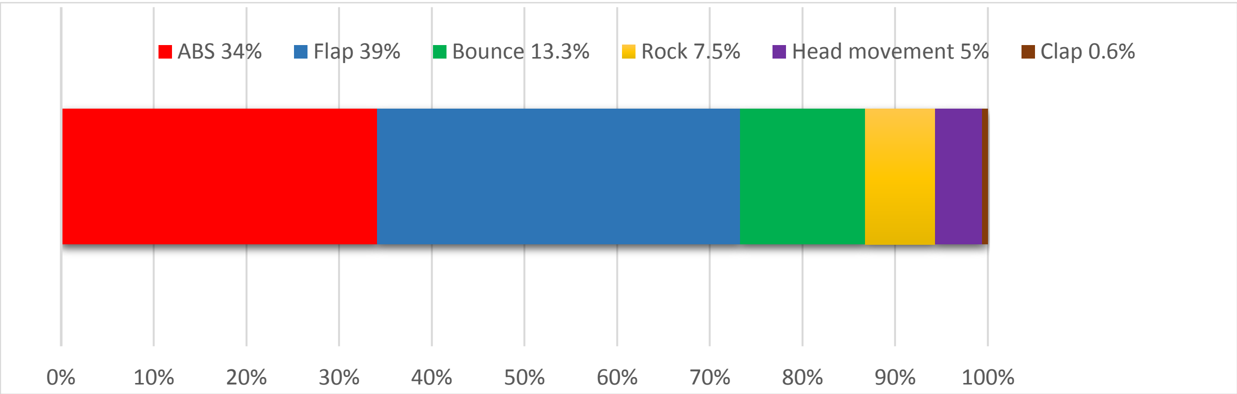

Figure 4.11b The relative rate of each behaviour category, presented as the percentage of the total repetitive behaviour. Behaviours observed during the late infancy individual testing.

4.3.3 Question 3 When in Development do Individual Differences in the use of Repetitive Behaviours First Appear?

4.3.3.1. Question 3A. Is the rate of motor stereotypies correlated with the rate of repetitive behaviours using objects at 6 and 12 months? In order to determine if it was the same infants who engaged in the two types of repetitive behaviours during the early infancy object exploration I explored the Kappa coefficient. The infants who engaged in motor stereotypies also engaged in repetitive actions with objects, Kappa value = 0.50, $p < .001$. The number of children who engaged in each type of repetitive behaviours during the 6 months object exploration task is shown in Table 4.4. In addition to the Kappa (used to determine the number of participants in each cell) I also calculated the Spearman correlation coefficient to determine whether the frequencies at which infants engage in repetition is correlated (i.e. do the participants who engage in a lot of motor stereotypies also engage in a lot of repetitive actions with objects?). The spearman correlation coefficient suggested that the frequency with which the infants showed motor stereotypies was not significantly correlated with the frequency of repetitive actions with objects, r_s (280) = .10, $p > .10$.

Table 4.4 The number of infants who engaged in motor stereotypies and repetitive actions with objects at the 6-month object exploration assessment.

		Motor stereotypies	
		Yes	No
Repetitive actions with objects	Yes	111	54
	No	48	68

To determine if it was the same infants who engaged in the two types of repetitive behaviours at age approximately 12 months, during the object exploration task I explored the Kappa coefficient. The infants who engaged in motor stereotypies also engaged in repetitive actions with objects (N=108), Kappa value = 0.60, $p < .03$. The number of children who engaged in each type of repetitive behaviours during the 12 month object exploration task is shown in Table 4.5. Within this table 17% (of the 234 participants) only engaged in repetitive actions with objects, 25% only engaged in motor stereotypies, 12% engaged in neither repetitive behaviours and 46% engaged in both types of repetitive behaviour. As such, participants who engage in one type of repetitive behaviour are likely to engage in the other type. At 12 months the Pearson correlation coefficient suggested that the frequency with which the infants showed motor stereotypies was not correlated with the frequency of repetitive actions with objects, r (234) = -.06, $p > .10$.

Table 4.5 The number of infants who engaged in motor stereotypies and repetitive actions with objects at the 12-month object exploration assessment.

		Motor stereotypies	
		Yes	No
Repetitive actions with objects	Yes	108	39
	No	59	28

4.3.3.2. Question 3B. At 12 months, is there consistency in infants' use of repetitive behaviour across the individual testing and free play contexts? As we have seen, the motor stereotypies and repetitive actions with objects were observed more frequently during the object exploration task. The rate of motor stereotypies during the free play session was significantly associated with the rate of stereotypies during individual assessment, *r* (243) = .16, *p* = .03. Furthermore, the rate of object-based repetition during the free play session was significantly associated with object repetition during individual assessment, *r* (242) = .16, *p* = .02.

4.3.3.3. Question 3C. Is there continuity in individual differences from 6 to 12 months in the use of repetitive behaviour? In order to answer this question I conducted nonparametric correlations from the 6 month object exploration task to the 12 month object exploration task. This allowed me to determine whether it was the same infants who showed more repetition across time. The Spearman correlations are shown in Table 4.6. Whilst there are significant correlations (between the frequencies at which infants engage in motor stereotypies and repetitive actions with objects) at the 6 month assessment, there were no correlations between the frequencies at the 12 month assessments and most notably there were no correlations across time. As such, engaging in frequent repetitive behaviours at 6 months does not mean that the child will engage in frequent repetition at 12 months.

Table 4.6 Spearman correlation between 6 and 12 month repetitive behaviour frequencies

	1.	2.	3.	4.
1.6 month motor stereotypy	-	.10†	.08	.02
		(281)	(215)	(215)
2.6 month repetitive action with object		-	.06	.01
			(215)	(215)
3.12 month motor stereotypy			-	-.06
				(234)
4.12 month repetitive action with object				-

† $p < .10$; n indicated in parentheses below the correlation coefficient.

4.4 Discussion

In this chapter I focused on Research Questions 1 to 3 (outlined in section 1.9, pages 41-43). I aimed to examine the frequency with which infants engaged in motor stereotypies and repetitive actions with objects during infancy, to identify the age of onset of each type of repetitive behaviour and to examine change over time. I also compared the rate of repetitive behaviour across the individual testing and free play contexts, and identified individual differences at each age.

The age of onset was examined by observing 6- month-olds during object exploration task. The observational data collected at the second wave of the nationally representative CCDS showed that approximately half of the 6-month-old infants assessed engaged in motor stereotypies and/or repetitive actions with objects, the latter of which was observed at a higher frequency. Furthermore, it was the same infants who engaged in both stereotypies and repetitive actions with objects, thus showing consistency across the different types of repetitive behaviours. In the cross-sectional analyses conducted at the early infancy assessment I found that the older infants engaged in significantly more repetitive behaviours than the younger infants. These findings corroborate those from previous research, suggesting that infants begin to engage in repetitive behaviours in the first months of life. In the longitudinal analyses I found that the individual differences were not consistent over time; the Spearman correlations suggested that those who engage in higher levels of repetition at 6 months are not necessarily engaged in elevated frequencies at 12 months.

The data collected at the late infancy assessment at 12 months corroborate the observations found for younger infants in the First Friends sample (Chapter 2). In the current chapter I found that repetitive behaviours are almost ubiquitous in the free play session and, despite the fact that fewer children exhibited the behaviour during the object exploration task, over three quarters of the sample did engage in a repetitive action. The repetitive actions with objects and motor stereotypies were observed significantly more frequently during the object exploration during the individual testing session, when compared to the free play session. Significantly more infants did engage in repetitive behaviours during the free play context but those that did engage in repetition during the individual testing did so at elevated frequencies when compared to the free play context. This can be attributed to the different context and the fact that during the individual testing the infants were continuously engaged in the object exploration, thus affording more time for the infants to engage in the repetitive behaviours. During the free play session infants were sometimes engaged in interaction and game play with the peers and caregivers but at other times they were not. This could result in less time during which infants able to engage in repetitive behaviours. However, this is only hypothetical. In order to make firm reference to the context in which repetition is used I will assess exactly what the infants are doing whilst engaged in repetition in the analyses of context in chapter 7.

With respect to Question 3, at 12 months the rate of repetitive behaviours was associated across the two contexts, thus suggesting some consistent individual differences across two settings. Importantly, the small correlation coefficient must be acknowledged here. This can be attributed to the fact that the assessments and tasks used for the analysis (i.e. the play with shape sorted and the free play session) and placed within the context of a battery of assessment. Behaviours are therefore influenced by situation specific influences and measurement variance, presumably larger correlation coefficients would be observed with more lengthy assessment. Despite this, the analysis yielded adequate power to detect effect in an effective manner.

It is also clear from the variability in each age group that there are individual differences in the rate with which infants use repetitive behaviour. Interestingly, the Spearman correlation across time (Question 3B) suggested that these individual differences are not yet consistent over time. The repetitive behaviours were not consistently frequent in the same infants at 6 and 12 months. Importantly, engagement is frequent repetitive behaviours at 6 months does not relate to frequent engagement in repetition at 12 months of age. Possible correlates that could account for these individual differences in the 11- to 14-month age range are examined in the next chapter.

Overall, the findings at this late infancy assessment support previous work by Gesell which stated that repetitive motor actions were common in infants (Gesell &Ilg, 1948; Gesell & Armatruda, 1941). The present findings also corroborate those obtained in Thelen's analysis of repetition in motor development (1979; 1980) and extend the findings of the recent questionnaire studies, which found that a range of rhythmic stereotypies were common in typically developing infants and toddlers (Arnott et al., 2010; Leekam et al., 2007).

To my knowledge, this is the only study of a nationally representative sample, using observational methods, that has completed such analyses and to this end this study has contributed to our knowledge of infants' use of motor stereotypies and repetitive actions with objects. This work carries implications for those attempting to diagnose autism in the first years of life by suggesting that motor stereotypies and repetitive actions with objects are almost ubiquitous at this age. Many of the ASD diagnostic tools observe infants during individual sessions where infants are exposed to structured and semi-structured tasks with an experimenter (Austism Diagnostic Observation Schedule; ADOS, ADOS-2 [contains a toddler module for specific use with children ages 12- to 30-months] and the AOSI). The procedures used within these diagnostic tools resembles the exploration of a novel object task during the individual testing session at Waves 2 and 3 of the CCDS.

However, the results presented within this chapter must be interpreted with caution. The object exploration task at the early and late infancy assessments were only 3 minutes in duration and the free play session at the late infancy period was only 20 minutes. These short time frames represent only a small snapshot of infants' day to day lives. Several factors may influence one's behaviours at any given time; fatigue, mood, hunger, situation or event anxiety, elated mood or temperature. An infant who is worried about the situation or an infant who is very happy could both equally engage in inflated amounts of repetitive behaviours. Ideally, longer testing sessions and subsequent duration of observation session or numerous testing sessions at a given time point would provide me with a more accurate representation of the infants' behaviours. However, this was not possible in the current study due to the number of participants observed. Additionally, when we address the question of whether infants engage in repetitive behaviours at 12 months a 3-minute task is sufficient to detect whether these behaviours are present in the infants' behavioural repertoire.

In summary, the findings presented within this chapter contribute significantly to our knowledge of infants' use of repetitive behaviours at 6 months and 12 months. I have shown that they are already part of the behavioural repertoire at 6 months, though not shown by all infants, are almost ubiquitous at 12 months and are consistent across individual and social contexts.

CHAPTER 5.

Are Individual Differences in the Use of Repetitive Behaviours in Late Infancy Associated with Age and Other Milestones in Motor and Communicative Development?

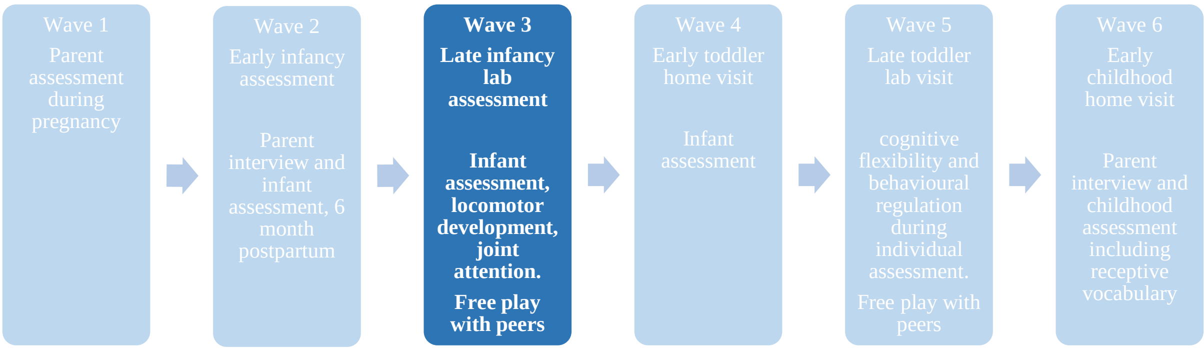

Figure 5.1 CCDS wave used within this chapter

5.1 Introduction

In the previous chapter I established that repetitive behaviours are present by six months of age and are almost ubiquitous amongst infants aged between 11 and 14 months, in the context of individual assessment. I also found that in the context of free play, the repetitive behaviours were almost ubiquitous in infants aged 9 to 14 months (Chapters 2 and 4). The use of repetitive behaviours transcended contexts. Significant individual differences in the rates at which infants engaged in both motor stereotypies and repetitive actions with objects were revealed in both contexts. The aim of this chapter is to explore further the individual differences in rate of repetitive behaviour seen in the Late Infancy age range in the CCDS sample to identify factors that are associated with relatively low or high rates of repetition. This chapter thus addresses the second part of Research Question 3 (section 1.9): *Are the individual differences in the use of repetitive behaviour associated with other milestones in motor and communicative development?* I also begin to address Research Question 4 (section 1.9): *Is there a normative decline in the use of repetitive behaviour from 12 months onward?*

Repetitive behaviours such as motor stereotypies and repetitive actions with objects have previously been conceptualised as developmentally immature behavioural responses (Leekam et al., 2011). Consequently, I will explore whether the repetitive behaviour at 12 months is related to maturational indicators such as infant chronological age, locomotor development and infant communication through joint attention. I decided to focus on locomotion and joint attention because they are developmentally appropriate key skills that begin to come in to the behavioural repertoire within this age range.

5.1.1 Does Infants' Use of Repetitive Behaviour Begin to Decline as Infants Enter their Second Year of Life?

Development is about continuity and change over time. Thus, a central question for developmental psychologists is how best to conceptualize the passing of time and the factors that accompany it. "In the first year of life, when motor action is less under voluntary control, motor stereotypies are relatively high in frequency" (Leekam et al., 2011 p.579). However, at the end of the first year, repetitive behaviours become more varied and infants' actions become more goal-directed and thus fewer instances of stereotypies and repetitive actions with objects may be seen (Leekam et al., 2011). It is possible that a decline in repetitive behaviour is already taking place shortly after the first birthday. For example, in a large British community sample, only about half of infants were reported to be using repetitive motor actions by 15 months of age (Arnott et al., 2010). Parents' reports thus indicate that repetitive behaviour is a part of typical development which starts to decline in the second year of life. This implies that as infants acquire more motor and communicative skills, they will exhibit less repetitive behaviour. However, it is important to supplement the questionnaire studies with direct observational evidence for the hypothesised decline. In this chapter I will explore whether the proposed decline in the use of motor stereotypies and repetitive actions with objects can be observed in infants aged between 11 and 14 months.

5.1.2 Repetitive Behaviours and Motor Maturation

In the literature review (in Chapter 1) I discussed the literature that related motor stereotypies and motor development fully. Briefly, investigators of motor development have previously suggested that repetitive behaviours were common in healthy, well-adjusted infants (Gesell & Armatruda, 1941). Repetitive motor behaviours are associated with particular stages of neuromuscular maturation; they represent a period of development that is more mature than spontaneous movement but less mature than voluntary, goal-directed behaviour (Gesell and Ilg, 1948; Gesell and Armatruda, 1941). Although initially driven by endogenous neural mechanisms (Thelen, 1980, 1981), the repetitive behaviours themselves have an impact on the developmental system, creating a developmental transformation in the organisation of behaviours.

Motor stereotypies amongst typically developing children symbolise periods where neuromuscular co-ordinations (such as the flexions, extensions or rotations) are most apparent (Thelen, 1981). The implications of Thelen's account are that repetitive behaviours have a systemic effect on development that go beyond the behaviours themselves and may be related to other aspects of development such as communication, language and social interaction (Iverson & Fagan, 2004; Iverson & Wozniak, 2007). To this end, repetitive behaviours may peak and then begin to reduce as infants acquire more advanced skills (such as locomotion and social communication). In this chapter I have therefore examined possible motor correlates of repetitive behaviour in this age range.

5.1.3 Repetitive Behaviours and Social Communicative Abilities

The present study focused on infants' joint attention (JA) abilities as an important component of early social interaction and as an early precursor to language acquisition (language is assessed in Chapter 7). Joint attention is one of the critical precursors to social learning in human development and it is defined as the ability to selectively attend to an object of mutual interest (Roberts et al., 2013). This joint attention skill develops when infants learn to use several social cues, such as gaze direction, pointing, and postural cues, that all indicate to an observer which object is currently under consideration. These abilities, collectively named mechanisms of joint attention, are vital to the normal development of social skills in children. Joint attention is a mechanism for allowing infants to acquire knowledge and skills to interact within and use their environment. They further allow the infant to manipulate the behaviour of their caregiver and thus provide a basis for more complex forms of social communication such as language and gestures (e.g. pointing). Joint attention has been investigated by researchers in a variety of fields. Specifically, experts in child development are interested in these skills as part of the normal developmental process that infants acquire extremely rapidly, and in a stereotyped sequence (Scaife & Bruner 1975).

Observations of joint attention behaviours provide important information about the development of mental processes in infancy that are critical to subsequent aspects of human social and cognitive development (e.g., Mundy & Sigman, 2006; Tomasello, Carpenter, Call, Behne, & Moll, 2005). This hypothesis has been supported by numerous studies that indicate that individual differences in joint attention skills among infants are related to subsequent language and cognitive development (e.g., Adamson et al., 2004; Bates, 1975; Carpenter et al., 1998; Delgado et al., 2002; Mundy & Gomes, 1998; Smith & Ulvund, 2003; Tomasello & Todd, 1983). Thus, the developmental continuity between infant joint attention and early childhood social and cognitive abilities is reasonably well supported in the literature.

The ability to engage in JA emerges gradually over the first year of life and requires shared attention, following the attention of another and directing the attention of another by pointing, for example. The development of the joint attention skill seemingly begins in the first part of their first year and becomes stronger through to the first birthday, at which point the skill is used interactively in order to allow the infant to engage more with their social world and communicate with others. Between 3 and 6 months of age, infants begin to follow other people's gaze. Infants' gaze following develops gradually from 3 months to 9 months or age, at which point this early communicative skill is seen as more robust (Butterworth, 2004; D'Entremont, 2000; De Groote, Roeyers & Striano, 2007; Perra & Gattis, 2010). Between 6 and 18 months of age, infants gradually spend more time engaged in coordinated attention (Adamson & Bakeman, 1985), this new and developing interest allows the infant to achieve the triadic coordination (between partner, object and self) required to maintain JA.

Simultaneously, during the first eighteen months of life, infants acquire and refine a whole set of new motor skills that significantly change the way in which the body moves and interacts with the environment (e.g. crawling and then walking allows the infants to become active participants within their environment). It is argued that motor development can provide infants with an opportunity to practice skills relevant to communication before they are needed for that purpose (Iverson, 2010), skills such as joint attention. Similarly, early motor stereotypies and repetitive action with objects develop early in the first year (see Chapter 4) and become more frequent until they peak at the end of the infants' first year (Arnott et al., 2010; Leekam et al., 2007; Thelen, 1979). Are these improvements in infants' motor development (repetitive behaviours and locomotor skill) and socio-communicative skills coincidental or are they functionally related? It is possible that the developing behaviours follow a parallel time course alternatively the improvements may be functionally related such that advances in one area support advances in another. The emergence of new motor skills changes infants' experience with objects and people in ways that are relevant for general communicative development. One could propose that as part of the developing motor system arm flapping allows the infants to practice the specific arm movement and control required for gesturing and pointing. Bouncing could be a means of initiating interaction by attracting the social-partners attention or banging could be a means of initiating joint attention by showing an object to the social partner. Demonstration of a link between these two developmental skills would not necessarily imply that one has a direct effect on the other. In this chapter I will explore the relationship between the developmentally appropriate early form of communication, joint attention, and the repetitive behaviours.

5.1.4 Aim of the Current Chapter

Within this chapter I will focus on the repetitive behaviour exhibited during the free play session only. This is because the free play session closely resembles the social situations and challenges that infants are confronted with on a day to day basis and this has a higher level of ecological validity. Repetition of motor actions and operations on objects is an important activity whereby infants can coordinate their actions with those of a peer (Goldman & Ross, 1978; Eckerman, Davis & Didow, 1989), and so the peer setting is one in which a variety of repetitive behaviours are likely to be observed. In this chapter I will assesses individual differences in repetitive behaviours in the context of free play session with unfamiliar peers. The study thus addresses Research Questions 3 and 4 (see section 1.9).

1. In cross-sectional analyses of infants in the late infancy age range (11 to 14 months), do older infants exhibit less repetitive behaviour?
2. Are infants with advanced locomotor development more/ less likely to use repetitive behaviours during free play?
3. Is joint attention associated with repetitive behaviours during free play?

5.2 Method

5.2.1 Participants

The analyses reported in this chapter were conducted on all of the children of the CCDS that attended the laboratory free play session at the late infancy visit (N = 253). A brief overview of the CCDS is in Figure 5.1, the full description of the study is in Chapter 3. The same 253 children were assessed in Chapter 4; the reasons for attrition and demographic characteristics of this subsample are reported in section 4.2.1.2 (Pg. 107).

5.2.2 Procedure

The overall procedure for Wave 3 (Late Infancy assessment) of the CCDS was described in Chapter 3. Briefly, at the late infancy assessment, when participants were approximately 12 months olds (range 11-14 months), infants and their caregivers were invited to the laboratory. Three infants were invited to attend the laboratory session at the same time. Upon arrival, infant and caregiver pairs (in 90% of the cases it was the mother who came to the laboratory session) were escorted to an individual testing room and assessed individually, in the presence of their caregiver, and were administered a battery of socio-cognitive tasks. For the purpose of the current chapter, I focused on joint attention as a developmentally appropriate measure of infants' communication skills. A video camera was placed in one corner of the room.

5.2.2.1 Joint attention task. The JA task, based on a modified version of the Responding to Joint Attention (RJA) task from the Early Social Communication Scales (Mundy, Delago, Block, Venezia, Hogan & Seibert, 2003) was divided into four trials (see also Roberts, Fyfield, Baibazarova, vanGoozen, Culling & Hay, 2013). In each trial the experimenter ensured that the infant was looking at him or her, before s/he looked at and pointed towards one of four posters for 6 seconds. The order in which the experimenter pointed to each poster was counter-balanced across participants. The experimenter pointed with his or her index finger whilst holding the arm next to the torso. During each trial, the experimenter called out the infant's name three consecutive times, before moving on to the next poster. Data are available on 236 (93%) of the 253 participants. Fourteen of the infants did not complete the task as they arrived late for the testing session and three of the infants could not be scored due to poor camera angles or the infant moving out of the view of the camera.

5.2.2.2 Free play paradigm. After the individual testing session was completed, infants (and their accompanying caregivers) were then observed together during a simulated birthday party. After a range of socio-emotional challenges had been presented to the infants the three families were asked to remain in the testing room for a further 20 minutes to allow observation of free play. The analyses of repetitive behaviour were undertaken using video records of this free play setting.

5.2.3 Measures

Both observation and questionnaire measures were used, details of which are described below.

5.2.3.1 Joint attention. Video records of the infant's response during the JA task were scored using frame by frame observation of where the infant was looking, whether the infant was pointing and in which direction (i.e., to which target poster or other area of the room). This enabled precise measurement on the infant's Gaze Following (GF) of the experimenter's gaze and point, Gaze Alternation (between the target poster and the experimenter/ caregiver) and pointing (PT) behaviour during the task. Operational definitions are presented in Table 5.1 Independent observers coded 20% of the video records, identifying GF, GA and PT with excellent agreement (Kappa coefficients ranging from .92 to .95).

Table 5.1 Coding Definitions for the Joint Attention Task.

Element Name	Definition	Scoring Criteria
Gaze Following	Looking at the location where the experimenter is looking and pointing	2 For looking at the correct poster 1 for looking in the correct direction (but not at the poster) 0 for looking in the wrong direction, looking at the experimenter or looking away
Gaze Alternation	Looking at a target, and then immediately looking at the experimenter	1 For looking at and object and then looking at the experimenter 0 For the absence of the above
Protodeclarative Pointing	Pointing somewhere using the index finger	1 For each point made by the infant. Where the infant pointed to was also noted from a defined choice: the correct target (poster), correct direction but wrong target, wrong direction, wrong target, experimenter, caregiver, away/ other Note: If the infant seemed to be pointing, but using his/ her hand, this was noted separately, but not considered in the current analysis

5.2.3.2 Infants' locomotor development. The accompanying caregivers (90% of whom were mothers) were asked to complete a questionnaire during the laboratory visit (the CCDSMSQ, see Hay, Perra, Hudson, Walters, Mundy, Phillips et al., 2010). Within the 38 items CCDSMSQ, 12 age-appropriate items derived from developmental norms established for the Bayley Scales of Motor Development were used to measure infants' motor development. The caregiver rated each item on a scale from 0 to 2, the scores signifying 'not yet' in the infant's repertoire; 'sometimes present' or 'definitely present'. Items included were '*has crawled on hands and knees', 'can pull up to a standing position while holding onto a piece of furniture', 'has taken two steps', 'can stand up without using support', 'can stand alone without support for at least 2 seconds', 'can walk when supported by an adult or piece of furniture', 'can walk for at least 3 steps without support', 'can walk independently for at least 5 steps with good co-ordination and balance', 'can walk backwards for at least 2 steps', 'can stand on 1 leg', 'can walk up at least 2 steps with help', 'can walk down at least 2 steps with help'.* A total score was calculated whereby higher scores were indicative of those with more advanced locomotor development.

5.2.3.3 Repetitive behaviours. The Repetitive Behaviour Coding Scheme (RBCS) was used to record repetitive behaviours during the free play session. These are the same data that were coded and analysed in Chapter 4, section 4.2.3.3.

5.2.4 Data Analysis

Within the context of the joint attention task, infants' frequency of pointing required transformation but measures of gaze following and gaze alternation did not. Square-root transformation of the frequency of pointing was used in subsequent analysis. The different elements of JA were examined to determine whether they correlated sufficiently to be regarded as reflecting one underlying construct (Cronbach & Meehl, 1955). Each element (gaze following, gaze alternation and pointing) correlated significantly with each other, indicating that they were measures of the same underlying construct. A principal components analysis designed to extract a single factor was conducted on gaze following, gaze alternation and pointing. The resulting factor score accounted for 68.5% of the variance (see Roberts, Fyfield, et al., 2013). The joint attention factor score was used in subsequent analyses.

5.3 Results

In preliminary analyses I found that there were no significant differences between boys and girls, and so subsequent analyses are conducted on the whole sample. The univariate associations between all of the behaviours assessed for this chapter can be seen in Table 5.2.

Table 5.2 Correlations between the repetitive behaviours during the late infancy free play, and infants' age, locomotor development and joint attention skills.

	1	2	3	4	5	N	Mean	SD
1.Motor stereotypies	-	.25***	-.25***	-.14*	-.30***	253	11.21	12.7
2.Object repetition		-	-.15*	-.05	-.03	253	8.96	10.59
3. Locomotor maturity			-	.15	.41***	240	13.90	6.42
4. Joint attention				-	.22**	236	.81	.59
5.Age					-	253	12.67	.99

Note. * indicates p < .05, ** indicates that p < .01, *** indicates that p < *.001*.
Correlations are based on the repetitive behaviours rates per hour.

N = number of participants for which data are available; SD = standard deviation. The mean and standard deviation presented for the joint attention task are based on the gaze following measure; the joint attention factor score was used in parametric analyses

5.3.1 In Cross-Sectional Analyses, do Older Infants Engage in Fewer Repetitive Behaviours?

I conducted a cross-sectional comparison in order to assess whether the older infants engaged in fewer instances of motor stereotypies and repetitive actions with objects. The mean bouts of motor stereotypies and repetitive actions with objects exhibited by infants in each age group are illustrated in Figure 5.2, with the number of participants at 11 months n= 32, 12 months n = 90, 13 months n = 66, 14 months n = 65. In the Pearson analysis, age was assessed in days. For the purpose of illustration, in Figure 5.2 age is rounded to the nearest month). The Pearson correlation coefficients representing the association between age and repetitive behaviours are presented in Table 5.2. The older children engaged in fewer instances of motor stereotypies but did not engage in fewer instances repetitive actions with objects.

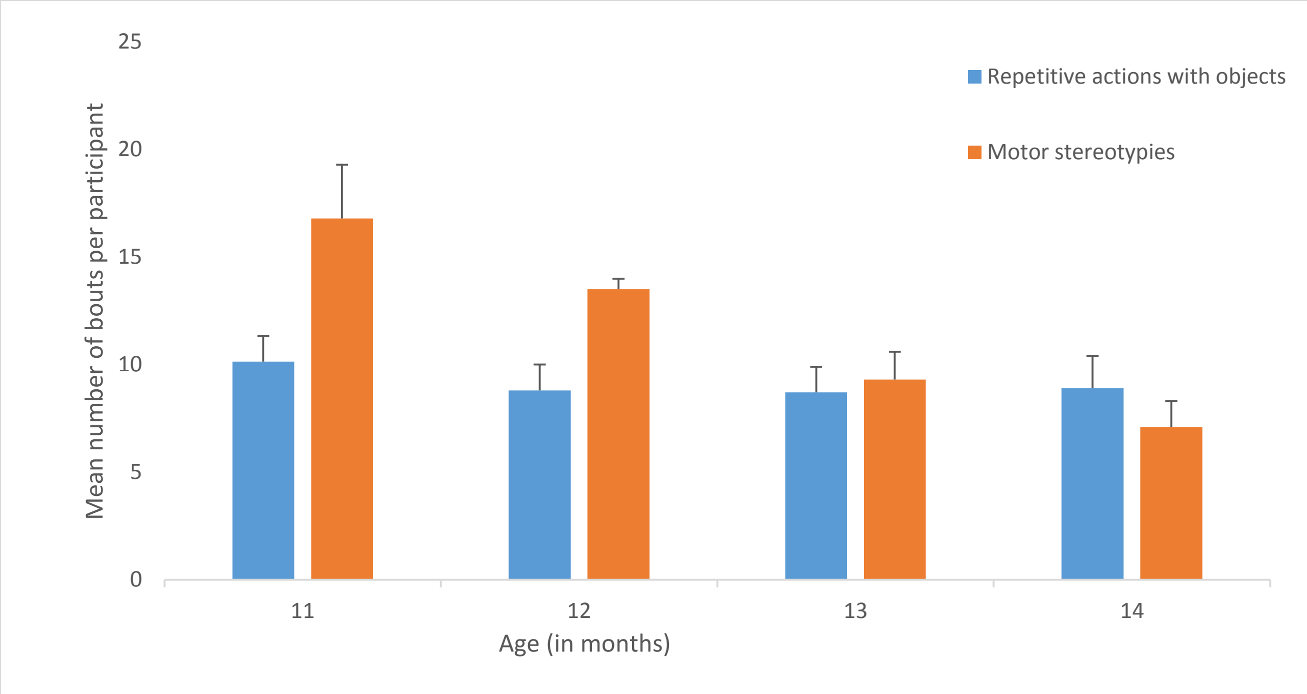

Figure 5.2. The mean bouts exhibited during the free play session by infants within each age group, frequencies are based on rates per hour.

5.3.2 Are Infants with Advanced Locomotor Development Less Likely to Use Repetitive Behaviours?

The Pearson correlations between locomotion and the repetitive behaviours are summarised in Table 5.2. I conducted a linear regression to investigate the relationship between infants' locomotion and motor stereotypies. Because the infant's age was a significant predictor of motor stereotypies, it was entered as a control variable at the first step of the regression model. Chronological age accounted for 5.9% of the variation in the frequency with which infants engaged in motor stereotypies (F (1,239) = 15.02, $p < .001$, Adjusted $R^2 = .06$, β= -.30. At the second step of the regression, locomotor maturity accounted for a further 2.9% of the variance, and significantly predicted to infants' use of motor stereotypies after controlling for chronological age, F (2,238) = 11.28, $p < .01$, $\Delta R^2 = .08$, $\beta = -.18$.

I conducted a second linear regression to investigate the relationship between infants' locomotion and repetitive actions with objects. Chronological age was again entered as a control variable at the first step of the regression model. Chronological age accounted for 2.8% of the variance and did not predict to repetitive actions with objects. At the second step of the regression, locomotor maturity accounted for a further 1% of the variance and was not associated with the frequency with which infants engaged in repetitive actions with objects. Thus infants with more advanced locomotor skills were less likely to use motor stereotypies, only.

5.3.3 Is Joint Attention Associated with Repetitive Behaviour?

I assessed infants' social and communicative skills by examining their ability to engage in a joint attention task. The Pearson correlations are reported in Table 5.2. Infants' ability to engage in joint attention with an experimenter was significantly associated with the frequency with which they engaged in motor stereotypies. To test whether the repetitive behaviours might be linked to JA when chronological age was controlled for, two multiple regression analyses were performed, with infant's age entered at the first step and the joint attention factor score entered at the second. The infant's age was a significant predictor of motor stereotypies but when joint attention was entered at the second step, it was no longer a significant predictor of motor stereotypies.

5.4 Discussion

The overarching aim of this chapter was to examine the individual differences in the frequencies of observed motor stereotypies and repetitive actions with object. This was done by examining the behavioural correlates of the repetitive behaviours. Possible correlates were sought in two domains: motor maturation and social-communicative development. Exploring the behavioural correlates of repetitive behaviour facilitates understanding of its developmental functions. Within this chapter I found that the infants with more advanced motor development were less likely to exhibit motor stereotypies. Those who crawled exhibited significantly more repetitive behaviours than those who could stand alone, and infants who could stand exhibited significantly more repetitive motor actions than those who could walk. The repetitive behaviours therefore represent a period of development that is more mature than spontaneous movement but less mature than voluntary, goal-directed action (McGraw, 1941, 1943). These findings corroborate with those previously published by Esther Thelen (see Thelen, 1979, 1980, 1981).

During the free play session at the third wave of assessment I conducted cross-sectional analysis and I found that the older infants engaged in significantly fewer motor stereotypies than younger infants. This trend was not echoed with the repetitive actions with objects. Thus this cross-sectional evidence is compatible with the proposal of a normative decline in repetitive motor actions over the second year of life. However, the test of that hypothesis requires longitudinal analysis (see Chapter 6).

The infants' ability to engage in joint attention did not predict their use of repetitive behaviours. Interestingly, there was no relationship between this early form of communication and the motor stereotypies and repetitive actions with objects. In terms of the ASDs my findings contradict those highlighted in previous work. Interestingly, the participants assessed within this chapter did not have poorer joint attention skills. Joint attention is often seen as a precursor to later socio-communicative skills such as language and thus I will explore the association between repetitive actions and communicative skills in the same children (from the CCDS) when they are older (see Chapter 7).

Infants engaged in a wide range of repetitive actions using objects that are also seen in children diagnosed with ASD. Unlike repetitive motor actions, the pattern of repetitive actions using objects was not related to maturational level, thus suggesting that the two forms of repetitive behaviour are subject to different influences. The infants exhibited repetitive actions using objects at the same frequencies (regardless of their chronological age or levels of motor and social development). The repetitive actions on objects cannot be said to be meaningfully related to maturational level. The implications of these findings will be discussed further in Chapter 8.

CHAPTER 6.

Does the Use of Repetitive Behaviours Decline from 12 Months Onward: Evidence from Longitudinal Analyses

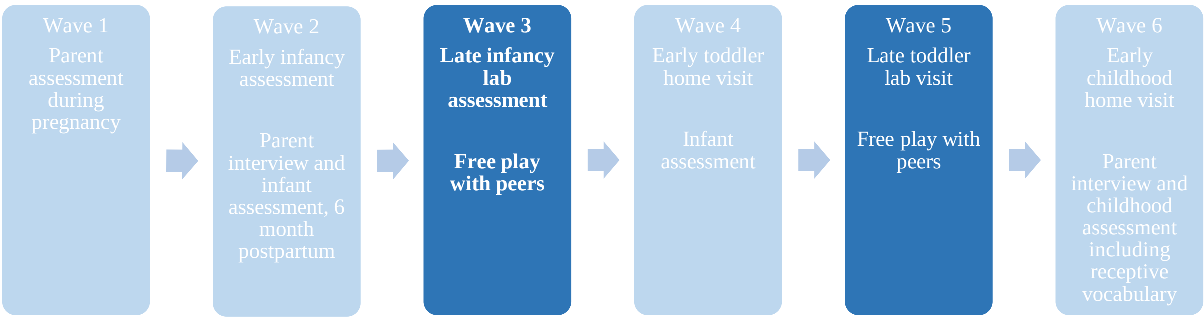

Figure 6.1 CCDS Waves used within this chapter.

6.1 Introduction

In this chapter, I address Research Question 4 (outlined initially in section 1.9), i.e., whether repetitive behaviour declines from 12 months onward, with longitudinal analyses of the CCDS sample. The findings of the previous chapters suggest that motor stereotypies and repetitive actions on objects are important features of development. During their first years the infants demonstrated a large amount and variety of these repetitive behaviours and they were almost ubiquitous in the first 14 months of life (Thelen, 1979, Fyfield, Leekam & Hay 2011; 2013). In cross-sectional comparisons at the Early Infancy assessment (Wave 2, range 5 to 8 months), I found that older infants were significantly *more* likely to engage in repetitive behaviour (Chapter 4). In contrast, in cross-sectional comparisons older infants (Wave 3, range 11 to 14 months) were significantly *less* likely than younger infants to use motor stereotypies during free play with peers (Chapter 5). Taken together with the findings from the First Friends sample reported in Chapter 2, it would seem that the frequency of repetitive behaviour rises from 6 to 12 months and may then begin to decline over the second year of life. However, a clear test of that developmental hypothesis requires longitudinal analysis of the same children.

Developmental theorists have argued that the motor stereotypies and repetitive actions on objects give way to higher level repetitive behaviours such as a compulsive need for sameness at approximately two years (Evans et al., 1997; Turner, 1997). Research with toddlers focuses primarily on such higher level repetitive behaviours (Ames, Ilg & Frances, 1976, Gesell, 1928, Gesell, Ames &Ilg, 1974). Consequently there is a paucity of empirical information regarding the continuity or change in repetitive behaviours such as motor stereotypies and repetitive actions with objects from infancy to toddler age, particularly within community samples. Important questions remain unanswered, such as the frequency of repetition during the toddler years, the continuity from infancy to toddlerhood and the number of children who engage in repetitive behaviours. Gaining a clear understanding of the frequency with which these repetitive behaviours are still used by toddlers is important in order to understand what degree of change occurs during the early years and how common these behaviours are in the toddler age range. It is also imperative to determine if there is any continuity in the use of repetition from infancy to toddler years, particularly in the context of early screening and diagnoses of ASDs. It is important to examine the potential for repetitive behaviour to change across time in order to generate developmental norms to compare to atypical trajectories. This chapter therefore aims to examine both continuity and change in motor stereotypies and repetitive actions on objects from the infancy to toddler period by using a longitudinal design. Relevant data are drawn from the late infancy and late toddler assessments of the CCDS (see Chapter 3), the protocol for the 20 minute free play session being identical at both time points.

6.1.1 Previous Research Suggests a Decline in the Use of Repetitive Behaviours

Relatively few empirical studies have examined repetitive behaviours longitudinally from infancy to the toddler years. In a cross-sectional analysis using parents' reports of 1,492 typically developing children aged between 8 and 72 months, Evans and colleagues (1997) examined the developmental trajectory of different types of repetitive and restricted behaviours. The authors used the Childhood Routines Inventory (CRI). The CRI measured frequency, onset and current engagement in compulsive-behaviours across participants. The CRI measures two constructs: just-right behaviours (which included behaviours such as 'prefers to have things done in a particular order or in a certain way') and repetitive behaviour/insistence on sameness (which included such behaviours as 'repeats certain actions over and over'). Over 60% of the children aged 24 to 35 months engaged in behaviours consistent with the repetitive behaviour/ insistence on sameness construct. Fewer children engaged in such behaviours after the age of 3 years. Children aged between 12 and 47 months exhibited significantly more behaviours consistent with the repetitive behaviour/ insistence on sameness construct than children younger than 12 months or older than 60 months. The results confirm that repetitive behaviours are commonly seen amongst toddlers and young children and that 'higher level' repetition might peak in the third year of life, followed by a reduction in the use of repetitive behaviour.

However, care must be taken when interpreting these results because of the cross-sectional design. Additionally, the behaviours were measured by parental report, not direct observation, and therefore subjective interpretations of behaviours may be present. In this thesis, I employ an observation method to record the motor stereotypies and repetitive action with objects. This method ensures that behaviours exhibited by each participant are measures using identical criteria and definitions and thus are not subjected to informants' interpretations of behaviours. Furthermore, the construct labelled as repetitive behaviour/ insistence on sameness included several items that address not only the motor stereotypies but also 'prefers the same household schedule or routine every day'. Consequently it is not clear how many participants engaged in the motor stereotypies and repetitive actions on objects. Further investigation is required to examine how many toddlers engage in these lower level behaviours and to examine the continuity and change in the use of them over time.

In another study employing a group comparison design, Werry and colleagues (1983) asked caregivers of 156 children between the ages of 3 and 59 months to complete an unstandardized questionnaire. Amongst other behaviours, the authors looked at prevalence of motor stereotypies. Instances of rocking and head banging were recorded. Motor stereotypies were still apparent in preschool children. Werry and colleagues (1983) did not look at change over time; the design of their study was cross-sectional. However, despite the limitations of the cross-sectional designs, both Werry and colleagues (1983) and Evans and colleagues (1997) provide a first step to estimating how common motor stereotypies and repetitive actions with objects are in toddlers.

As part of a larger longitudinal study of a community sample in North East England, the Teeside Baby Study, Leekam and colleagues did report changes in repetitive behaviours over time in their community sample of children aged 15 months (Arnott et al., 2010) and 2 years (Leekam et al., 2007) . Their data were collected using the Repetitive Behaviour

Questionnaire (RBQ-2; see Leekam et al., 2007), a 20 item questionnaire designed to record repetitive behaviours known to occur in children with ASD, but which also occur in typically developing children. When the participants were 15 months old, the mothers of 139 infants completed the RBQ-2 (Arnott et al., 2010). When the participants were in their third year of life (aged between 24 and 36 months) the mothers of 678 children completed the RBQ-2 (Leekam et al., 2007). The repetitive behaviours were common across a range of types (motor, sensory, routines, interests) at both time points. At 15 months, 89% of the sample fiddled repetitively with toys, 68% rocked and 67% exhibited hand and finger mannerisms (Arnott et al., 2010). At 2 years, 57% of the sample fiddled repetitively with toys, 20% rocked and 31% exhibited hand and finger mannerisms (Leekam et al., 2007). Although no direct comparisons were made, the two papers taken together suggest that some motor stereotypies and repetitive action on objects continue to exist amongst 2-year-old children. As the 15 month old and the 2 year old data were published separately, it is unclear how many of the participants were seen at both time points and thus comparisons between the two papers must be made with caution. These studies supplement Evans and colleagues' cross-sectional study of repetition by assessing the same participants over time. Unfortunately, the RBQ does not distinguish between those children who *never* and *rarely* engage in a behaviour so we are unable to conclude how many individuals engage in repetitive behaviours. Within this chapter I will supplement the questionnaire studies with direct observation of the frequency of repetitive behaviour and also identify those toddlers who do engage in repetition versus those who do not.

Recently, Wolff and colleagues (2014) conducted a longitudinal study assessing the course of repetitive behaviours in toddlers at low and high risk for autism. The caregivers of 250 children completed the Repetitive Behaviour Scale (RBS-R); a 43 item parent report consisting of six subscales designed to assess repetitive behaviours (Bodfish, Symons & Lewis, 1999). One of the subscales was behavioural stereotypies. Of the 250 participants, 149 were high risk without autism (siblings of those with autism but no present diagnosis themselves), 41 were high risk autism (siblings of those with autism and a present diagnosis themselves) and 60 were low risk (sibling of a child without autism). The caregivers completed the RBS-R at two time points, when their infants were 12 and 24 months old. There were no significant changes over time in the frequency with which infants engaged in the behavioural stereotypies. This suggests that the duration between the assessment points needs to be large enough to detect longitudinal change in repetitive behaviours. To my knowledge, the study by Wolff and colleagues is the first published study that has used observation as well as parents' reports to assess change from 12 months onward in the same participants and thus the absence of significant change in motor stereotypies over this period is noteworthy.

Since I began this thesis, another recently published study, also using a longitudinal design, has contributed significantly towards our understanding of the early presentation of motor stereotypies and repetitive actions with objects. Harrop and colleagues (2014) used observational methods to measure infants and toddlers' use of repetitive behaviours during a free play session. It was only one child that was present during the play session. Harrop and colleagues assessed two groups of children: a group of 49 children who were on average 45 months old and had been diagnosed with an ASD and a group of 44 24-month-old children who had been matched with the first group according to their nonverbal development. The children within the latter group had no diagnoses. The participants had been assessed upon entry to the study, 7 months post entry and 13 months post entry. This short term longitudinal study assessed repetition in a play context, as well as children's language skills. There was no significant main effect of time on the frequency of repetitive behaviours observed. Additionally, there was no significant interaction between group and time point. It is possible that 13 months is not a sufficient time frame in which to observe statistically significant change in either group. There were no significant differences between the time points. The design of this study suggests that a free play context using observation method is ideal to study naturally occurring repetition. I aim to use this same design, within the context of the Cardiff Child Development Study, in this chapter.

I aim to supplement the longitudinal work carried out in these studies (Wolff et al, 2014; Harrop et al., 2014) by assessing the members of a representative community sample at two time points, approximately 21 months apart (the Late Infancy and Late Toddler assessments of the CCDS; see Chapter 3). This should allow for sufficient development to take place in order to detect longitudinal change. In the cross-sectional analyses in Chapter 5 I found that the older infants engaged in significantly fewer instances of motor stereotypies than younger infants. This trend was not echoed with the repetitive actions with objects. Thus this cross-sectional evidence is compatible with the proposal of a normative decline in repetitive motor actions over the second year of life (e.g. Thelen, 1979), but only for motor stereotypies. However, a test of that hypothesis requires longitudinal analysis. Within this chapter I will examine whether this proposed decline is evident across both categories of repetitive behaviour, using the longer time interval from a mean of 12 to a mean of 33 months. The observation method employed ensures that all behaviours are measures consistently and are therefore not subjected to bias or subjective interpretation.

6.1.2 Aims of the Chapter

The aim of the present chapter is to address Question 4 by examining the occurrence of motor stereotypies and repetitive actions with objects at a mean of 12 months and again at a mean of 33 months to establish patterns of change over time. The children of the Cardiff Child Development Study were assessed longitudinally in the same laboratory setting, using the same protocol at 12 months and 33 months of age. This longitudinal design allows for the detection of continuity in individual differences as well as the pattern of change over time. The following specific questions are asked:

1) Will fewer children engage in repetitive behaviours at 33 than at 12 months?

2) Will the children exhibit fewer instances of repetitive behaviour on average at 33 than at 12 months?

3) Is there continuity in individual differences in the use of repetitive behaviours from 12 to 33 months?

4) Are there any children who exhibit repetitive behaviours at 33 months but not at 12 months? Are there children who exhibit repetitive behaviours more frequently at 33 than at 12 months?

6.2 Method

6.2.1 Participants

As in Chapters 4 and 5, the analyses reported in this chapter derive from longitudinal observations of the children of the Cardiff Child Development Study (CCDS). Two hundred and ten infants were assessed at both late infancy (Wave 3) and late toddler (Wave 5). Figure 6.2 explains the reasons for attrition from the original sample recruited in pregnancy. The mean age of the participants at the late infancy assessment was 12.73 months (range = 11 to 16 months) and the mean age at late toddler assessment was 33.64 months (range = 29 to 41 months). Ninety-two of the participants were female and 118 were male. The participants' demographic characteristics do not differ significantly from those of the original sample. All of the participants who attended both laboratory assessments were included in this chapter; no exclusion criteria were used.

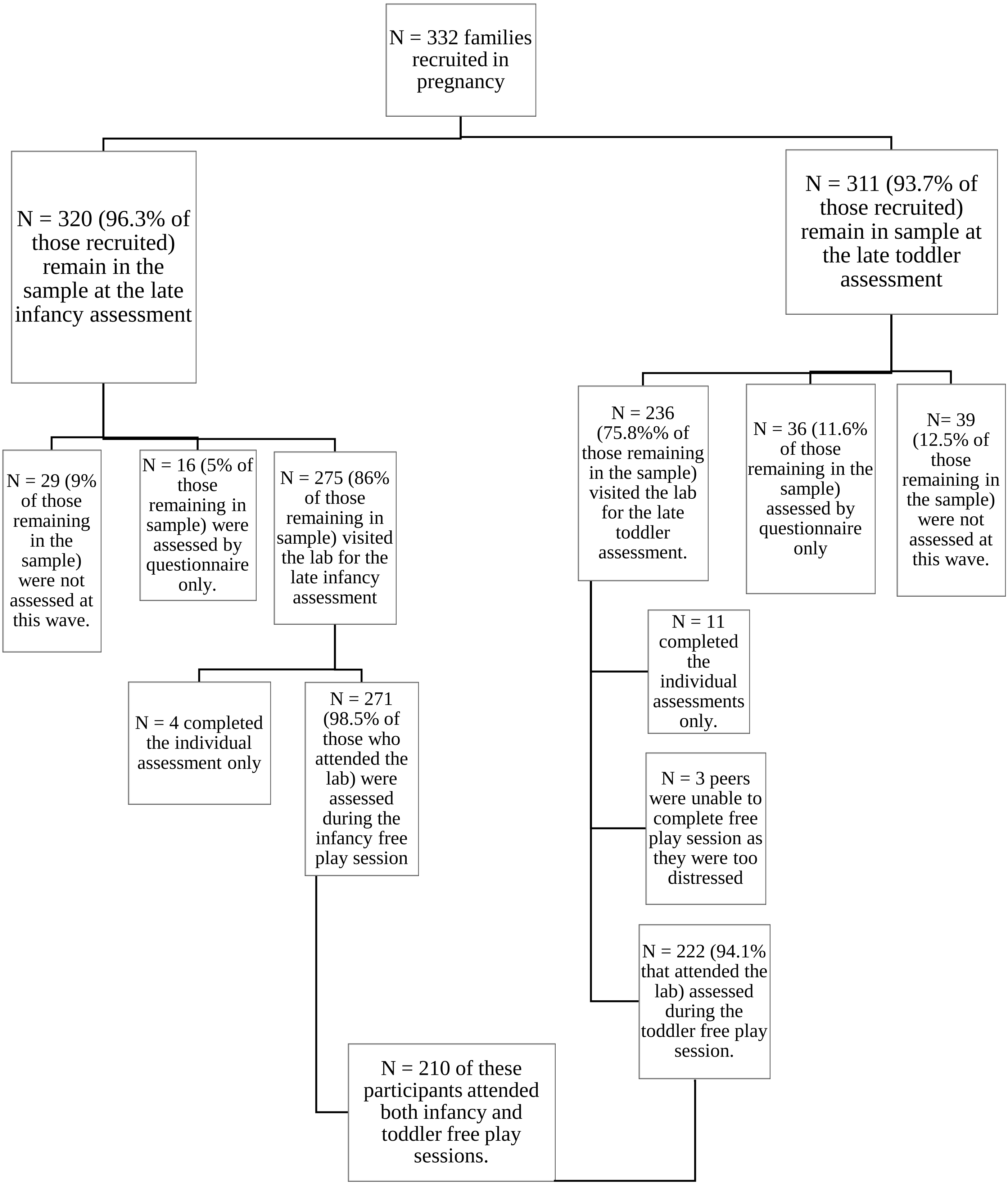

Figure 6.2. Progression of the sample from recruitment to the 210 participants assessed in this chapter

6.2.2 Procedure

The procedures for both the late infancy and late toddler assessments are described in detail in Chapter 3 (sections 3.3.3 and 3.3.5, pages 93 and 95, respectively). The protocol administered at both assessments was the same. Three families were invited to the laboratory on the same afternoon. Due to cancellations and rescheduled visits, two to four children might be seen on the same occasion. A caregiver attended the laboratory session with each child. Following a 30 minute individual assessment consisting of a battery of social-cognitive assessments, the families were invited to enter a sitting room and take part in a simulated birthday party. This consisted of a 3 minute Teddy Bears Picnic scenario designed as an emotional challenge (see Waters et al., 2013).   Following this, participants completed a 20 minute free play period. For the purpose of the analyses conducted within this chapter, the observations were derived from the identical 20 minute free play interaction sessions at both the late infant and late toddler assessments.

During the free play period, the attending caregivers were provided with the same instructions at both time points (i.e., to act naturally and to respond to their infants naturally, as they would at a friend's house or at a birthday party). The assessments took place in the same laboratory, with the same furniture at both time points, but age-appropriate toys were provided on each occasion.

6.2.3 Measure

The RBCS developed in Chapter 2 was used to code all observed instances of motor stereotypies and repetitive actions with objects during the free play sessions. Four observers identified episodes of repetition which are subdivided to repetitive operations on objects and motor stereotypies. Operational definitions are seen in Table 2.2. Behaviours were defined as repetitive when the movement of a part of the body was repeated in the same form, at least three times consecutively within a five second period. Observers timed the duration of each episode by noting down the onset and offset times as defined in the RBCS. The observers also transcribed the behaviour using a set of predetermined criteria (flap, bounce, rock, head movement, arm bang surface, clap, and bang toy against toy or another object). Observers noted whether the behaviour occurred with or without an object and noted the number of repeated actions per episode. Independent observers coded 25% of video records during the infancy assessment and 25% of the video records of the toddler assessment. Agreement was established for the infancy videos (median *ICC* = .92) and for the toddler videos (median *ICC* = .94).

Due to cancellations and rescheduled visits, two, three and sometimes four peers were present in the peer session. The repetitive behaviour data at both assessments were therefore checked for dependencies using SPSS linear mixed-models analysis. There was no significant effect of the pairings with particular peers in the observation session on the infants' or toddlers' engagement in repetitive behaviours. In subsequent analyses, all scores are therefore treated as independent observations. Due to the fact that a different number of peers were present in the parties, I conducted a one way ANOVA to determine if the number of participants present at a peer session had an impact on the frequency of the repetitive behaviours exhibited. During infancy, it did not have an impact on motor stereotypies ($p > .10$) or repetitive actions with object ($p > .90$) Similarly, during the toddler assessment the number of participants present did not have an impact on the motor stereotypies ($p > .90$) or repetitive actions with object ($p > .10$).

6.2.4 Data Preparation and Analyses

Both the late infancy and late toddler free play peer session was designed to last 20 minutes. Sometimes the infants and toddlers were out of the view of the camera (i.e. to use the bathroom or hiding behind a sofa). In cases where this was longer than 5 seconds, coders noted the duration of time (in seconds) that the participant was out of the view of the camera. The total duration of time spent out of view was calculated at the end of the coding session. When the duration of time in view was less than 19 minutes, the observed behaviour was pro-rated to 20 minutes, thus resulting in equivalent data for each of the participants.

For ease of comparison with other research and in order to compare the descriptive information with that presented in Chapters 2 and 4, measures of repetitive behaviour derived from the RBCS (total repetitive behaviour, motor repetitions and object-based repetitions) were converted to rates per hour. A rate per hour was also calculated for the individual behavioural categories (flapping, bouncing, rocking, head movements, clapping, and banging).

6.3 Results

Using a two 2 x 2 ANOVA test it was determined that there was no significant interaction between the change over time in motor stereotypies or repetitive actions with objects and the participants' gender. Subsequently analyses were conducted on the full sample.

6.3.1 Will Fewer Participants Engage in Repetitive Behaviours at the Late Toddler Assessment than the Late Infancy Assessment) and Spend Less Time in Repetition?

As we have seen in Chapter 3, repetitive behaviour was commonly shown at 12 months. In the present sample tested at both ages, 88.6% engaged in motor stereotypies or repetitive actions on objects at 12 months. When the participants were observed again at a mean of 33 months, only 38.1% exhibited motor stereotypies or repetitive actions on objects. Table 6.1 shows that fewer participants engage in each of the different behavioural categories during their toddler assessment, although some forms show more of a decline over time.

The onset and end time of each bout of repetition and the amount of time engaged in repetition was calculated. When the participants were observed in late infancy, they spent on average 6% of their time engaged in bouts of repetition. One participant spent almost 41% of his time engaged in repetition at the 12-month assessment. When the same participants were observed again at the late toddler assessment, on average they spent only 0.01% of their time engaged in bouts of repetition. No participant spent more than 0.06% of time engaged in repetition at the 33-month assessment and thus more variation was recorded at the 12 month assessment.

Table 6.1 The Percentage of Participants Exhibiting each Behaviour Category During the Late Infancy and Late Toddler Assessments.

Behavioural category	Late infancy (12m) assessment % of infants engaging in behaviour	Late toddler (33m) assessment % of infants engaging in behaviour
Flap	75.5	20.5
Bounce	37.5	7
Rock	35	5.5
Head movement	11.5	1.5
Clap	8	0
Bang toy against a toy	31.5	9.5
Bang toy against other	14	6
ABS	22.5	4.5

Note. ABS = Arm banging against a surface.

6.3.2 Will the Participants Exhibit Fewer Bouts of Repetitive Behaviours When they are Toddlers?

The mean, standard error during late infancy and late toddler assessments are in Figure 6.3.

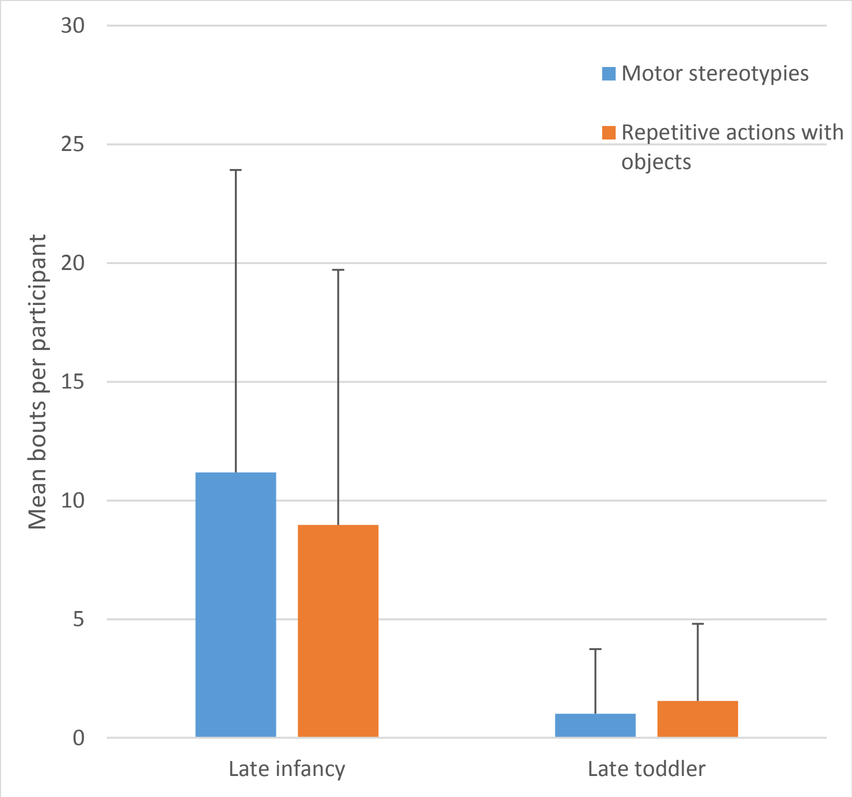

Figure 6.3. Mean and standard error of observed motor stereotypies and repeated actions on objects at the 12- and 33-month assessments.

Repeated measures analysis of variance tests were used to determine whether the observed decline in repetitive behaviours over time was significant. Participants engaged in significantly fewer bouts of motor stereotypies at 33 than at 12 months, F (1,199) = 128.00, $p < .001$, $\omega^2 = .40$. Furthermore, the participants engaged in significantly fewer bouts of repetitive actions on objects at 33 than at 12 months, F (1,199) = 89.39, $p < .001$, $\omega^2 = .3$

6.3.3 Is there Continuity in Individual Differences in the use of Repetitive Behaviours from 12 to 33 Months?

Pearson's correlation coefficients were used to test for continuity of individual differences in the mean rate of repetitive behaviours from 12 to 33 months, against the background of the general decline in repetitive behaviour over that time period. No significant associations were found (Table 6.2). Indeed, it was not the same infants who were engaging in high frequencies of repetitive behaviours at the two assessment points. Kappa coefficients were used to test whether if it was the same participants who engaged in repetition at both assessment points. A Kappa coefficient of 1 suggests that it is exactly the same participants who engaged in repetition and a Kappa coefficient of 0 suggests that none of the participants who engaged in repetition at infancy/ toddler also engaged in repetition at another assessment. The Kappa coefficient for engagement in motor stereotypies in infancy and toddler years was 0. The analogous Kappa value for the repetitive actions with objects at 12 and 33 months was 0.03. In general, there are consistent individual differences at each assessment point but no individual differences that are stable over time.

Table 6.2 Correlation coefficients for the infancy and toddler repetitive behaviours.

	1	2	3	4
1.Infant motor stereotypies	-	.25***	.07	.04
2.Infant repetitive actions with objects		-	.04	.05
3.Toddler motor stereotypies			-	.27***
4.Toddler repetitive actions with objects				-

N = 210. Note ** indicates < .01

6.3.4 Which Children Engage in Repetitive Behaviours at 33 but not at 12 months?

Some participants who had not exhibited repetitive behaviours during the infant assessment did so during the toddler assessment. Ten (4.7%) of the participants had not shown any motor stereotypies during the infancy assessment but did so at the toddler assessment and a further four (1.9%) of the participants showed a higher rate of stereotypies during their toddler assessment.

Fourteen (6.6%) of the participants had not shown any repetitive actions with objects in the infancy assessment but did so at the toddler assessment, and a further five (2.3%) of the participants showed a higher amount of repetitive actions with objects during the toddler assessment. There were only two participants (1%) who had not shown either type of repetitive behaviour at 12 months but did engage in both stereotypies and repetitive actions with objects at 33 months. Thus, despite the general trend for a decline in repetitive behaviour over time, some participants were more likely to engage in repetitive behaviours at the toddler assessment. Table 6.3 shows the number of participants that engaged in motor stereotypies at infancy and toddler assessments whilst Table 6.4 shows the number of participants that engaged in repetitive actions with objects.

Table 6.3 Cross tabulation of the infancy and toddler motor stereotypies

		Toddler assessment (33 months)	
		Yes	No
Infancy assessment	Yes	30	130
(12 months)	No	10	40

Table 6.4 Cross tabulation of the infancy and toddler repetitive actions with objects

		Toddler assessment (33 months)	
		Yes	No
Infancy assessment	Yes	45	96
(12 months)	No	14	55

6.4 Discussion

The aim of this chapter was to examine whether motor stereotypies and repetitive actions on objects declined from the infancy to toddler age. I used the Repetitive Behaviour Coding Scheme (RBCS) to code observed bouts of motor stereotypies and repetitive actions on objects in 210 children of the Cardiff Child Developmental Study. The longitudinal design allowed the same participants to be observed in the same social context, in the same room at two time points: during late infancy (Wave 3 of the CCDS, mean age 12 months) and late toddler age (Wave 5 of the CCDS, mean age 33 months). To my knowledge this is the largest study of repetitive behaviours in a community sample that has assessed the participants longitudinally using observational methods. In doing this, I was able to assess both continuity and change in repetitive behaviours over time. Assessing the change allowed me to determine the degree to which change is possible from infancy to toddler age whilst assessing continuity of individual differences over time.

6.4.1 Summary of the Findings

Fewer participants exhibited motor stereotypies and repetitive actions with objects when they were toddlers. Three quarters of the children who had exhibited motor stereotypies during infancy did not exhibit any stereotypies during the late toddler assessment. Two thirds of the children who had exhibited repetitive actions with objects during infancy did not exhibit any during the toddler assessment. This dramatic reduction represents a large change in repetitive behaviours from infancy to toddler years. To my knowledge, this is the first study that has quantified the longitudinal change in repetitive behaviours from infancy to toddler age. The participants spent much less time engaged in repetition when they were toddlers and used repetitive behaviour at much lower rates. Both motor stereotypies and the repetitive actions on objects declined over time.

Follow up analyses found that all of the behaviour categories of the RBCS had reduced from the infancy to toddler age. Despite this significant reduction in the number of participants exhibiting repetitive behaviour, the time spent engaged in repetitive behaviours and the number of repetitive bouts recorded, over a third of the sample was still engaging in repetitive behaviours as toddlers. Some participants who had shown no repetitive behaviour in infancy did so during the toddler assessment. Within the next chapter I will examine the differences between these participants and the ones who had stopped using repetitive behaviours.

6.4.2 How do the Results Relate to Other Research?

The findings extend the work of Evans and colleagues (1997) and Leekam and colleagues (2007) who found that a declining number of toddlers showed motor stereotypies. In the Teeside Baby Study (Leekam et al., 2007; Arnott et al., 2010), when caregivers of 15-month-old infants and 2-year-old children reported instances of repetitive behaviours using the RBQ-2 there was a 22% reduction in the instances of repetitive fiddling with toys, a 47.5% reduction in the instances of rocking and 35.5% reduction in the reported instances of repetitive hand and finger mannerisms. It is noteworthy that the original published articles did not compare their findings. In order to obtain this difference I compared the descriptive results that Arnott and colleagues (2010) provided for the subsample of 15-month-old infants and the descriptive data that Leekam and colleagues (2007) provided for the 2-year-old children. Neither Arnott & colleagues (2010) nor Leekam and colleagues (2007) compared the frequencies at each age. Furthermore, the sample size was different in the two studies, it is unclear how many of the children were seen at both time points. Significantly more 2 years olds were assessed (Leekam et al., 2007).

However, these figures can be compared with the children of the Cardiff Child Development Study who showed a 49.5% reduction in instances of repetitive actions on objects, a 29.5% reduction in the observed instances of rocking and a 54.5% reduction in the observed rate of flapping (which nonetheless remained the most commonly occurring behaviour at 33 months). The findings reported in this chapter complement the findings from parents' reports by showing that, when the definition of repetitive movements is operationalised in the RCBS, a significant reduction is still apparent.

6.4.3 Conclusion

This current study makes an important and unique contribution to the literature by investigating motor stereotypies and repetitive actions on objects in an observational study of young children when they were infants and toddlers. The normative decline seen from infancy to toddler age is likely to coincide developmentally with increasing voluntary control of motor and goal-driven behaviours. Noteworthy is the range of repetitive behaviours observed in the children. The change in the type of repetitive behaviour seen in typically developing children has been previously been attributed to cognitive maturation (Piaget, 1952) and the development of emotions and social communication (Berkson, 1983; Evans et al., 1997). In view of those claims, the occurrence of the repetitive behaviours in over a third of the sample suggests further questions. Do the participants who continue to use repetitive behaviours differ from the rest of the sample? Do the participants who engaged in repetitive behaviours during the toddler assessment only differ from the rest of the sample? What are the correlates of repetitive behaviour at the toddler age? The next chapter will examine these questions.

CHAPTER 7.

Does the Continued Use of Repetitive Behaviours at 33 Months Relate to Children's Activity Levels, Inhibitory Control or Socio-Communicative Skills?

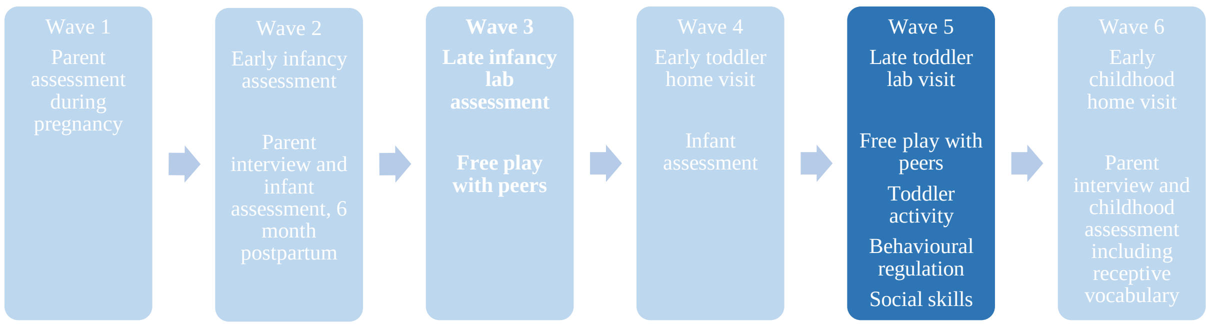

Figure 7.1 CCDS Wave used in this chapter

7.1 Introduction

In the previous chapters I established that the repetitive behaviours assessed in this thesis are almost ubiquitous in infancy. Despite a significant decrease in the number of participants engaging in repetitive behaviours between 12 and 33 months, 38% of the 210 participants assessed longitudinally still exhibited at least one form of motor stereotypy or repetitive action on an object during the free play session at the late toddler assessment. The main aim of this chapter is to examine the differences between those who stopped engaging in repetitive behaviours in that setting and those who have not stopped. I focused on exploring the differences in toddlers' behavioural regulation and cognitive flexibility, their activity levels and their ADHD symptoms, and the toddlers' social and communicative skills. Identifying such differences is essential to place repetitive behaviours at this age in a broader developmental context. Furthermore, repetitive behaviours can fulfil different functions over time (Thelen, 1981; Troster, 1994). In order to determine the potential role that the repetitive behaviours may play in children's social interactions I will also examine whether the observed repetitive behaviours took place within the context of episodes of interaction with unfamiliar peers.

7.1.1 Repetitive Behaviours and Executive Functioning

As discussed in the literature in Chapter 1, executive functions are a set of cognitive skills that are associated with the frontal lobe and involve tasks such as planning and executing, inhibition, attention shifting and cognitive flexibility (Lewis & Kim, 2009). They are essential for adaptation to novel and unfamiliar circumstances, and thus are relatively inactive when executing well-learned behaviours and familiar routines (Walsh & Darby, 1999). In section 1.4.2 (Pg. 13) I outlined theories and empirical examples that have assessed executive function impairment and poor control of behaviour in relation to elevated use of repetitive behaviours. Lopez and colleagues (2005) for example, found that three dimensions of executive function (cognitive flexibility, working memory and response inhibition) were associated with repetitive behaviours. Executive function deficits have been implicated in the presence of repetitive behaviours; individuals who engage in higher frequencies of repetitive behaviours have poorer executive function skills (Barber, 2008, unpublished thesis).

In terms of research into ASDs, impairments in behavioural regulation, control, and inhibition have been implicated in motor stereotypies and repetitive actions with objects (Turner 1997, 1999). Turner (1997, 1999), proposed two separate hypotheses, one relating to an inability to inhibit ongoing behavior and another related to an inability to generate novel behavior. Over a decade of research has not been able to fully substantiate either hypothesis. There have been mixed results concerning evidence for executive dysfunction, with a number of variables including type of tests used, child age, overall cognitive ability and language facility significantly modifying results in assessment tasks. Turner (1999) suggested that executive dysfunction explains the rigidity and invariance seen in repetitive behaviours, proposing that an inability to appropriately regulate behaviours limits variability of movements and actions resulting in repetition and restricted behaviours.

Turner's (1999) principle may be applied to community samples of children. Immaturity of the executive system in preschool children might result in repetitive behaviours as the children adhere to over-learned behaviours (Tregay, Gilmour & Charman, 2009). An inability to think flexibly by switching attention and shifting between strategies, difficulties in generating new behavioural patterns and ways of exploring objects or lack of inhibitory control could all result in rigid or repetitive patterns of behaviour such as motor stereotypies (Tregay et al., 2009). However, there is relatively little evidence for this. The majority of the published examples refer to the relationship between executive dysfunction and repetitive behaviours in adults or children diagnosed with an ASD. Little empirical information exists that has specifically examined this link in a community sample of children, most of whom will not be diagnosed with an ASD. By taking a broader developmental perspective, Leekam and colleagues (2011) state that it is "unlikely that EF could have a direct causal role since repetitive behaviours emerge so early in typical development, hence it may be more appropriate to consider the effect of repetitive behaviours on neurocognitive functioning, than any causal role" (p. 578). It seems that the question is not whether there is a clear causal role but whether the decline is partly accounted for by the development of better inhibitory control in this time period.

In one example of such research, Evans and Iobst (2003 as cited in Evans et al., 2004) explored the role of inhibition and cognitive flexibility in repetitive behaviours. A community sample of children aged six to 11 years completed a series of computer-generated tasks designed to examine the executive function constructs of motor suppression, response inhibition and cognitive flexibility. The participants' parents completed the Childhood Routines Inventory (CRI, Evans et al., 1997) which was described fully in Chapters 2 and 6. The CRI repetitive behaviour factor score was predicted by a combination of poor cognitive flexibility and response inhibition (Evans et al., 2004). Readers must note that the repetitive factor score from the CRI includes items relating to the motor stereotypies and repetitive actions on objects assessed in this chapter but also includes questions relating to children's insistence on sameness. This suggests that a relationship does exist between cognitive flexibility, response inhibition and CRI repetitive behaviour but it is unclear how much of this is attributable to insistence on sameness. Further examination is therefore required.

The association between repetitive behaviours and three aspects of executive functioning (cognitive flexibility, response inhibition and generativity of words within 60 seconds) was also examined by Tregay and colleagues (2009). A community sample consisting of 78 children aged between 37 and 107 months was recruited for the study. Children completed several executive function tasks (card sorting test, Luria hand game and category fluency) and their parents completed the CRI. Cognitive flexibility (but not response inhibition or generativity) was most strongly associated with repetitive behaviour factor score of the CRI. The younger (< 67.5 months) children's repetitive behaviour score was significantly associated with their cognitive flexibility. Higher rates of repetitive behaviours were associated with higher error rate on the card sort task, thus indicative of poorer cognitive flexibility. As noted previously, the CRI repetitive behaviour factor score also includes questions regarding insistence on sameness. Consequently, conclusions must be drawn cautiously.

Inflexible thought and behaviour could conceivably underpin the repetitive behaviours where difficulties disengaging from a particular mode of thinking could result in both the repetition of familiar over-learned patterns of behaviours such as motor stereotypies or repetitive actions with objects. Compared to infants, toddlers are more able to inhibit their behavioural responses and think flexibly. During this same developmental period, I have already documented a significant decline in the use of repetitive behaviours. These two seemingly independent behaviours are changing in parallel; as executive function abilities increase, repetitive behaviour is declining. It is therefore possible that the same developmental process (i.e. maturation of the prefrontal cortex) might underlie both phenomena. It may therefore be useful to consider the effect of neurocognitive functioning on repetitive behaviours and consider if toddlers *who are less able to inhibit their behaviours are more likely to engage in repetitive behaviours*. I will examine whether those toddlers who show less mature behavioural regulation abilities are more likely to engage in motor stereotypies and repetitive actions with objects.

7.1.2 Repetitive Behaviours and Toddlers' Activity Levels

Children's increasing inhibitory control abilities allow them to regulate their attention and activity. At the toddler age, repetitive behaviour could possibly reflect one sort of unregulated activity. Activity level is a dimension of temperament that varies amongst children but high rates of activity are symptomatic of ADHD. The repetitive behaviours assessed within this thesis, specifically repetitive motor actions with and without objects, are one of the more common forms of hyperkinetic movement disorders in childhood (Srinivasan & Mink, 2012). Although commonly associated with autism and other developmental disorders, they are also seen in many children with no other neurologic disorders. The association between elevated movement and repetitive behaviours have largely been studied in terms of symptomatology relating to ADHD and ASD.

In one empirical example Mahone and colleagues (2004) characterised the clinical features and associated problems for children with complex motor stereotypies. The authors reviewed the medical records of 40 children aged between 9 months and 17 years, all of whom had been diagnosed with complex motor stereotypies. Associated disorders and behaviours were determined by review of patient history (i.e. the diagnosis had been made by another provider using DSM-IV criteria). A diagnosis of ADHD was confirmed by using the ADHD Rating Scale and the Conners Parent Rating Scale. Ten (25%) children in the sample met the criteria for ADHD and thus a total of 25% had comorbid attention deficit hyperactivity disorder (Mahone et al., 2004). This suggests that repetitive behaviours seen in children are associated with symptoms associated with ADHD. However, the authors do not describe which symptom domain in ADHD was associated with repetitive movements and thus more detailed examinations are required.

In other work, the relationships between repetitive behaviours and associated clinical features were examined in two groups (high nonverbal IQ ≥ 97 versus low nonverbal IQ ≤ 56) of children with autism spectrum disorders (n = 14; mean age = 10 years, 7 months). For the group as a whole, nonverbal cognitive ability (NVIQ), adaptive functioning level, the presence of sleep problems, and three scales of the Aberrant Behavior Checklist (ABC) (Irritability, Lethargy, and Hyperactivity) were highly correlated with total repetitive behaviour scores on the Repetitive Behavior Scale-Revised (RBS-R). After controlling for NVIQ, adaptive level, sleep problems, and two scales of the ABC (Irritability and Lethargy) were not significantly associated with repetitive behaviour scores. However, there remained a significant positive correlation between the presence of repetitive behaviours and the hyperactivity scale of the ABC (Gabriels, Cuccaro, Iners, & Goldson, 2005). This strengthens the proposition that children's repetitive behaviours is associated to elevated motor movements.

The association between elevated movement and repetitive behaviours have largely been studied in terms of symptomatology relating to ADHD and ASD. Consequently, there is a paucity of information available regarding the association between repetitive behaviours and movement. We do not know whether elevated or increased movement is associated with repetition in community samples of children. Given the empirical examples reviewed within this section, it seems reasonable to suggest that children in the CCDS sample who continue to engage in repetitive behaviours at the toddler assessment may engage in generally higher levels of activity and movement. In other words, those children who continue to engage in motor stereotypies and repetitive actions with objects may merely be the ones who move around the most in general. In order to assess this, I aimed to test the association between children's directly measured activity levels and the repetitive behaviours, during the free play. It will also be possible to examine repetitive behaviour at the toddler age with reference to informants' reports of toddlers' symptoms of ADHD.

7.1.3 Repetitive Behaviours and Social-Communicative Skills

Piaget's (1952) theoretical account of the sensorimotor stage of development argues that repeating an activity increases the mastery of symbolic representation. During this stage of development, it is likely that infants perform repetitive behaviours to acquire understanding of the properties of objects and people and in order to prolong interesting events (described by Piaget as secondary circular reactions [see chapter 1 for more information]). During the sensorimotor stage repetition can play a functional role in terms of acquiring social understanding. It can therefore be argued that repetitive actions might facilitate social development in infancy (Flavell, 1963; Piaget, 1952; Murdoch, 1997).

Indeed, early interactions around objects have been associated with the development of some of the abilities required for relating successfully to other people, including the regulation of affect and the recognition that other people have minds distinct from one's own (Adamson and Bakeman, 1985; Hobson, 1993). Thus, as well as providing a foundation for the development of social and communicative abilities, repetitive behaviour and play involving circular reactions might contribute to infants' social cognitive development (Thelen, 1980).

In the context of a cooperative game or social interactions, repetitive signals to the partner indicate that a game is in progress (actions such as showing, offering, giving or banging, for example). Cooperative social games can be identified by the key features of *mutual engagement*, *repetition of actions* and *alternation of turns* (i.e., the infant who is playing a game repeats actions in alternating sequence with the adult or peer partner), often accompanied by signs of playfulness and positive affect (Hay, 1979; Ross and Goldman, 1977). Hay (1979) recorded cooperation and sharing between parents and their 12-, 18- and 24-month-old children. Hay defined a coordinated interchange as a mutual involvement of two partners, repetition of discrete actions with only a small range of permissible variation and alternation of turns (see also Ross & Goldman, 1977, who also required that the games have a playful, 'non-literal' quality). In this context, the adults' and infants' repetitive behaviours facilitated cooperative interaction and subsequent play. Hay (1979) found that 12% of the participants engaged in repeated, distinctive manipulations of the toys provided. This repeated action was included as one theme constituting cooperative interchange.

Furthermore, infants' own use of repetitive behaviour contributes to the success of cooperative games with parents and other interactive partners. In an experimental study, when adult experimenters deliberately fail to take their turns, infants repeat their actions to try to get the partner to continue (Ross & Lollis, 1989). Children can therefore cooperate by repeating discrete actions and taking turns to sustain the interaction. The literature reviewed within this section suggests that the repetitive behaviours assessed within this thesis may be associated with some forms of interaction and exchange between social partners. As such, one could propose that conventional social interactions and games are often grounded by repetitive actions. It seems that there is some rudimentary association between cooperative exchanges, game (which constitutes repeated action with some variation) and the repetitive behaviours assessed within this thesis. Such a proposal requires formal testing however, in order to establish whether there is indeed a link between these seemingly associated behaviours. As such, within this chapter I will assess early forms of games in toddlers as well as assess their use of repetitive behaviours in the same social context in order to test whether there is indeed an association between early forms of play and motor stereotypies/ repetitive actions with objects.

Early games between peers at the toddler age often constitutes offering and giving objects. Offering is an example of topic-related interaction between peers and is characteristic form of play in the second year of life. It can be used to direct attention or attract attention of the social-partner (Hay, 2004) and as such, will be assessed as one form of non-verbal communication. Despite being observed less frequently at the toddler age, giving is a further example of toddlers' early non-verbal communication (through play). Giving may represent toddlers' interpretation of their peers as intentional agents in the course of interaction, when one peer gives an object to another peer (Hay, 2004). The understanding of the intentions of other peers as social agents may be viewed as an early step in the development or social understanding and prosocial behaviour. As such, within these analyses I will focus of offering and giving as early forms of social-communicative skills (i.e skills which are coming into the behavioural repertoire and are not dependent upon language).

Conversely, as children move out of Piaget's sensorimotor stage, they acquire language and thus increasingly complex means of communication. Subsequently they may have less need to use repetitive behaviours to communicate with others. It seems reasonable to suggest that toddlers may therefore engage in repetition less often as they acquire more complex social and communicative skills.

Furthermore, conventional social interactions around objects facilitate the acquisition of early communicative and linguistic skills in infants (Bakeman and Adamson, 1984; Bruner, 1975; McArthur and Adamson, 1996; Tomasello and Farrar, 1986). According to Bruner (1975; 1982) the predictable communicative formats that emerge between the child and caregiver in reciprocal back-and-forth games structurally underpin many features of language.

The relationship between repetitive behaviours and earlier forms of language development has been documented (Iverson & Fagan, 2004). The associations between early verbal social-communication skills and repetitive behaviours were initially discussed in

Chapters 1 and 5 of the thesis. The relationship between repetitive behaviours and socio-communication domains of functioning in young children is not well understood (Harrop et al., 2014). The repetitive behaviours examined within this thesis are typically associated with poorer adaptive skills and chronological age (Leekam et al., 2011 for review). This vocal-rhythmic movement coordination has largely been studied in infants and a paucity of information is available regarding the association between repetitive behaviour and language in toddlers. Indeed Iverson (2010) states that little attention has been devoted to exploring the relationship between motor movement and language development, particularly in the context of toddlers in a community sample. This is surprising given the belief that when children acquire new motor skills, progress in language comes to a halt (see Iverson, 2010 for a review). In one recent study, Harrop and colleagues (2014) observed repetitive behaviours during a play session and measured the children's language skills (the language skills were measured with the Preschool Language Scales; PLS; Zimmerman and colleagues, 1992). They found that language skills were significantly and negatively associated with the frequency with which toddlers engaged in repetition. This was true for both toddlers who were assigned to the typically developing (mean age 24 months) group and ASD group (mean age 45 months).

In the literature review conducted for this thesis I did not find any other empirical examples regarding the association between repetitive behaviours and language, or indeed other types of socio-communicative skills, in a community sample of toddlers. Subsequently, in this chapter I assessed language skills in the community sample of toddlers in order to determine whether this association exists between these domains of development. I focus on these skills as research with younger infants suggest an association however a paucity of information is available regarding toddlers.

The form of the repetitive behaviour does not always relate to the purpose for which it is used. Children use whatever behaviour that they have available at a given time to do what they want to do at that time, including contingent control of people and objects, communication and exercise (Thelen, 1981). Thus, it seems sensible to suggest that repetitive behaviours are therefore linked to children's ability to interact with others. In the context of social interaction repetitive behaviours facilitate game play and, in preverbal children, act as a means of communication and thus facilitate interaction (e.g., Bruner, Ross & Goldman, 1977). To this end, I ask whether the repetitive behaviours shown by toddlers are more likely to occur within or out of the context of social interaction with other toddlers. This chapter will therefore examine whether those who exhibit repetitive behaviours are less likely to communicate verbally and also examine if they are less likely to attempt to engage unfamiliar peers in cooperative games, as defined by Hay (1979).

7.1.4 The Current Study

The current study was designed to answer the following questions:

1. Do the toddlers who engage in repetitive behaviours have poorer inhibitory control?
2. Do the toddlers who engage in repetitive behaviours have more symptoms relating to ADHD?
3. Do the toddlers who engage in repetitive behaviours as have poorer socio-communicative skills? Is the observed repetitive behaviour more likely to occur in the context of social interaction with unfamiliar peers?

This chapter will also focus on the children highlighted in the previous chapter who had only engaged in repetitive behaviours as toddlers in order to determine if they are different from the children who have not shown repetitive behaviour at the toddler assessment on any of these dimensions.

7.2 Method

7.2.1 Participants

The analyses reported in this chapter derive from observations of the children of the Cardiff Child Development Study. Information regarding the study and the sample was presented in Chapter 3. The participants focused on in this chapter are all of the 222 toddlers that were observed in the laboratory during the late toddler assessment (Wave 5), regardless of whether they had been assessed in late infancy. Figure 7.2 shows the progression of the sample from recruitment in pregnancy to the 222 that visited the laboratory for the late toddler assessment. The participant's mean age was 33.60 months (range = 27.6 to 41.2 months). The demographic characteristics of the 222 participants did not differ significantly from the original sample.

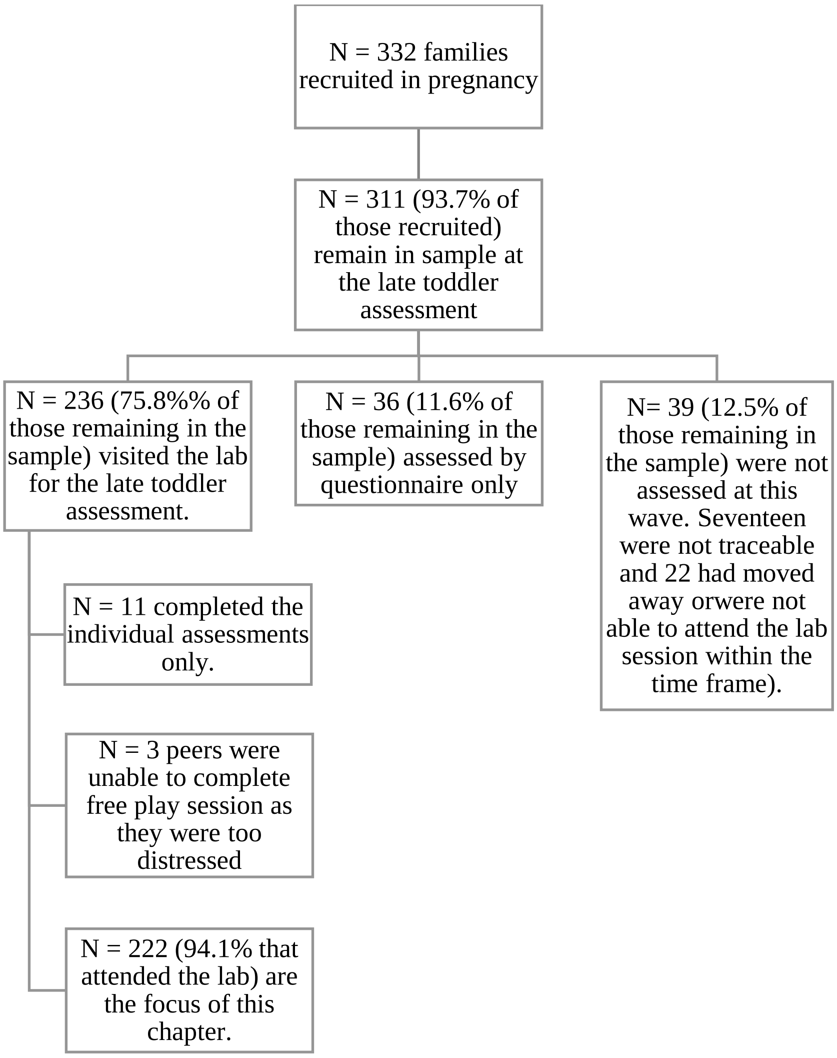

Figure 7.2. The progression of the sample from recruitment in pregnancy to the 222 participants assessed in this chapter.

7.2.2 Procedure and Measures

The overall procedure used at the late toddler assessment was described in Chapter 3. Three toddlers and their accompanying caregivers were invited to the laboratory session at the same time. Upon arrival to the laboratory, children were escorted into an individual testing room by a researcher. Once the toddler and the caregiver were comfortable a second researcher entered the room in order to attach the Actigraph and heart rate monitor to the toddler (see below for detail). The first researcher then administered a battery of individual tasks (within the individual testing rooms). The battery of tasks included four age appropriate, previously validated inhibitory control tasks; two were designed to assess behavioural regulation and two were designed to assess cognitive flexibility. These were used in the current analyses, the details of which are below. The order of the task presentation was counterbalanced across participants. All of the tasks were recorded using standard video recorders which were used for later observational coding. After this, the families were then escorted to the large testing room, decorated to look like a large living room for the free play session. The observations of the repetitive behaviours derive from the free play session. This is the same free play session that was used in the toddler assessment described in Chapter 6 and is identical to the protocol administered at the late infancy assessment of the CCDS. The measures used consist of both observational data and questionnaire data (collected from the mother, father and a third person who knows the child well). The questionnaire data provided the basis for the toddler ADHD symptoms, as measured by the Child Behaviour Checklist for toddlers (CBCL; Achenbach & Rescorla, 2000).

7.2.2.1 Question 1: Do the toddlers who engage in repetitive behaviours have poorer inhibitory control? The toddlers' behavioural inhibition was measured by administering two tasks designed to assess children's behavioural regulation and two tasks designed to assess their cognitive flexibility. These are described below.

7.2.2.1.1 Behavioural regulation tasks. The toddlers' ability to regulate their behaviour was assessed using two tasks: the raisin task, a delay of gratification task, and the whisper task, which involved vocal inhibition. Both of these tasks were initially developed by Kochanska and colleagues (1996) and adapted for use in this study. The tasks were never described in terms of prohibitions, but rather were presented as challenging games. The experimenter never communicated to the child that his or her performance was correct or sub-standard. Each task is described below.

7.2.2.1.1.1 Raisin task (adapted from Kochanska's Snack Delay task). This task consisted of three identical trials, each 30 seconds in duration. Within each trial children were presented with a raisin enclosed within a transparent plastic container (Kochanska's original task used chocolate). The container was placed on the testing table. Participants were instructed not to touch the box until the experimenter had rung a small bell (also located on the testing table). After this explanation the trial began. During the 30 second trial the experimenters did not respond to the child's vocalisations or speech; did not initiate any interactions and did not respond to bids of interaction made by the child. After 30 seconds had lapsed the experimenter rang a bell and the child could eat the raisin, which indicated the end of the trial. In cases where the participant had eaten the raisin before the 30 seconds had lapsed, the experimenter would still ring the bell and proceed to the next trial.

The child's response to each of the 30 second trials was scored as 0 if the child ate the raisin before the experimenter had rung the bell, 1 if the child touched the bell, box or raisin, but did not eat the raisin and 2 if the child did not eat the raisin and did not touch the bell, box or raisin. Thus higher scores were indicative of those who demonstrated more inhibition. Data are available on 213 (96%) of the 222 participants included in this chapter. Six cases did not do the task due to late arrival at the laboratory testing session. Data are unavailable on three of the participants due to technical difficulties with the video records. Independent observers coded videos for 25.6% of the participants to establish coder reliability. The median intra-class correlation coefficient (ICC) was .96.

7.2.2.1.1.2 Farm whisper task (adapted from Kochanska et al., 1996). Kochanska's original whisper task used posters as stimuli; in extending the task to a new sample in a different cultural context, the task was adapted for use with a toy farm set. Participants were presented with a toy farmyard consisting of a large plywood base (decorated with a field, a pond, a gravel area and a vegetable patch), a toy barn with a removable roof and ten small plastic common farm animals. The ten farm animals used were a horse, donkey, cow, calf, sheep, lamp, chickens, ducks, pig and goat. Whilst setting up the farm scene, experimenters explained that the animals were asleep and the participant's task was to wake the animals without frightening them, by naming each one in turn and whispering 'good morning'. This task therefore consisted of 10 trials, the order of which were counterbalanced across participants.

The participants' response to each trial was scored as 0 if the participants shouted the animal's name, 1 if they used a normal tone of voice, 2 if they used a low vocal sound or 3 if they whispered. A higher score indicated more frequent use of vocal inhibition. Data are available on 212 (95.5%) of the 222 participants included in this chapter. Seven participants did not complete the task due to late arrival to the laboratory testing session and data are unavailable on three of the participants due to technical difficulties with the video records. Independent observers coded 25% of the participants to establish coder reliability. Excellent coder reliability was found with ICC coefficient of .98.

7.2.2.1.2 Cognitive flexibility tasks. In order to assess cognitive flexibility, two tasks were administered to the participants. These are described below.

7.2.2.1.2.1 Tower of Cardiff. Participants were presented with a graduated plastic tower and three plastic rings of varying sizes (exact stacker seen in Figure 7.3a, similar can be purchased at toy retailers). The tower is narrower at the top than at the base, which affords stacking the rings in a graduated order. The frequency with which participants built such a graduated tower was an indication of conventional use of the toy. This task consisted of two identical trials. Within each trial, participants were presented with an example of an unusual tower that the experimenter had previously built (Figure 7.3b). Participants were then presented with an empty pole and three individual rings and were asked to copy the experimenter's unusual tower with the following preamble: "This is my tower, can you build a tower just like mine?" The words copy or imitate were not used. Participants were given 40 seconds to attempt a replication, after which any attempt was pulled apart and the procedure was repeated for a second trial.

Figure 7.3.

7.3a (left) depicts the tower used in the Tower of Cardiff planning task with the rings stacked in the way afforded by the tower and 7.3b (right) depicts the unusual tower modelled by the experimenter.

Participants' responses to the two trials were scored as 0 if no tower was built at all, 1 if the tower did not resemble the experimenter's tower and was not the conventional tower, 2 if the child built the conventional tower (i.e. with the rings being placed in an order from large to small) and 3 if participants had replicated the experimenter's unusual tower. The

Tower of Cardiff Planning task provides a measure of cognitive flexibility in order to reproduce the experimenter's tower. Data are available on 209 (94%) of the 222 participants included in this chapter. Ten cases did not complete the task due to late arrival for the laboratory testing session and data are unavailable on three of the participants due to technical difficulties with the video records. Independent observers coded 25.6% of the participants to establish coder reliability. Perfect coder reliability was found with an Kappa of 1.00.

*7.2.2.1.2.2 Big Bear Little Bear (adapted from Hughes & Ensor, 2005)***.** In this task, participants were presented with an A3 illustration of two cartoon bears, introduced to the participant as Big Bear and Little Bear (see Figure 7.4). Participants were asked to point in turn to the big bear and then to the little bear to ensure that they understood the difference. The experimenter then placed the laminated drawing flat on the testing table and presented two cups (one large, one small) and two spoons (one large, one small). The experimenter told the participants that the smaller items belonged to the big bear and the larger items belonged to the little bear and placed each item in turn on top of the appropriate bear. The experimenter then removed the four plastic items and proceeded to ask the participant to give an item to the correct bear by placing the item on top of the bear in the picture. This was repeated four times such that each bear would have one cup and one spoon. The order of the four trials was counterbalanced across participants.

Participants' responses to each of the four trials were coded as no response, conventional response (incorrect) or correct response. The total scores ranged between 0 and 4, depending on how often the correct response was given, one score was given for each action per trial. In addition to measuring the participants' ability to inhibit the response I was able to measure the frequency that participants gave a conventional response (placing the big cup on top of big bear, for example). Data are available on 208 (93.6%) of the 222 participants included in this chapter. Ten of the cases did not complete the task due to late arrival at the laboratory testing session and data are unavailable on three of the participants due to technical difficulties with the video records. Independent observers coded 25.6% of the participants to establish coder reliability. Excellent coder reliability was found with ICC = .98.

Figure 7.4 Materials used in the Big Bear, Little Bear task.

7.2.2.1.2.3 Extracting factor scores from the behavioural inhibition tasks. A principal components analysis was conducted on the four behavioural inhibition tasks that I have outlined in this section. Additionally, two further tasks were included in the PCA. These were two tasks designed to assess toddlers' ability to imitate and were not included in the analyses for this study. In the PCA of the six tasks I used a varimax rotation and missing values were replaced with the mean score. Three factors were extracted from the scores on the six cognitive tasks. The Raisin task score and the Whisper task score loading heavily on the first factor which was therefore labelled *behavioural regulation*. This factor score is the composite measure of the toddlers' behaviour regulation used in the present analyses. The Tower of Cardiff score and the big Bear Little Bear score loaded heavily on the second factor which was therefore labelled *cognitive flexibility*. This factor score is the composite measure of the toddlers' cognitive flexibility used in the present analyses. The third factor score did represent imitation but I did not use this factor score in the current analyses. Consequently, the toddler's inhibitory control was assessed by using the two continuous variables: the behavioural regulation factor score and the cognitive flexibility factor score. These were inserted into ANOVA as dependent variables.

7.2.2.2 Question 2: Do the toddlers who engage in repetitive behaviours have more ADHD symptoms? In order to determine whether the toddlers still engaged in repetitive behaviours had more symptoms that related to ADHD I assessed 1) their activity levels using a physiological method and 2) the caregiver rating of the toddlers' ADHD symptoms. These are both described below.

7.2.2.2.1 Toddlers' activity levels. In order to determine whether those who still engaged in repetitive behaviours were more active it was essential to measure activity level. At the start of this testing session an Actigraph Actitrainer was attached to the toddler by an experimenter. The ActiGraph ActiTrainer has dimensions of 8.6 cm by 3.3 cm by 1.5 cm and weighs approximately 1.8 ounces. The device was packaged in a plastic enclosure and attached to the toddlers' left leg with a Velcro strap. A baseline period of activity data was then collected for approximately 3 minutes and the actigraph was not removed until the end of the assessment. Activity data were therefore available during the free play session. The children's activity levels were objectively measured using the ActiGraph ActiTrainer (Manufacturing Technology, Inc, MTI). The ActiGraph ActiTrainer contains an activity monitor with a built-in accelerometer, which records accelerations ranging in magnitude from 0.05 to 2 G's. The output from the accelerometer is digitized by an Analog to Digital Converter (ADC) at the rate of thirty times per second (30 Hertz (Hz)) and the signal then passes through a digital filter, which band-limits the accelerometer to the frequency range of 0.25 Hz to 2.5 Hz. These limits allow detection of normal human motion, whilst motion from other sources is rejected. For this study, each motion sample was initially summed over a specified epoch of 15 seconds.

The data were downloaded via the integrated USB plug, stored in ASCII format and subsequently converted into a Microsoft Excel file with the Actilife Software. The data were cleaned and total activity scores were calculated for 30 second epochs. The activity levels were assessed during the free play session, which is ecologically more similar to a situation that might be encountered within the home-environment. The analyses within this chapter will focus on the activity levels during the birthday party free play session. A sample of 5 minutes of activity was collected from the free play period. This was used as a measure of activity during peer interaction.

The settings for the activity data resulted in the number of movements being collected and summed for specified epochs of 15 seconds. The data were subsequently cleaned and divided into 30 second epochs. A mean activity score was calculated for each condition, which was used for all further analysis.

The activity data were screened for violations in the assumptions of parametric tests. The assumptions of normality were not met and subsequent log transformations were required. This successfully transformed the toddlers' activity levels. Data are available on 151 of the cases. This is the case because toddlers were often unwilling for the physiologist (researcher assigned the task of collecting physiological data) to attach the actigraph strap to their leg. The actigraph strap had to be applied onto their skin and this often involved the caregiver removing trousers or tights in order to attach the strap. Many children were unwilling for this to happen and thus data are available for 151 of the 222 cases.

7.2.2.2.2 Toddlers' ADHD symptoms. In addition to the physiological measure of toddlers' activity, I also included informants' ratings of ADHD symptoms. At the toddler wave of the CCDS the widely used and repeatedly validated Child Behaviour Checklist for toddlers (CBCL version 1.5 to 5 years; Achenbach & Rescorla, 2000) was embedded within a milestones questionnaire given to the mother, father and significant other person. The CBCL is a standardised questionnaire, which requires them to rate 100 items of behavioural and emotional problems exhibited by their children, on a 3-point scale (0-2). The ADHD subscale consists of six items. These include: (1) *cannot concentrate, cannot pay attention for long*, (2) *cannot sit still, restless or hyperactive*, (3) *cannot stand waiting, wants everything now,* (4) *demands must be met immediately*, (5) *gets into everything* and (6) *quickly shifts from one activity to another*. The total score can thus range from 0 to 12. The CBCL has previously been used at age 3 as a measure of ADHD symptoms where moderate stability was established from three to seven years (Rietveld et al., 2014). This suggests that the ADHD symptoms can be detected at 33 months the age at which the participants were assessed in this study.

Within this study, the CBCL was completed by at least one informant from 254 families of the CCDS (240 mothers, 176 fathers and 182 significant others). The internal consistency of this scale was assessed using alpha coefficient, where $\alpha = .73$ (mothers), $\alpha = .74$ (fathers) and $\alpha = .75$ for the third informant. The mothers' reports were significantly associated with fathers' reports, $r\ (168) = .42$, $p < .001$, and with the third informant, $r\ (172) = .49$, $p < .001$. The fathers' report were significantly associated with the third informant, $r\ (150) = .31$, $p < .001$.

Also embedded within the milestones questionnaire were three items relating to early symptoms of ADHD, specifically '*restless, overactive, cannot stay still for long'*, '*constantly fidgeting or squirming*' and '*is easily distracted, concentration wanders*'. Informants rated these items as 'not true (0)', 'somewhat true (1)', or 'certainly true (2)' and the total score could thus range from 0 to 6. At the late toddler assessment the scale was completed by at least one informant in 243 families of the CDS (228 mothers, 178 fathers and 180 third informant). The scale showed good internal consistency with alpha coefficients at 33 months of .74, .78 and .76 for mother, father and third informants' ratings respectively.

In order to maximise the sample size for this scale, the scores from an identical questionnaire collected during a previous wave (early toddler Wave 4; mean age 21 months, SD = 2.27) were used to impute missing scores at 33 months. At 21 months the scale was completed by at least one informant in 243 families (235 mothers, 189 fathers, 194 third informants). The scale had good internal consistency with alpha coefficients at 21 months of .77, .77 and .72 for mother, father and third informant respectively. Mothers' reports at 21 months were significantly associated with fathers' reports, $r\ (186) = .41$, $p < .001$, and with the third informant, $r\ (186) = .37$, $p < .001$. Father and third informants' reports also correlated significantly, r (159) = .24, p = .002. Imputing predicted scores resulted in a sample size of 284 families for the milestones ADHD scale.

Mplus 7 (Muthén & Muthén, 2012) was used to construct toddler age ADHD factor scores based on the three informants rating on the Developmental Milestones and CBCL questionnaires. Mplus 7 uses Full-Information Maximum Likelihood methods (FIML) which allow factor scores to be computer based on all available information (thus including cases where only one informant provided a rating). This resulted in latent factor scores being available for a total of 286 families (86.1% of the initial sample). A confirmatory factor analysis, using a Maximum Likelihood estimator with robust standard errors (MLR) to allow for deviations from normal distributions of the indicators was conducted which included these 6 indicators and 3 latent factors (Figure 7.5). The resulting factors scores were analogous to standardised scores, with the mean and variance of the factor variables constrained to be 1 and 0 respectively. The toddler age ADHD factor explained 54.6% and 79.8% of the variance in the latent CBCL and Developmental Milestones factor respectively, whilst explaining 77.4, 31.2, 21.6, 81.3, 27.0 and 35.8% of the variance in mothers', fathers' and third informants' reports of these two respective scales. Standardised path coefficients are presented in Figure 7.5. The Mplus output along with further information can be seen in Appendix IV.

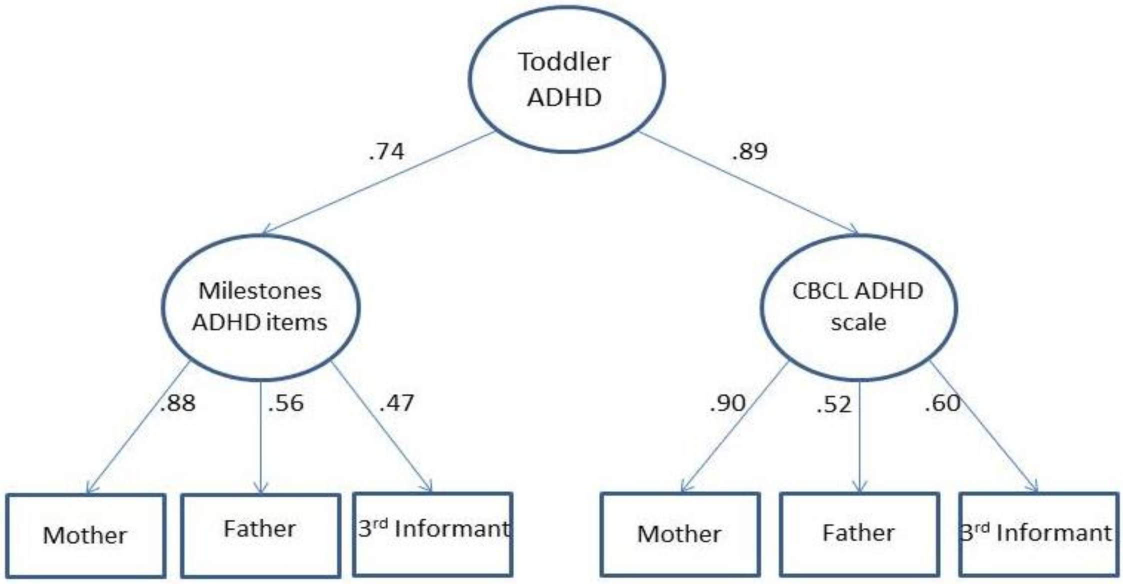

Figure 7.5 Structural model used to construct the toddler ADHD factors score with standardised path coefficients.

In summary, toddlers' activity levels and ADHD symptoms were measured in two ways, by assessing their activity using a physiological measure and by examining informants' report of ADHD symptoms. These two measures resulted in two continuous variables both of which were used as dependent variables in the analyses.

7.2.2.3 Question 3: Do the toddlers who engage in repetitive behaviours have poorer social and communicative skills? In order to assess participants' socio-communicative skills I observed their ability to interact with other children by offering/giving and by communicating verbally through speech. As noted in section 7.1 offering and giving are early forms of interaction and game playing that toddlers at this engage are capable of displaying. These socially directed behaviours are becoming a part of toddler's behavioural repertoire and thus individual differences in the use of offering and giving is expected. Offer and give are seen as behaviours that demonstrate understanding that peers are social agents with their own intentions and thus recording these behaviours ought to provide a good basis for measuring the participants' non-verbal social competence. These were based on observation data coded from the free play session. After the individual assessment, the participants were escorted to the Party Room for the stimulated birthday party. Full details of the party protocol can be read in Chapter 3. Following the Teddy Bear's Picnic emotional challenge, families were asked to remain in the testing room for 20 minutes to allow for observation of free play amongst the toddlers. The 20 minute free play period in the laboratory room closely replicated a scenario at a birthday party or at a parent toddler group. It allowed for interactions between the participants (up to three unfamiliar peers) and their families. Subsequently both the observed instances of repetitive behaviours and social communication with a peer were recorded. Notably, the procedures used within the simulated birthday party at the late toddler assessment exactly replicated the procedures used at the late infancy assessment. The participants were therefore exposed to the same stimuli, in the same room when they had been observed as 12-month-old infants. The observed instances of repetitive behaviours and social communication with a peer were recorded during the 20 minute free play session. Details of the observation coding follow.

7.2.2.3.1 Repetitive behaviour coding scheme. All observed instances of motor stereotypies and repetitive actions on objects during the free play session were coded using the Repetitive Behaviour Coding Scheme (RBCS). This coding scheme was developed in Chapter 2. Data are available on all 222 of the participants that attended the laboratory session. An independent observer coded 25% of video records and showed significant agreement in the number of repetitive behaviours observed ICC = .95, number with an object, ICC = .94, number of motor stereotypies, ICC = .92 and type of behaviour, ICC = .96. For ease of comparison with other research and in order to compare the descriptive information with those presented in previous chapters, a rate per hour was calculated for total repetitive behaviour observed, sum of motor stereotypies observed and sum of object based repetition observed. A rate per hour was also calculated for the individual behavioural categories (flap, bounce, rock, head movements, clap, banging categories).

Two, three and sometimes four peers were present in the peer session. In order to ensure that all frequencies were independent (and not influenced by the behaviour exhibited by other participants in the room) the repetitive behaviour continuous data were checked for dependencies using SPSS linear mixed-models analysis (see Appendix I). The SPSS linear mixed-model analysis ensures that the parametric assumption of independence is met. At the toddler assessment there was no significant effect of the pairings with particular peers in the observation session on the infants' or toddlers' engagement in repetitive behaviours. Therefore, in subsequent analysis, all scores are treated as independent observations independent.

Because few participants exhibited repetition at the toddler assessment, a dichotomous measure was created, indicating that the toddler did engage in repetitive behaviours (1) or did not engage in any repetitive behaviours (0). This dichotomous variable was used as the predictor in all of the ANOVA analyses conducted.

7.2.2.3.2 Social-communicative skills with a peer. Social communication with a peer was measured in two ways, by recording instances of verbal and non-verbal communication. Both types of social communication directed at a peer were measured using the Peer Interaction Coding Scheme (PICS; Hay, Mundy, et al., 2011). The PICS is designed to capture episodes of social interaction between at least two infants or toddlers and had previously been used in studies of 1- to 3-year-old children (Caplan, Vespo, Pederson & Hay, 1991; Hay, Castle & Davies, 2000). Social interaction between the peers is defined as an alternating sequence of each child's peer-directed behaviours. Peer-directed behaviours may be physical, vocal, or verbal, but they must clearly be directed to the peer, as signalled by the toddler's gaze at the other child, or by words (e.g., calling the other child by name). Trained observers used the PICS to record interactions among peers. Episodes of peer interaction were transcribed and each child's interactive move was coded based on a predetermined set of behavioural categories, which included discrete instances of offering and giving. Any spoken language during episodes of peer interaction was transcribed. These are described in more detail below. Appendix V shows the Peer Interactive Coding Scheme. Appendix VI shows an example of a PICS transcript with codes from the RBCS transcript inserted where appropriate. Data are available on all 222 participants.

7.2.2.3.2.1 Non-verbal communication. Observers recorded whether offering and giving of an object was definitely present (score of 2) or possibly present (score 1). Discrete action of offer/give was defined as 'The actor extends an object toward the peer's hands or lap, possibly releasing it into the recipient's hand or lap'. Scores were added together to obtain a measure of offer/give during observation sessions. Independent observers transcribed 23 (25%) observational sessions of 60 (27%) participants with excellent observer agreement, ICC = .97. Using SPSS linear mixed-models analysis it was ascertained that there was no significant effect of pairings with particular peers in observational sessions on the infants' or toddlers' offer/ give behaviours. Any instances of offering or giving when the actor extends an object towards the peer's hands or lap whilst pretending that the object is something else or whilst pretending an object was present when it wasn't (e.g. pretending to pour tea from a teapot into a cup for the peer) was coded as examples of socially-directed pretence. Pretend offering was scored as definitely present (2) or possible present (1). Participants' scores were summed to yield a composite measure of pretend sharing.

7.2.2.3.2.2. Verbal communication. Speech was coded from the PICS transcripts where observers had transcribed any spoken words within episodes of peer interaction. The observers' transcripts of the toddler's speech during the episodes of peer interaction were coded for (1) conversations and (2) the number of words spoken per move by each participant. A minimal form of conversation between the peers was identified in the observer's transcript; within episodes of interaction verbal exchanges were identified. These were sequences of at least two moves in which one toddler's utterance was replied to by the peer with another utterance (Hay, 2006). Utterances must contain intelligible words to be included. The mean number of words spoken was calculated by counting the number of words (sounds and other vocalisations/noises were not included) uttered by the participant in a move. The sum of the total number of words spoken to a peer during the free play session was then divided by the number of moves that included speech. This resulted in a mean number of words spoken per move. Finally I was able to assess the proportion of peer directed actions that contained speech by dividing the number of moves that included speech by the number of peer directed moves enacted by each participant.

7.2.2.3.2.3 Extracting factor scores from the social-communicative skills. A principal component analysis was conducted in order to extract factor scores that best represented toddlers' socio-communicative skills. I entered frequency of offering (which had been transformed using square root to create normality), frequency of pretence offering, mean words spoken per move and the proportion of moves including speech into the principal component analysis. A varimax rotation was applied. Two factors resulted, which accounted for 73.9% of the variance. The mean words spoken per move and the proportion of moves including speech loaded heavily on the first factor. This factor thus represented verbal communication and represented 42.6% of the variance.

Secondly, offer and pretence offer loaded heavily on the second factor and thus this represents offering. This second factor represented 31.3% of the variance. The two continuous variables, representing verbal and non-verbal communication skills were used as continuous variables within the ANOVA analyses in this study.

In addition to the direct observation of children's speech to peers, informants reported on children's language skills on a developmental milestones questionnaire and on the MacArthur-Bates questionnaire. Mplus 7 was used to construct language ability factor scores based on three variables: (1) the milestone checklist item 'my child knows 100 words'; (2) the number of words endorsed as known by the child on MacArthur-Bates 100 word list; and the MacArthur-Bates question 'my child can combine words'. This resulted in latent factor scores reported language ability being generated for a total of 243 families. A confirmatory factor analysis was conducted which included these 3 indicators and 1 latent factor. An MLR estimator was used with the mean and variance of the factor variables constrained to be 1 and 0 respectively. Toddlers with higher factor scores on the observational measure of peer-directed language also had higher ratings on the informants' questionnaires (r_s (211) = .20, p < .01). Preliminary analyses of the CCDS sample at follow-up at age 7 showed that toddlers' peer-directed language skills were significantly associated with higher receptive vocabulary scores at age 7, as measured by the British Picture Vocabulary Scale, r_s (91) = .30, p < 001.

7.2.3 Data Analysis

The free play peer session was designed to last 20 minutes. Sometimes the toddlers were out of the view of the camera (i.e. to use the bathroom, view obscured by a sofa). In cases where this was longer than 5 seconds coders noted the duration of time (in seconds) that the participant was out of the view of the camera. The total duration of time out of view was calculated at the end of the coding session. When the duration of the observed coding was less than 19 minutes (for each participant), the observed category of repetitive or communicative behaviour was pro-rated to 20 minutes for ease of comparison across participants.

Three overarching questions were asked in this chapter. In this section I will outline how I answered each question in the analyses. In all instances in conducted ANOVAs in which both the repetitive behaviour status and child gender were entered as predictor. This is because I wanted to determine what the differences were (if any) between two groups of children: those who had or had not stopped exhibiting repetitive behaviours. The outcome variable entered into the analyses differed for each of the questions asked.

7.2.3.1 Question 1: Do the toddlers who engage in repetitive behaviours have poorer inhibitory control? I performed two ANOVA analyses to answer this question. In the first ANOVA the behavioural regulation factor score was entered as the dependent variable and in the second ANOVA the cognitive flexibility factor score was entered as the dependent variable.

7.2.3.2 Question 2: Do the toddlers who engage in repetitive behaviours have more symptoms relating to ADHD? I performed two ANOVA analyses. In the first activity level was the dependent variable. In the second the informants' ADHD factor score was the dependent variable.

7.2.3.3 Question 3: Do the toddlers who engage in repetitive behaviours have poorer socio-communicative skills? Is the observed repetitive behaviour more likely to occur in the context of social interaction with unfamiliar peers? I conducted two ANOVA analyses to answer this question. The first entered the verbal language factor score as the dependent variable. In the second ANOVA I entered the offer factor score as the dependent variable. Furthermore, in order to examine the context in which the repetitive behaviours occurred I read through the raw data (transcripts) for the peer interaction coding and the repetitive behaviour coding and noted whether the repetition occurred in the context of an interaction or out of the context of an interaction. Appendix VI shows an example of the peer interaction coding transcript. Where appropriate I have inserted the bouts of repetitive behaviour to the transcript. By doing this I was able to present the amount of repetitive behaviours that occurred within the context of social interaction and out of the context of social interaction.

7.3 Results

Eighty-three (37.4%) of the 222 children exhibited at least one repetitive action during the free play session. The mean score for each of the factor scores assessed in this chapter are presented in Table 7.1 (mean score for each of the individual tasks are presented in Appendix VII). It is noteworthy that the analyses were conducted on the factor scores that represented the key dependent variables (as outlined in 7.2.4).

	Any repetitive behaviour during the toddler assessment?			
	Yes		No	
Gender	Female	Male	Female	Male
Behaviour regulation	.18 (.96)	.01 (1.1)	.11 (.98)	-.15 (.92)
Cognitive flexibility	.01 (1.07)	.07 (.99)	-.01 (1.02)	-.09 (.93)
Toddler activity	638.68 (350)	721.88 (354)	529.67 (285)	779.13 (440)
ADHD symptom rating	.54 (.07)	.53 (.06)	.54 (.08)	.55 (.08)
Language skills	.48 (1.16)	.05 (.77)	-.36 (.89)	.01 (1.01)
Offering	.09 (.84)	.28 (1.6)	.02 (.72)	-.21 (.72)

Table 7.1 Mean (standard deviation) score for each of the factor scores used within this chapter

7.3.1 Question 1: Do the Toddlers that Engage in Repetitive Behaviours have Poorer Inhibitory Control?

The means and standard deviations for each group on the inhibitory control measures are presented in Figures 7.6 (behavioural regulation factor) and 7.7 (cognitive flexibility factor). In the first ANOVA, where behavioural regulation was entered as the outcome variable, there were no significant main effects of gender or repetitive behaviour status and no significant interaction effect. Similarly, in the second ANOVA, where cognitive flexibility factor score was entered as the outcome variable there were no significant main effects of gender or repetitive behaviours status and there was no significant interaction. There were no significant differences between toddlers who did and did not use repetition on either of these measures of inhibitory control.

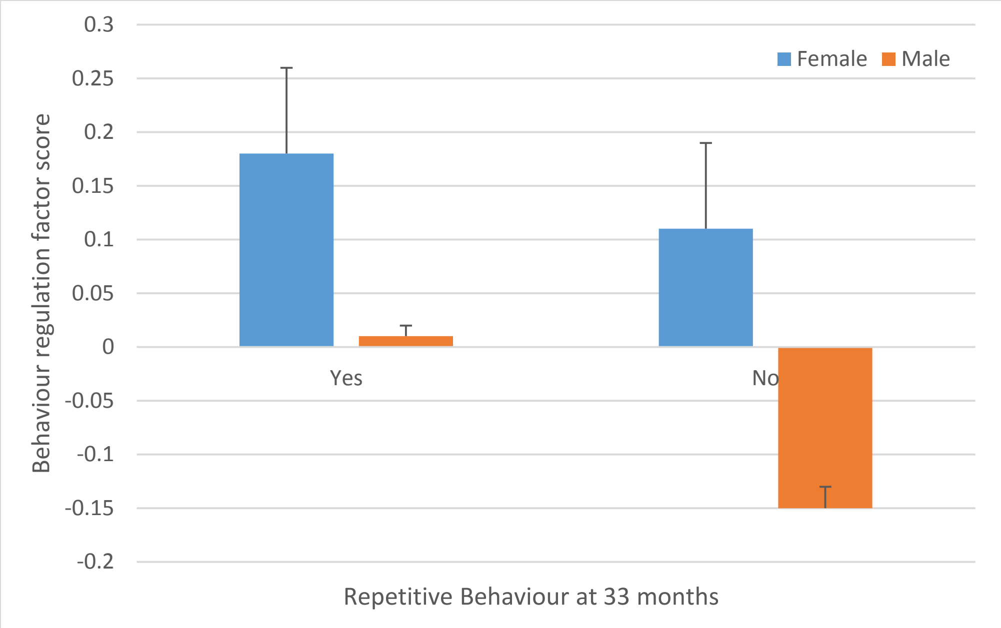

Figure 7.6 Mean behavioural regulation score in terms of those toddlers who did or did not engage in repetitive behaviours.

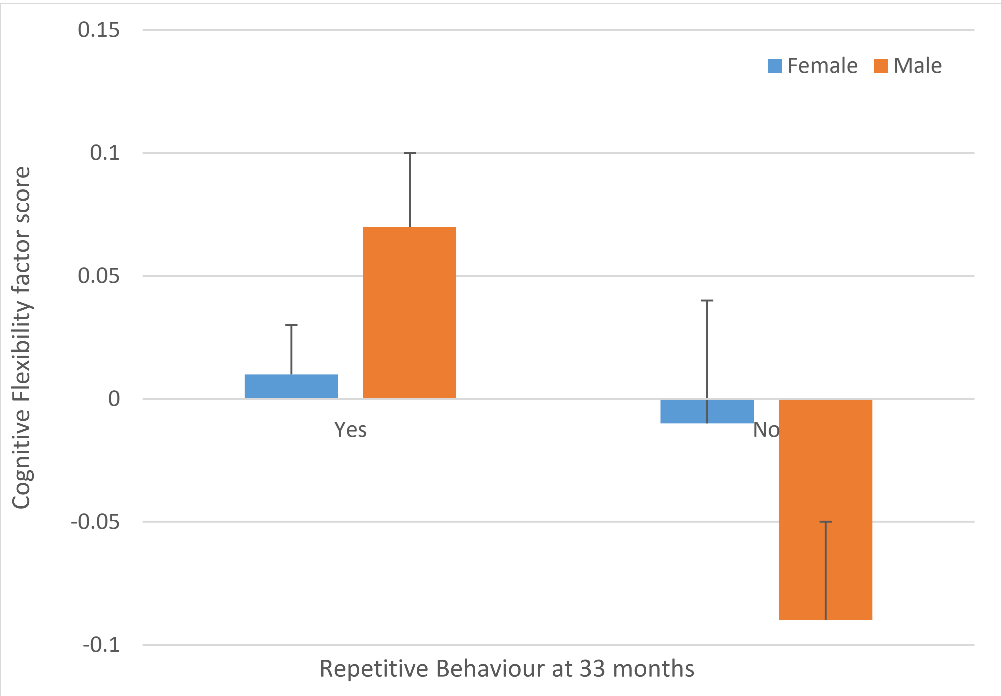

Figure 7.7 Mean cognitive flexibility score in terms of those toddlers who did or did not engage in repetitive behaviours.

7.3.2 Question 2: Do the Toddlers Who Engage in Repetitive Behaviours Have Higher Activity Levels and More Symptoms of ADHD?

Analysis of the actigraph data showed that participants who did not engage in repetitive behaviours had mean activity levels of 678.26 (SD = 394.85), whereas those who did engage in repetitive behaviours had mean activity levels of 677.60 (SD = 346.39). In the ANOVA, where repetitive behaviour status and participant gender were entered as predictor variables there was a significant main effect of gender, where boys were more active than girls ($F(1,134) = 5.35$, $p < .05$). However, there was no significant main effect of repetitive behaviour status and no significant interaction. This is depicted in Figure 7.8.

In the second ANOVA, where the mean informant-rated ADHD symptom factor score was entered as the dependent variable there was no significant main effect of gender or repetitive behaviour status and there was no significant interaction. The means are depicted in Figure 7.9.

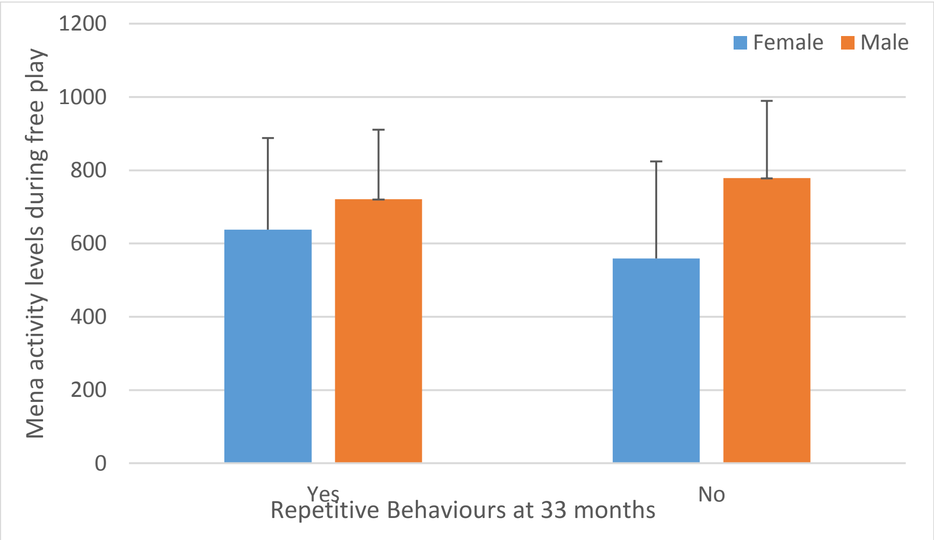

Figure 7.8 Mean activity levels during the free play session for those who did or did not engage in repetitive behaviours

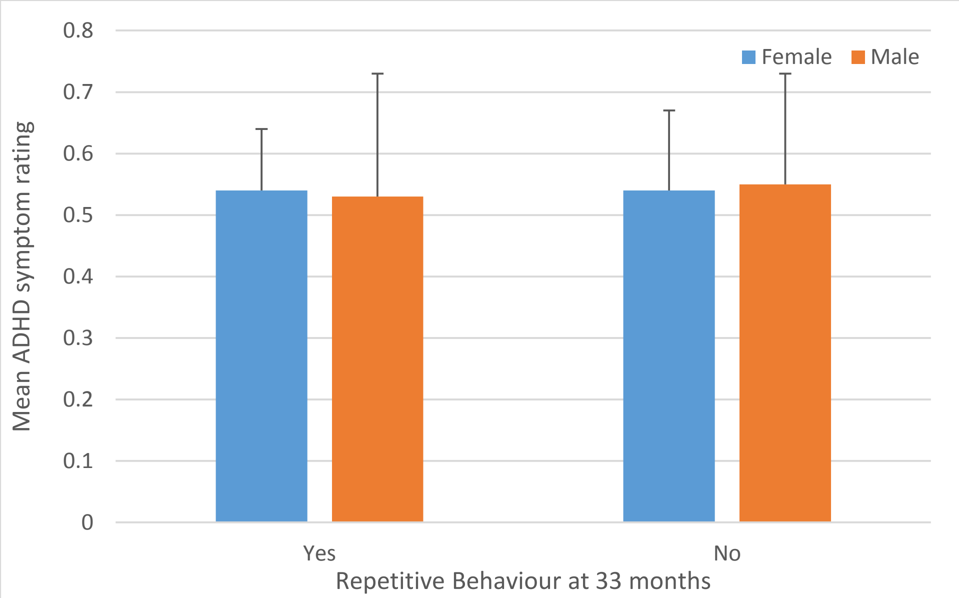

Figure 7.9 ADHD symptom rating for those who did or did not engage in repetitive behaviours at 33 months.

7.3.3 Question 3: Do the Toddlers Who Engage in Repetitive Behaviours Have Poorer Socio-Communicative Skills? Is Repetitive Behaviour More Likely to Occur in the Context of Social Interaction?

The mean and standard deviations for the toddlers' nonverbal communication (the offering factor score) are presented in Figure 7.10. There was no significant main effect of gender. However, there was a significant main effect of repetitive behaviour status, where those children who engaged in repetitive behaviours engaged in significantly more nonverbal offering behaviours than those who did not exhibit repetitive behaviours, $F(1,218) = 4.24$, $p < .05$. There was no significant interaction.

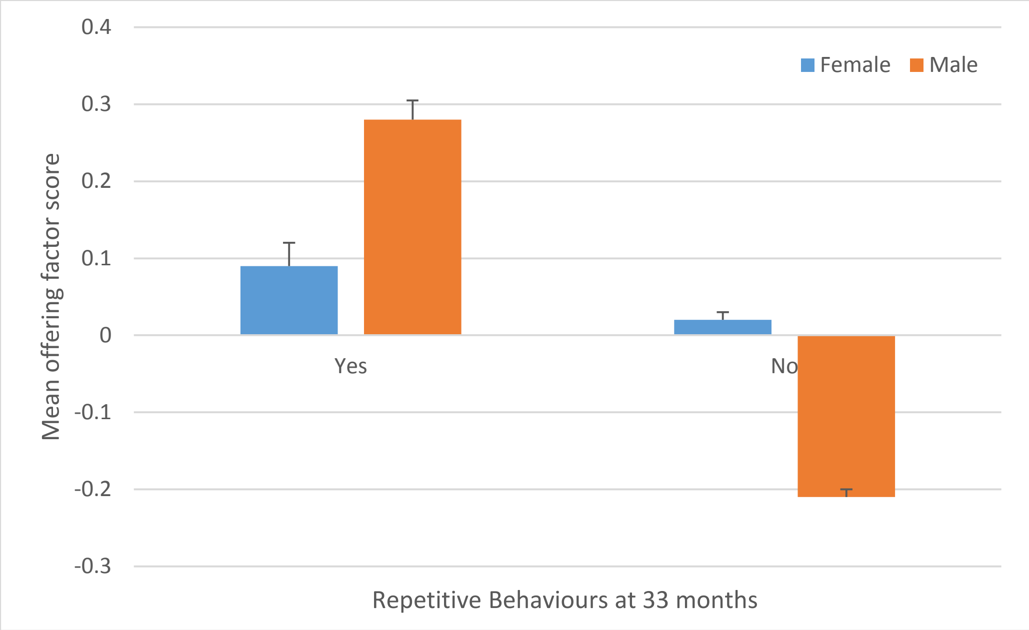

Figure 7.10. Mean offering score for participants who did or did not engage in repetitive behaviours at 33 months.

The means and standard deviations for the observed language skills factor score are presented in Figure 7.11. There was no significant main effect of gender. However, there was a significant main effect of repetitive behaviour status, where those who had engaged in repetition had significantly higher language scores than those who had not engaged in repetitive behaviours, F (1,218) = 10.60, $p < .001$. Furthermore, there was a significant interaction between gender and repetitive behaviours status, F (1,218) = 8.87, $p = .003$.

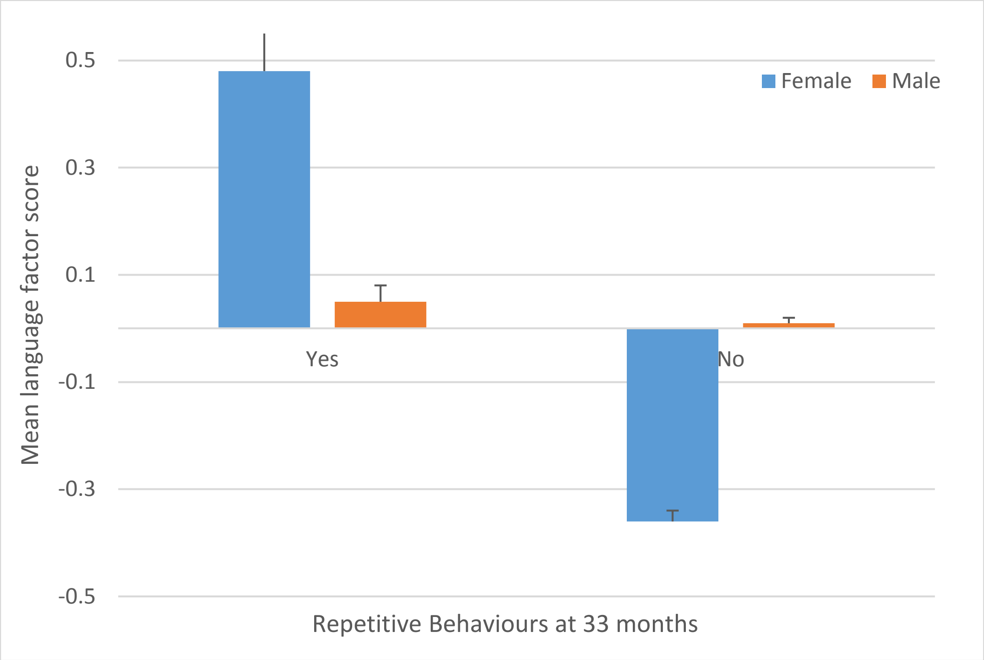

Figure 7.11 Mean language ability for males and females who did or did not engage in repetitive behaviours at 33 months.

These findings suggest that toddlers who still show repetitive behaviour had better communication skills. However, it was not clear whether or not the repetitive behaviour was actually being used during peer interaction. In order to determine whether the repetitive behaviours were demonstrated within or out of the context of social interaction I assessed the independent transcripts for peer interaction and the repetitive coding system. The timings of the interaction episodes and the bouts of repetition were lined up in order to determine how much of the repetitive actions with object and motor stereotypies occurred within the context of social interaction. Appendix VI shows an example of the peer interaction coding transcript. I have inserted the bouts of repetitive behaviours in to the transcript. Table 7.2 shows the percentage of participants that did engage in repetitive actions with objects and/ or motor stereotypies inside and outside of the episodes of interaction with a peer or caregiver. For participants who engaged in repetitive behaviours, most repetitive behaviours were exhibited outside of the context of social interaction. Thus toddlers were more likely to engage in repetitive behaviours when they were *not* engaged in interaction with peers. Subsequent to this I went back through the video data and described the events occurring around the toddler at the time that they engaged in repetition. A sample of the descriptions is in Appendix VIII. The implications of this qualitative information is noted in the discussion.

Table 7.2 Percentage of participants that engaged in repetitive behaviours within and out of social interaction with a peer.

Repetitive Behaviour	In the context of social interaction	Out of the context of social interaction	Both in and out of the context of social interaction
Repetitive action with object	14%	75.8%	9.7%
Motor stereotypies	3.5%	81.8%	14.5%

7.3.4 Examination of the Participants Who Had Not Exhibited Repetitive Behaviour as Infants

In the previous chapter I identified a group of participants who had not exhibited any repetitive behaviour at the 12-month assessment. However, these participants exhibited repetitive behaviours during the 33-month assessment (N=22). I compared this small subsample with the rest of the sample in terms of behavioural regulation, cognitive flexibility activity level, ADHD symptoms, and offering and language skills. I conducted one way ANOVA tests where the repetitive behaviour status was entered as the predictor variable (i.e. either repetitive behaviour during infancy and then reduced or stopped by toddler assessment [level 1] or no repetitive behaviour at infancy but repetitive behaviours exhibited at toddler assessment [level 2]). When compared to the rest of the sample those who exhibited repetitive behaviours during the toddler assessment were no different from those who had declined or stopped using repetitive behaviours.

7.4 Discussion

The main aim of this chapter was to examine the differences between the 37% of the toddlers that did and the 63% that did not exhibit repetitive behaviours during the late toddler assessment of the Cardiff Child Development Study. To examine the differences between these two groups of toddlers three main questions were asked, 1) Do the toddlers who engage in repetitive behaviours have poorer inhibitory control? 2) Do the toddlers who engage in repetitive behaviours have more symptoms relating to ADHD? 3) Do the toddlers who engage in repetitive behaviours have poorer socio-communicative skills? Is the observed repetitive behaviour more likely to occur in the context of social interaction? These questions were addressed by examining the children of the CCDS. I assessed all of the toddlers' who attended the late toddler laboratory assessment, as the participants approached their third birthday. I chose to do this as this age is critical in terms of advancing socio-linguistic skills and key when considering diagnostic definitions of developmental disorders such as ASDs.

In order to address these questions I assessed the participants' scores on two behavioural regulation tasks and two cognitive flexibility tasks, I also assessed the toddlers' activity levels and their parents' rating of ADHD symptoms and finally I assessed their ability to interact with unfamiliar peers and their ability to speak to their peers. I used the

Repetitive Behaviour Coding Scheme (RBCS) to code observed bouts of repetitive behaviours. To my knowledge, this is the largest observational study of repetitive behaviours in a community sample that is representative of the U.K. This study contributes to the literature by placing these repetitive behaviours within the context of development at this age.

In the preliminary analyses I did not find a significant effect of age or gender on participants' repetitive behaviour. In terms of my exploratory question, the findings will be discussed individually.

7.4.1 Do the Toddlers that Engage in Repetitive Behaviours have Poorer Inhibitory Control?

Within the context of the peer interaction session, the toddlers who engaged in repetitive behaviours did not have poorer behavioural regulation of cognitive flexibility skills. This suggests that, contrary to the definition that sees repetitive behaviours as involuntary, those who did exhibit a stereotypy are able to think and subsequently behave in a flexible fashion. The boys who engaged in repetitive behaviours had better cognitive flexibility scores and better behavioural regulation than the boys who did not engage in repetitive behaviours. This same pattern was present for the females. The results confirm that the effects were the same for males and females. My results did not support the findings of Tregay and colleagues (2009), who noted that immaturity of the executive system in preschool children might result in repetitive behaviours as the children adhere to over-learned behaviours. The participants who engaged in repetitive behaviours were therefore not disadvantaged in their ability to inhibit their behaviours, contrary to other research (Tregay et al., 2009).

7.4.2 Do the Toddlers that Engage in Repetitive Behaviours have more Symptoms relating to ADHD?

The toddlers who engaged in the repetitive behaviours during the free play session were no more active than those who had stopped. Furthermore, the toddlers who engaged in the repetitive behaviours were not rated as showing elevated scores on informants' ADHD symptom scale. This pattern of results were present for both males and females where the males who engaged in repetitive behaviours were no more active and had no more symptoms of ADHD than the males who did not engage in repetitive behaviours. This patters of results was the same for females. In general males were more active than females; this can be attributable to boys 'more boisterous style of play at this age. These results suggest that the children that are engaging in repetitive behaviours are, on average, no more active than the ones who have stopped.

7.4.3 Do the Toddlers that Engage in Repetitive Behaviours have Poorer Socio-Communicative Skills? Is the Observed Repetitive Behaviours more likely to Occur in the Context of Social Interaction?

I assessed the toddlers' social-communication abilities by observing their ability to share, by observing their overall level of sociability, and by assessing their verbal skills. Children's ability to share and offer at this age is a standard measure of early sociability in children's play. I found that the participants' score on all of the social-communication measures were consistently higher for the group of participants who had engaged in repetitive behaviours. By assessing the factor scores created, which represented non- and verbal communication I found that those participants who did engage in repetitive behaviours had better socio-communicative skills. The participants who engaged in repetitive behaviours were more likely to engage in non-verbal socially directed actions in the form of offering and pretence offering of toys within the free play session. This effect was the same for both boys and girls where both boys and girls who engage in repetitive behaviours were more likely to offer than the boys and girls who did not engage in repetitive behaviours.

In terms of the verbal socio-communicative skills, the participants who engaged in repetitive behaviours had better linguistic skills than those who did not engage in repetitive behaviours. This means that they spoke more words per move and more of their peer directed actions contained instances of speech. Interestingly, the effects differed significantly between the boys and girls and this was evident in the significant interaction. The girls who engaged in repetitive behaviours had significantly better than average linguistic skills, but the girls who did not show repetitive behaviours had significantly poorer linguistic skills. This pattern was not present for males and thus it seems that the effect differed between female and male participants. This pattern of results, where the mean scores fluctuated more for females than males may be attributable to gender differences in the development of language skills (see Heilmann et al., 2005, Määttä et al., 2012, for example). Although, for the purpose of the analysis within this chapter it is mostly important that the reader notes that the children who did still engage in repetitive behaviours (both the boys and the girls) showed better linguistic skills than their counterparts who had not engaged in repetitive behaviours. Together, these findings might suggest that repetitive behaviours may act as a means of communication and thus facilitated interaction between the peers. The repetitive behaviours observed could be interpreted as tools to facilitate interaction between the female toddlers. This certainly warrants further study of the role of repetitive behaviours in language, especially for females.

Finally I assessed the context in which the repetitive behaviours occurred. Specifically, I looked at whether the repetitive behaviours occurred during an episode of interaction with a peer or out of this social context. I found that most of the repetitive behaviours occurred out of the context of social interaction. This supports previous work by Esther Thelen (1979, 1981). Thelen examined the proximal cause of repetitive behaviours and found that infants often engaged in stereotypies when in a non-alert state. Furthermore, it seems plausible to speculate that the structured nature of the interaction, which contains a lot of socially directed repetition (i.e. episodes of sharing) suppresses the individual type of repetition. It also seems plausible to speculate that these secondary circular reactions involving objects may still underpin toddlers' interactions and facilitate moving from lower level repetitive behaviour to a more socially directed set of communicative actions. However, further analyses would be required in order to determine whether this is the case. At this point in development, the many participants with good social-communication skills were still engaging in the repetitive behaviours out of the context of social interaction. In order to examine the context surrounding the repetitive behaviour I present data that describe the events and occurrences that occur around the participants during a random selection of repetitive actions. This is presented in Appendix VIII and suggests that the actions occur when nothing interesting is occurring. However, further analyses would be required in order to determine or substantiate this claim.

7.4.4. Study Limitations

This study has several limitations. The repetitive behaviours were observed and coded from a 20 minute free play session and several situational factors could have an impact on their behaviours and the way in which they interact with the other participants. Despite this, the free play session does closely emulate situations in which toddlers are often placed, a comfortable room in which peers and mothers are interacting freely.

I am unable to infer causality in the data. I am unable to determine if the presence of repetitive behaviour causes better social-communication abilities. These data allow me to make an association, to state that there is a link between these behaviours. Despite this, the study makes a significant contribution to the understanding of repetitive behaviours in the context of development as I am able to see that those participants who continue to use repetitive behaviours are not showing worse behavioural regulation and social communication skills.

7.4.5 Conclusion

In summary, this study suggests that repetitive behaviours are not associated with immaturity of executive functioning and are not associated with poor social-communication ability. Conversely I am able to suggest that the repetitive behaviours observed in the 222 toddlers are representative of those with better socio-communicative skills. Furthermore, these data show that repetitive behaviours remain a part of the toddlers' behavioural repertoire as they approach the third birthday and also highlight the fact that repetitive behaviours must be treated cautiously when used as a diagnostic marker for developmental disorders such as ASDs.

CHAPTER 8.

General Discussion

The overarching aim of this thesis was to extend Thelen (1979, 1980) and Piaget's (1952) developmental perspectives on repetitive behaviours by exploring the presence and course of motor stereotypies and repetitive actions with objects from 6 to 36 months, the developmental period in which, according to diagnostic criteria, the onset of autism must be identified and the period during which important developmental milestones are achieved. Two samples were used, the First Friends study (Chapter 2) and the nationally representative Cardiff Child Development Study, a prospective longitudinal study of first time parents and their young children followed from pregnancy to 7 years postpartum (Chapter 4, 5, 6 and 7).

8.1 Summary of Findings

In this section I will summarise the key findings in relation to each of the five key questions set out at the start of the thesis, in section 1.9. The first objective of this thesis however was to develop a relatively simple observation coding system for repetitive behaviours that can be applied to children aged from 6- to 36-months. In Chapter 2 (the first empirical chapter) I developed the Repetitive Behaviour Coding Scheme (RBCS). The RBCS is an event based coding scheme designed to record instances of motor stereotypies and repetitive actions with objects. It consists of eight behavioural categories recorded in children with autism which are also seen in community samples. The RBCS followed Esther Thelen's definition of repetitive behaviours, specifically '*the behaviour must be repeated in the same form three times in* *order to be deemed repetitive'.* The RBCS was a reliable measure, both trained and untrained observers were able to establish excellent coder agreement with the primary coder. In developing this standardised observation coding scheme I further knowledge in this field by standardising the measurement of motor stereotypies and repetitive actions with objects. By developing the RBCS from a continuous narrative record of infants' behaviour I am also able to present this coding scheme as one that accurately reflects all movements made by young children.

When the RBCS was applied to the 100 children of the First Friends study I found that during infants' free play the repetitive behaviours were almost ubiquitous. I found great individual differences and in a cross-sectional analysis of the 9- to 12-month olds I found that the older infants engaged in more motor stereotypies and repetitive actions with objects (Chapter 2). The findings within this chapter support previous work (e.g. Thelen and colleagues) which thus suggests that the RBCS does reliably measure behaviours that other researchers have previously recorded. The work in chapter 2 also extends previously published work by developing a reliable, simple yet effective observational coding scheme that can be applied easily to young children.

I then turned my attention to examining the motor stereotypies and repetitive actions with objects in the children of the Cardiff Child Development Study, a nationally representative prospective longitudinal assessment of children in the South Wales area. The assessments conducted as part of the CCDS allowed me to answer the remaining five questions set out in section 1.9 of the thesis. I will now summarise the research findings in relation to each of these questions.

8.1.1 Question 1: Are Repetitive Behaviours Already Evident by Six Months of Age and Does it Increase over the First Year?

In Chapter 4 (empirical chapter 2) I returned to the individual testing context. The context was originally used by the vast majority of researchers reviewed in Chapter 1. This allowed me to verify the RBCS and assess whether motor stereotypies and repetitive actions with objects were evident at 6 months old. The method of assessment was designed to emulate the testing sessions previously employed by other researchers such as Thelen (1979) and theorists such as McGraw (1943) and Gesell (1942). In Chapter 4 I found that at a mean age of six months, approximately half of the infants engaged in repetitive behaviours. It was the same infants who engaged in the stereotypies and repetitive actions with objects. In the cross sectional analyses I found that the older infants engaged in significantly more instances of repetitive behaviours than the younger infants. These findings suggest that repetitive behaviours are beginning to come into young infants' behavioural repertoire at 6 months post-partum and have become increasingly more common when infants get older. Repetitive behaviour therefore increases over the first year. These findings corroborate with Thelen (1979, 1980) who suggested that the repetitive movements increase throughout the first year before peaking at approximately 8-months.

In order to establish the longitudinal trends I then focused on examining the motor stereotypies and repetitive actions with objects in the same children when they were 12 months old. I focused on the repetition observed during an object exploration task in order to replicate the testing environment from the 6 month assessment. In Chapter 4 I found that repetitive behaviours were almost ubiquitous amongst 12 month olds' (range 11 to 14 months) object exploration. The 12 months olds engaged in significantly more bouts of repetition when compared to the 6 months olds.

8.1.2 Question 2: Are there Individual Differences in rates of repetitive Behaviours between Individual Assessment and Social context?

In Chapter 4 I also explored the consistencies in the use of repetitive behaviours from the individual testing in the presence of a researcher context to a free play with unfamiliar peers' context. I found that, despite the fact that repetitive behaviours are observed more frequently during individual observation, there was consistency across context. Infants who engaged in the repetitive behaviours most frequently during individual testing engaged in repetitive behaviours most frequently during the free play session of the late infancy assessment (Wave 3 of the CCDS). These findings also corroborate with Chapter 2 where I found that motor stereotypies and repetitive actions at 12 months are almost ubiquitous. Interestingly, these findings contribute to our understanding of the implications of the context in which children are assessed. Despite the correlation between the frequencies across both context, the repetitive behaviours observed during the individual testing at the late infancy assessment were recorded more frequently and thus it seems possible to suggest that the frequencies are inflated during individual observation.

8.1.3 Question 3: When in Development do Individual Differences in the use of Repetitive Behaviour First Appear and are they associated with Milestones in Motor and Communication Development?

In Chapter 5 I paid attention to the individual differences in the use of repetitive behaviour during the late infant assessment in order to examine possible behavioural correlates of motor stereotypies and repetitive actions with objects at 12 months postpartum. I focused on the free play session outlined in Chapter 4. In Chapter 5 I sought possible correlates in two domains, locomotor development and social-communicative skills. I also conducted a cross sectional analysis as the infants at the 12 month assessments were between 11 and 14-months. I focused on these domains of development because locomotion is a skill that comes into the behavioural repertoire at around 12 months and shows great individual differences in onset. Furthermore, the socio-communicative skill, joint attention, is an early precursor to later complex communication and also comes into infant's skill set at this age. In chapter 5 I found that motor stereotypies, but not repetitive actions with objects represent a less mature stage of development. Those who had fewer locomotor skills engaged in motor stereotypies more frequently. However, this trend did not exist for the repetitive actions with objects. Furthermore, I did not find a relationship between the repetitive behaviours and joint attention skills. Due to this I decided to further investigate the relationship between communication and repetition at a later age, when more complex forms of communication have developed (see chapter 7). In cross sectional analyses I found that older infants engaged in significantly fewer motor stereotypies than the younger infants. This pattern was not detected for the repetitive actions with objects. Together these findings support previous work by Gesell and colleagues (Gesell & Ilg, 1948, Gesell & Armatruda, 1941), Thelen (1979, 1980, and 1981) and they extend the questionnaire work of Leekam and colleagues (Arnott et al., 2010; Leekam et al., 2007).

8.1.4 Question 4: Is There a Normative Decline in the use of Repetitive Behaviour from 12 Months Onwards?

In Chapter 6 I focused on the question of whether there is a normative decline in the use of motor stereotypies and repetitive actions with objects from 12 to 36 months. Within this chapter attention was paid to the children of the CCDS, specifically to the 20 minute free play that 210 infants took part in at both 12 months and 33 months lab assessments. The protocol at both assessments was identical and thus this allows direct comparison of the behaviours. Notable also is the fact that the free play sessions were the same as the free play used in the First Friends study presented in Chapter 2. Within Chapter 6 I found a significant decrease in the number of infants and the time spent engaged in the motor stereotypies and repetitive actions with objects. Furthermore, I found that on average infants engaged in significantly fewer instances of repetition when they were toddlers. Previous research with toddlers has mostly focused on higher level repetitive behaviours such as children's insistence on sameness (e.g. Evans et al., 1997). To my knowledge, the findings presented in Chapter 6 are the first systematic observational investigation of the continuity and change in the use of repetition from infancy to toddler period. It is important to know what degree of change is possible in community samples in order to compare to atypical trajectories and the findings within this chapter provide the first steps towards facilitating this comparison. Noteworthy is the fact that the repetitive behaviours were maintained in over a third of the sample and also a small subsample of children (*n* = 22) had engaged in repetitive behaviours as toddlers but not as infants. The final empirical chapter therefore paid attention to the toddlers who had maintained the use of repetitive behaviours.

8.1.7 Question 5: Does the use of Repetitive Behaviours at 33 Months Relate to Inhibitory Control, Activity or Social and Communicative Skills?

In the Chapter 7 I assessed the differences between the third of the sample who had maintained the use of repetitive behaviours and those who had stopped using the repetitive behaviours by 33 months. I sought possible differences in terms of inhibitory control (specifically behavioural regulation and cognitive flexibility), ADHD symptoms (both physiological activity and symptoms as rated by three informants that knew the child well), and assessed the toddlers' language and non-verbal social skills. I found that those who were still engaging in repetitive behaviours were no worse in terms of other skills than those who had stopped. They were no more active and thus the repetitive behaviour was not a product of increased activity of ADHD symptomatology. Furthermore, the continued use of repetitive behaviour did not represent those who were less able to inhibit their behaviours or think flexibly.

Interestingly and perhaps most noteworthy, the toddlers who had maintained the repetitive behaviours were more sociable, were more likely offer and pretend offer and had better linguistic skills. Noteworthy was the context in which the repetition took place. I assessed toddlers' use of repetition alongside their socially directed moves towards a peer (see Appendix VI) and found that the majority of repetition at this toddler assessment took place outside of the context of social interaction. This does lead to questioning when and why the repetition occurs, and consequently I went back and created qualitative information regarding the events that occurred before, during and after each instance of repetition. By looking at this information (Appendix VIII) I detected no trends and thus it seemed logical to conclude that the toddlers engaged in repetition when nothing else was happening in their environment.

8.1.8 Overall Summary of Findings

The results presented in Chapters 2, 4 and 5 suggest that repetitive behaviours increase from five to 12 months. Thereafter, motor stereotypies but not repetitive actions with objects, decline as a function of age, locomotor development and social-communication skills. These results contrast with those reported by Watt, Wetherby, Barber & Morgan (2008) who found that repetitive behaviour involving objects predicted to developmental level whereas repetitive motor actions did not. These differences can be attributed to different sample characteristics; Watt and colleagues (2008) studied a sample of individuals with ASD. The repetitive behaviours with objects distinguish their ASD group from that of the developmental delay or typically developing groups. Interestingly their sample consisted of 50 participants with ASD and 25 participants with developmental delay. Repetitive behaviour with objects therefore distinguish participants with ASD and those who are typically developing (Watt et al., 2008). In the context of this thesis, the different pattern between the two subtypes of repetitive behaviours draw our attention to the fact that some repetitive actions are maintained into the second year of life, where behavioural signs of autism first emerge.

The significant decline from infancy to toddlerhood quantifies the degree of change evident for repetitive behaviours in the early years, in the context of a representative community sample. Finally, these data show that repetitive behaviour remains part of toddlers' behavioural repertoire as they approach the third birthday and also highlight the possibility that the presence of repetitive behaviour must be treated cautiously when used as a diagnostic marker for developmental disorders such as ASDs.

These collective findings presented within this thesis allow us to further knowledge gained through previously published questionnaire studies (e.g. Leekam and colleagues and

Evans et al., 1997). The findings have contributed significantly towards our understanding of motor stereotypies and repetitive actions with objects in the first 36 months.

8.2 Implications of the Findings for Developmental Psychology

The findings presented within this thesis confirm that motor stereotypies and repetitive actions within objects are a part of development for almost every infant. This ubiquity suggests a possible cause or function and potential evolutionary advantage of these behaviours (Thelen, 1981), although no firm conclusion will be drawn here in regards to the findings of this thesis. The implications of these findings will first be discussed in the context of children's development before the clinical implications of the findings are discussed in section 8.4.

The development of expressive and communicative behaviours in infancy is rooted in developmental biology and movement science. In line with a nativist view, communicative and expressive actions can be seen as a complex cooperative system with other elements of infants' physiology, behaviour and social environment (Fogel & Thelen, 1987). Rhythmic motor stereotypies can function to increase the effectiveness of communication; the repetition of a signal increases its potency for communication (Thelen, 1981). In this view, during the pre-verbal years infants can communicate with their environment using the techniques and behaviours that are available to them. Crying for example is a means of expressing a need to others, it signals the need for nutrition of vestibular stimulation through contact with others. In another method, repetitive movements allow the infant to communicate with their environment by repeating actions. This allows the infant to enforce consistency on the environment (Piaget 1952). Repetitive behaviours are ubiquitous at a stage in development, a stage that is more mature than spontaneous movement but less mature than goal directed actions (Thelen 1979; 1980). Subsequently, as infants become older and more mobile they can exert influence and enforce consistency over their environment by moving around in order to reach a goal (e.g. contact with a caregiver, acquiring a toy). The motor stereotypies are thus no longer required and are exhibited less frequently. When infants become more able to interact with others they can engage in games, such as reciprocal turn taking games where cooperative exchanges are performed. This goal directed action serves a purpose and thus the motor stereotypies are no longer required.

As other means of communication become available they take precedence over the less mature forms of communication (e.g. crying, repetitive movements). Thus, to this end we can see motor stereotypies as important during some stages of development but as development of other skills takes place the individual repetition is no longer required. The repetitive behaviours serve various forms of adaptive functions but they no longer serve an appropriate developmental function. This suggests that repetitive behaviours are immature behavioural responses (Leekam et al., 2011).

Notable within Chapters 4 and 5 was the difference that emerged between repetitive motor behaviours and repetitive actions involving objects. Whereas motor repetition related to age, locomotor development and social-communication abilities, repetitive behaviours involving objects did not. This suggests that these two behaviours should be considered and treated differently. Such results can be considered in the context of the dynamic systems theory (Thelen, 1981). Whilst better locomotor ability relates to fewer repetitive motor behaviours, this alone was not sufficient for a significant reduction in repetitive behaviours involving objects to occur. Other developmental skills, which may be acquired at later stages of development or at later ages, may also need to be present in order for a significant reduction in repetitive behaviours with objects to occur. Further work is therefore required in order to determine if this is the case.

With this in mind, the maintenance of repetitive behaviours in over a third of the toddlers within the nationally representative CCDS sample suggests that for some individuals the developmental significance and function of repetitive behaviours extend beyond the pre-linguistic stage in infancy. The maintenance of repetitive behaviours did not impede development. Perhaps the repetition serves as a regulatory behaviour that regulates internal states in order to allow the child to focus on other complex domains of development such as interaction with a peer. However, more research is required before any conclusions can be drawn.

8.3 Limitations and Future Directions

Within this representative community sample living in South Wales I was able to track the course of repetitive behaviours from 6 to 36 months. In doing this I have provided a detailed description of the rise and fall of motor stereotypies and repetitive actions with objects in a community sample of very young children. However this study only assessed a community sample. In order to truly understand how the use of repetitive behaviours differ in those with autism, a group comparison design needs to be employed. The frequencies and behavioural correlates established within this thesis provided a platform from which future studies with clinical populations can be based and thus a comparison can be drawn. However, a true comparison of the differences between groups requires a group comparison design.

The repetitive behaviours were measured using the RBCS (the development of which was reported in Chapter 2). This observational method is new and therefore serves to supplement previous questionnaire work (e.g. Leekam et al., 2007; Arnott et al., 2010). The coding scheme was used to assess the behaviours exhibited by infants during 20 minute free play sessions and during 3 minute object exploration tasks. In order to compare the frequencies of repetitive behaviours recorded across context and time within this thesis, and in order to further compare the repetitive behaviours observed with those reported in other empirical papers I decided to calculate the frequency rate per hour. I must therefore acknowledge the fact that this may distort the relative frequencies of the behaviours observed. In the context of the analyses conducted for this thesis all behaviours from all participants were subjected to the same inflation (to rate per hour), however this limitation must be acknowledged.

Despite the fact that the coding scheme yielded reliable data from an ecologically valid source we must take caution in interpreting the results. How much can we really conclude about an infant or toddler in such a short period? Several factors can influence an individual's behaviours during the observation period; the child may be tired, hungry, frightened of a new situation, or even just really happy that day. The presence of such situational factors can interact to impact on the children's behaviours during the assessment. Thus, to overcome such situational influences, a future study should aim to use a mixed method design where information about repetitive behaviours are provided by different informants (e.g. caregivers and teachers) through questionnaire and interview, in addition to the observation method.

This thesis examined the behavioural correlates of motor stereotypies and repetitive actions with objects. In doing this I was able to put the repetitive behaviours within a developmental context and thus suggest some functional benefits of the behaviours. However, this thesis did not determine proximal causes of the repetitive behaviours. Future research needs to focus attention on the proximal causes of the stereotypies and repetitive actions with objects in order to further understand their role (if any) in development.

The participant attrition increased as the CCDS study progressed, particularly in terms of visits to the laboratory. This is inevitable in longitudinal research as participants are difficult to trace, particularly when they have moved to a different address or to another region or country. Measures were taken throughout the study to ensure maximum participation at each assessment. A designated administrator within the study was tasked with contacting the families regularly for booking and to send out newsletters. Consequently, despite some attrition the overall participation for the CCDS is good, with 79% of the families that remained in the study participating during the late toddler assessment, and 86% participating in one or both of the toddler assessments. Lower participation at the late toddler laboratory visit may be because the assessment took place during weekday afternoons, a period during which caregivers often have work commitments. Given these constraints, the rate of participation was still acceptable at the late toddler assessment.

The vast majority of the data on motor stereotypies and repetitive actions with objects derived from observations during infants' and toddlers' free play with unfamiliar peers in a laboratory setting. This setting limits the applicability of my findings to other situations. The vast majority of previous research had focused on assessing repetition in the context of individual testing. Within this thesis I took a different approach. I did this because I believed that a free play session with other children and adults present is a more naturalistic setting, one that closely emulates the world in which infants and toddlers exist. Young children spend much of their time engaged in some form of interaction (e.g. in nursery, parties, parent-baby groups etc.), which the free play context closely resembles. Recent work by Harrop and colleagues (2014) also used a free play paradigm but this was with the caregiver and not peers. Whilst the context in which I observed repetition is ecologically valid, I must acknowledge the limitations that the choice of setting places on the generalizability of my data. However, when I performed correlational analyses in order to determine if different patterns emerged from the observation of repetition during individual testing with an experimenter, those who engaged in repetitive behaviours more frequently during the free play engaged in significantly more repetition during the individual testing (Chapter 4). This confirms that the RBCS scores derived from the free play sessions are representative of the child's general level of repetitive behaviour at that age.

Despite the limitations and the need for future work, this thesis has contributed significantly to our understanding of the presentation of repetitive behaviours in very young children. It was essential to establish these trends and behavioural correlates and it was important to document the change from infancy to toddler before looking at the causal mechanisms and the proximal causes at work in the developmental presentation and maintenance of lower level repetitive behaviours.

8.4 The Implications of the Findings for Clinical Practice

The results speak not only to an area of developmental psychology that has received little study, but also have implications for the study of neuromuscular maturation and the study of ASD. By definition, repetitive behaviours are considered to be symptoms of ASD, and are highlighted as potential indicators for ASD in current clinical practice. However, it is important that practitioners observing repetitive behaviours in 12- to 18-month-old children take into account the fact that such behaviours are still common in typically developing infants. The present findings highlight a normative decline between 11 and 14 months in one class of repetitive behaviour, motor stereotypies, but no similar decline in repetitive behaviour using objects. Whereas motor repetition related to age, locomotor development and social-communication abilities in turn taking games; repetitive behaviours involving objects did not. This suggests that these two behaviours should be considered and treated differently. These findings provide relevant data for studies of at-risk samples.

The normative decline recorded between infancy and toddler assessments provide a direct indicator of the degree of change that is possible in community samples of children. This is important when comparing the developmental trajectory in atypical or at-risk samples or patients. The absence of continuity in the use of repetition from infancy to toddlers suggests that those who engage in a lot of stereotypies and repetitive actions with objects during infancy are not necessarily those who will engage in the behaviour in years to come. The maintenance of repetitive behaviours in over a third of the CCDS sample in the toddler assessment may suggest that there are different pathways for the development of repetitive behaviours (beyond infancy), one in which repetitive behaviours rapidly decline and another in which they are maintained over a longer period of time. On one pathway the repetition may support development and on another it may impede it. However, further research is required before any firm conclusions can be drawn.

8.5 Final Conclusion

Within this thesis I have studied the rise and fall in the use of repetitive behaviours, namely motor stereotypies and repetitive actions with objects, across the first three years of life. The results presented speak to topics within developmental psychology that had remained relatively understudied and also speak to researchers in the field of autism. I have shown that repetitive behaviours are ubiquitous in infancy and the normative decline for motor stereotypies but not repetitive actions with objects is contingent on locomotion as well as chronological age. Furthermore, despite a significant reduction in the use of repetition between infancy and the toddler years, over a third of the toddlers in a nationally representative community sample still engaged in repetitive behaviour. These children were not developmentally delayed in terms of communication or executive functioning skills. Their continued use of repetitive behaviours at 33 months was related to better verbal and non-verbal communication. My findings thus support Thelen and Piaget's theoretical perspectives on motor and cognitive development by calling attention to the positive functions of repetitive behaviour in early life.

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Appendix I.

Assessing Repetitive Behaviour in the Context of Peer Interaction

The vast majority of the repetitive behaviour data analysed within this thesis derived from observations of infants and toddlers during a free play session. The free play session was part of the assessment given at the late infancy and late toddler waves of the CCDS and occurred immediately after each participant had been assessed in a battery of individual tasks. Each free play session involved 20 minutes of play with an unfamiliar peer and each participant's caregiver was present in the testing room.

Within the design of the CCDS three participants were always invited to the laboratory for the free play session. At times some participants did not show or cancelled at the last minute. Consequently only two participants were present during these free play sessions. When two families did not show the laboratory session took place with the one participant; however we could only conduct the individual tasks. Consequently this one participant would be re-invited back to the laboratory again for the free play session only. As a result, some free play sessions had four participants present. Each of the free play sessions had either two, three or four participants present in the interaction. This could impact the behaviours exhibited by the individual participants. Consequently I checked whether the number of participants present for the free play session had an impact of the frequency of repetitive behaviour exhibited by each participant. I did this by conducting a series of ANOVA test where the number of participants present was entered as the predictor variable and the frequency of motor stereotypies and repetitive actions with objects were entered as the outcome variable.

Additionally, because repetition has previously not been assessed in the context of peer interaction I checked for dependencies. In doing so I was able to check whether the interaction setting, in which participants were in a room with other children of the same age had an impact on the behaviour. Here I conducted SPSS linear mixed-model analyses.

The results of these analyses are presented in the table below.

Chapter	Sample	N	Effect of number of peers	Dependencies
CHAPTER 2	First Friends	100	Not assessed, two peers were always present	No dependencies
CHAPTER 4	CCDS W3	253	No significant impact	No dependencies
CHAPTER 6	CCDS W3	210 (longitudinal assessment)	No significant impact	No dependencies
	CCDS W5	210 (longitudinal assessment)	No significant impact	No dependencies
CHAPTER 7	CCDS W5	222	No significant impact	No dependencies

Appendix II

Repetitive Behaviour Coding Scheme (RBCS) transcript from the First Friends study (Chapter 2).

W5 RBCS [INSERT TESTING DATE HERE]

Coder – [INSER CODER INITIALS HERE]

Date coded – [INSERT DATE OF CODING HERE]

Start of peer session- 7 minutes from start of video [START OF CODING PERIOD NOTED HERE]

Behaviour Start	Category (notes)	Number of repeats	Behaviour End	With or without object
8.10	Flap (move both arms up and down from shoulder whilst holding toy)	5	8.12	With
8.32	Flap (move one arm from side to side whilst holding toy)	4	8.35	With
9.04	Flap (move two arms from side to side) and Bounce (this happens at the same time)	5 5	9.09	Without
9.52	Rock (from side to side, quickly whilst sitting next to peer on the floor)	3	9.58	Without
14.23	Flap (move one arm from side to side whilst holding a toy in that hand)	9	14.29	With
17.05	Arm bang surface	6	17.07	Without
19.10	Clap (hands together whilst leaning on the sofa)	3	19.12	Without
24.55	Flap (both hands up and down from shoulder whilst standing alone) End coding 27.00 Duration coded 20 minutes.	7	25.03	Without

Appendix III- Correlation between all of the behaviours assessed in this thesis

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.	20.	21.	22.
1.6 month MS	–																					
2.6 month RAO	.17 * (281)	–																				
3.12 month object exploration MS	.17* (215)	.06 (215)	–																			
4.12 month object exploration RAO	.02 (215)	.03 (215)	.08 (234)	–																		
5.12 month free play MS	.13* (231)	.02 (231)	.16* (234)	.15* (234)	–																	
6.12 month free play RAO	.15 * (231)	.02 (231)	.05 (234)	.16* (234)	.25 *** (253)	–																
7.33 month MS	-.05 (201)	-.03 (231)	.16* (187)	-.06 (187)	.07 (210)	.04 (210)	–															
8.33 month RAO	.01 (201)	-.05 (201)	-.08 (231)	.04 (187)	.04 (210)	.05 (210)	.27 *** (222)	–														
9.Age at early infancy assessment	.27 *** (281)	.27 ** (281)	-.03 (234)	.08 (234)	.02 (250)	-.04 (250)	.05 (217)	.13† (222)	–													
10. Age at late infancy assessment	-.06 (231)	.11 (231)	-.09 (199)	-.24 *** (234)	-.30 *** (253)	-.03 (253)	-.03 (200)	.10 (210)	.08 (250)	–												

11.Age at toddler assessment	-.06 (214)	.05 (214)	.07 (199)	.13† (199)	-.07 (213)	.06 (210)	-.05 (222)	-.02 (222)	.13† (231)	.05 (213)	–											
12.Social risk index	.12 (193)	.13 (193)	-.06 (193)	.03 (193)	-.14† (200)	.08 (253)	.03 (210)	.12† (210)	.10 (208)	.05 (200)	.11 (210)	–										
13.Joint attention	.04 (233)	.11† (233)	.10 (226)	.01 (226)	-.08 (236)	-.05 (236)	-.06 (200)	-.12† (200)	.06 (252)	.22*** (236)	-.02 (214)	-.06 (198)	–									
14.Infancy locomotor development	-.08 (221)	.21 *** (221)	.08 (225)	-.17 ** (225)	-.25 *** (241)	-.15* (241)	-.03 (193)	.03 (193)	.03 (238)	.41 *** (241)	-.03 (206)	.16* (193)	.15* (227)	–								
15.Change in motor stereotypy	.14† (192)	.04 (192)	.18* (187)	.12 (187)	.97 *** (210)	.23 *** (210)	-.21 ** (210)	-.09 (210)	.01 (208)	-.28 *** (200)	-.07 (210)	-.16 * (210)	-.08 (198)	.26* ** (193)	–							
16.Infancy to toddler change is RAO	.13† (192)	.06 (192)	.11 (187)	.15* (187)	.21** (210)	.96 *** (210)	-.02 (210)	-.25 ** (210)	-.06 (218)	-.07 (200)	.05 (210)	.01 (210)	-.01 (198)	-.12† (193)	.19 ** (210)	–						
17.Toddler ADHD	-.04 (253)	-.11 (253)	.18* (223)	-.08 (223)	-.15* (239)	-.01 (239)	-.10 (218)	-.06 (218)	-.04 (273)	.01 (230)	-.10 (231)	-.13 (206)	.06 (239)	-.06 (229)	.01 (206)	.03 (206)	–					
18.Toddler activity level	.09 (140)	-.02 (140)	-.07 (136)	-.05 (136)	.03 (144)	-.06 (144)	-.03 (151)	.02 (151)	-.03 (154)	-.05 (144)	-.09 (157)	.09 (145)	-.02 (144)	.01 (139)	.01 (145)	-.09 (145)	-.10 (154)	–				
19.Cognitive flexibility	-.04 (209)	-.04 (209)	-.04 (194)	.16* (194)	.15* (208)	.16 * (193)	.05 (218)	.09 (218)	.04 (226)	-.04 (208)	.04 (231)	-.12 (206)	-.03 (209)	.01 (201)	.10 (206)	.08 (206)	-.08 (226)	.05 (155)	–			
20.Toddler language	.08 (201)	.15* (201)	.22* * (187)	-.06 (187)	.03 (200)	.01 (210)	.21 ** (222)	.20* (222)	.00 (217)	-.05 (200)	.04 (222)	.03 (210)	.10 (200)	-.02 (193)	.01 (210)	-.04 (210)	-.10 (218)	.03 (151)	.04 (218)	–		
21.Toddler offering	.09 (201)	-.05 (201)	.02 (187)	-.08 (187)	-.08 (200)	-.08 (200)	.14* (222)	.25* ** (222)	.04 (217)	.03 (200)	.04 (222)	.12 (210)	.12 (200)	.04 (193)	-.07 (210)	-.14* (210)	.01 (218)	.06 (151)	-.05 (218)	.29*** (222)	–	
22.Toddler	.20 **	.05	-.01	-.06	-.04	-.06	.19*	.27	.05	-.10	.10	.06	.14*	.06	-.04 (210)	-.12† (210)	-.04 (218)	.12 (151)	-.04 (218)	.61*** (222)	.66*** (222)	–

sociability	(201)	(201)	(187)	(187)	(200)	(200)	* (202)	*** (222)	(217)	(200)	(222)	(210)	(200)	(193)								
23.Early childhood receptive vocabulary	-.05 (105)	-.05 (105)	.20† (90)	-.15 (90)	.05 (96)	.15 (96)	.18† (91)	-.08 (91)	-.14 (112)	-.03 (96)	-.11 (93)	-.20† (88)	.01 (96)	-.02 (91)	-.07 (85)	.17 (88)	.14 (133)	-.04 (54)	.09 (92)	.27** (91)	.09 (91)	.01 (91)

† < .10, * p < .05, ** p < .01, *** p < .001, number of participants is shown in brackets below the correlation, MS = motor stereotypies, RAO = repetitive actions with objects

Appendix IV

Mplus Output for Toddler ADHD Symptoms Factor Scores

In Chapter 7 of this thesis I explored whether toddlers who engage in repetitive behaviour have higher activity levels and more symptoms of ADHD. In order to address this question I looked at an objective measure of physical activity and also caregiver ratings of toddlers ADHD symptoms. Three informants completed the ADHD scale of the CBCL (which served to create three variables used) and the same three informants completed hyperactivity questions in a milestones questionnaire (which served to create another three of the variables that were used). Further information regarding the questionnaire is described in section 7.2.2.2.2. The information presented within Appendix IV served to provide further information regarding the factor score that I used in Chapter 7 of this thesis. The proceeding information is a printed output from Mplus VERSION 7.11 MUTHEN & MUTHEN (06/25/2014 1:57 PM). It first shows the instructions that were used to create the factor score and secondly shows the summary of the analysis. Deep gratitude is paid to Mirjam Meeuwsen for her help here. My contribution towards the factor scores was faciliting with the entering and cleaning and checking the questionnaire data (in August 2012). Mirjam's Phd addresses the identification of precursors in the early development of ADHD and her knowledge and expertise in Mplus allowed her to create these factor scores.

```
Mplus VERSION 7.11

MUTHEN & MUTHEN

06/25/2014   1:57 PM
```

INPUT INSTRUCTIONS

```
TITLE:            factor scores for adhd scale across 3 informants

DATA:            FILE IS W4W5HYPandCBCL.dat;

VARIABLE: NAMES= famcode mqcbcl fqcbcl soqcbcl mqmshyp fqmshyp  soqmshyp;

          USEVARIABLES ARE mqcbcl fqcbcl soqcbcl mqmshyp fqmshyp soqmshyp;

                        MISSING IS ALL (-9);

MODEL:          f1 by mqcbcl fqcbcl soqcbcl;

                          f1@1 ; [f1@0];

                      f2 by mqmshyp fqmshyp soqmshyp;

                          f2@1 ; [f2@0];

                             f by f1* f2;

                                f@1 ; [f@0];

ANALYSIS:     Estimator=MLR;
```

```
OUTPUT:      STANDARDIZED sampstat MOD;
SAVEDATA:   file= toddlerW4W5adhd.dat;
                       missflag=-9;
                       save= fscores;
*** WARNING
  Data set contains cases with missing on all variables.
  These cases were not included in the analysis.
  Number of cases with missing on all variables:  46
   1 WARNING(S) FOUND IN THE INPUT INSTRUCTIONS
factor scores for adhd scale across 3 informants

SUMMARY OF ANALYSIS

Number of groups                                                 1
Number of observations                                         286
Number of dependent variables                                    6
Number of independent variables                                  0
Number of continuous latent variables                            3
Observed dependent variables

  Continuous
   MQCBCL      FQCBCL      SOQCBCL     MQMSHYP     FQMSHYP     SOQMSHYP

Continuous latent variables
   F1          F2          F

Estimator                                                      MLR
Information matrix                                        OBSERVED
Maximum number of iterations                                  1000
Convergence criterion                                    0.500D-04
Maximum number of steepest descent iterations                   20
Maximum number of iterations for H1                           2000
Convergence criterion for H1                             0.100D-03
Input data file(s)
  W4W5HYPandCBCL.dat
```

Input data format FREE

SUMMARY OF DATA

Number of missing data patterns 24

COVARIANCE COVERAGE OF DATA

Minimum covariance coverage value 0.100

PROPORTION OF DATA PRESENT

Covariance Coverage

	MQCBCL	FQCBCL	SOQCBCL	MQMSHYP	FQMSHYP
MQCBCL	0.839				
FQCBCL	0.587	0.615			
SOQCBCL	0.601	0.524	0.636		
MQMSHYP	0.832	0.598	0.626	0.965	
FQMSHYP	0.664	0.615	0.559	0.748	0.769
SOQMSHYP	0.717	0.577	0.633	0.811	0.703

Covariance Coverage

	SOQMSHYP
SOQMSHYP	0.829

SAMPLE STATISTICS

ESTIMATED SAMPLE STATISTICS

Means

	MQCBCL	FQCBCL	SOQCBCL	MQMSHYP	FQMSHYP
1	4.326	4.390	3.656	2.385	2.243

Means

	SOQMSHYP
1	1.717

Covariances

	MQCBCL	FQCBCL	SOQCBCL	MQMSHYP	FQMSHYP
MQCBCL	5.947				
FQCBCL	2.729	6.613			
SOQCBCL	2.983	2.255	5.964		
MQMSHYP	2.312	1.389	1.238	2.590	
FQMSHYP	1.775	2.898	1.575	1.246	3.195
SOQMSHYP	1.075	0.955	2.213	0.894	1.057

Covariances

	SOQMSHYP
SOQMSHYP	2.379

Correlations

	MQCBCL	FQCBCL	SOQCBCL	MQMSHYP	FQMSHYP
MQCBCL	1.000				
FQCBCL	0.435	1.000			
SOQCBCL	0.501	0.359	1.000		
MQMSHYP	0.589	0.336	0.315	1.000	
FQMSHYP	0.407	0.631	0.361	0.433	1.000
SOQMSHYP	0.286	0.241	0.587	0.360	0.383

Correlations

	SOQMSHYP
SOQMSHYP	1.000

```
MAXIMUM LOG-LIKELIHOOD VALUE FOR THE UNRESTRICTED (H1) MODEL IS -2582.294

THE MODEL ESTIMATION TERMINATED NORMALLY
```

MODEL FIT INFORMATION

```
Number of Free Parameters                       18

Loglikelihood

          H0 Value                       -2646.380

          H0 Scaling Correction Factor      1.0310
            for MLR

          H1 Value                       -2582.294

          H1 Scaling Correction Factor      1.0304
            for MLR

Information Criteria

          Akaike (AIC)                    5328.761

          Bayesian (BIC)                  5394.569

          Sample-Size Adjusted BIC        5337.489
            (n* = (n + 2) / 24)

Chi-Square Test of Model Fit

          Value                            124.529*

          Degrees of Freedom                     9

          P-Value                           0.0000

          Scaling Correction Factor         1.0293
            for MLR

*   The chi-square value for MLM, MLMV, MLR, ULSMV, WLSM and WLSMV cannot
be used for chi-square difference testing in the regular way.  MLM, MLR and
WLSM chi-square difference testing is described on the Mplus website.
MLMV, WLSMV,and ULSMV difference testing is done using the DIFFTEST option.


RMSEA (Root Mean Square Error Of Approximation)

          Estimate                           0.212

          90 Percent C.I.                    0.180  0.246

          Probability RMSEA <= .05           0.000

CFI/TLI

          CFI                                0.670

          TLI                                0.450
```

```
Chi-Square Test of Model Fit for the Baseline Model

          Value                              364.961
          Degrees of Freedom                      15
          P-Value                             0.0000

SRMR (Standardized Root Mean Square Residual)

          Value                                0.127
```

MODEL RESULTS

```
                                                    Two-Tailed
                    Estimate       S.E.  Est./S.E.    P-Value

 F1       BY
    MQCBCL             1.000      0.000    999.000    999.000
    FQCBCL             0.593      0.134      4.438      0.000
    SOQCBCL            0.661      0.108      6.133      0.000

 F2       BY
    MQMSHYP            1.000      0.000    999.000    999.000
    FQMSHYP            0.676      0.133      5.072      0.000
    SOQMSHYP           0.485      0.113      4.292      0.000

 F        BY
    F1                 1.987      0.163     12.196      0.000
    F2                 1.097      0.096     11.438      0.000

 Means
    F                  0.000      0.000    999.000    999.000

 Intercepts
    MQCBCL             4.323      0.153     28.299      0.000
    FQCBCL             4.410      0.188     23.507      0.000
    SOQCBCL            3.631      0.175     20.787      0.000
    MQMSHYP            2.383      0.097     24.689      0.000
    FQMSHYP            2.238      0.118     18.985      0.000
    SOQMSHYP           1.717      0.099     17.323      0.000
    F1                 0.000      0.000    999.000    999.000
    F2                 0.000      0.000    999.000    999.000

 Variances
    F                  1.000      0.000    999.000    999.000

 Residual Variances
```

MQCBCL	1.136	0.498	2.280	0.023
FQCBCL	4.708	0.581	8.097	0.000
SOQCBCL	3.874	0.552	7.021	0.000
MQMSHYP	0.642	0.307	2.093	0.036
FQMSHYP	2.223	0.287	7.736	0.000
SOQMSHYP	1.885	0.230	8.179	0.000
F1	1.000	0.000	999.000	999.000
F2	1.000	0.000	999.000	999.000

STANDARDIZED MODEL RESULTS

STDYX Standardization

	Estimate	S.E.	Est./S.E.	Two-Tailed P-Value
F1 BY				
MQCBCL	0.902	0.044	20.313	0.000
FQCBCL	0.519	0.091	5.732	0.000
SOQCBCL	0.598	0.077	7.749	0.000
F2 BY				
MQMSHYP	0.880	0.053	16.481	0.000
FQMSHYP	0.558	0.088	6.345	0.000
SOQMSHYP	0.465	0.094	4.927	0.000
F BY				
F1	0.893	0.015	60.325	0.000
F2	0.739	0.029	25.202	0.000
Means				
F	0.000	0.000	999.000	999.000
Intercepts				
MQCBCL	1.753	0.086	20.488	0.000
FQCBCL	1.737	0.099	17.506	0.000
SOQCBCL	1.478	0.081	18.291	0.000
MQMSHYP	1.413	0.074	19.207	0.000
FQMSHYP	1.245	0.066	18.814	0.000
SOQMSHYP	1.107	0.066	16.713	0.000
F1	0.000	0.000	999.000	999.000

F2	0.000	0.000	999.000	999.000
Variances				
F	1.000	0.000	999.000	999.000
Residual Variances				
MQCBCL	0.187	0.080	2.332	0.020
FQCBCL	0.730	0.094	7.764	0.000
SOQCBCL	0.642	0.092	6.954	0.000
MQMSHYP	0.226	0.094	2.400	0.016
FQMSHYP	0.688	0.098	7.002	0.000
SOQMSHYP	0.784	0.088	8.947	0.000
F1	0.202	0.026	7.643	0.000
F2	0.454	0.043	10.471	0.000

STDY Standardization

	Estimate	S.E.	Est./S.E.	Two-Tailed P-Value
F1 BY				
MQCBCL	0.902	0.044	20.313	0.000
FQCBCL	0.519	0.091	5.732	0.000
SOQCBCL	0.598	0.077	7.749	0.000
F2 BY				
MQMSHYP	0.880	0.053	16.481	0.000
FQMSHYP	0.558	0.088	6.345	0.000
SOQMSHYP	0.465	0.094	4.927	0.000
F BY				
F1	0.893	0.015	60.325	0.000
F2	0.739	0.029	25.202	0.000
Means				
F	0.000	0.000	999.000	999.000
Intercepts				
MQCBCL	1.753	0.086	20.488	0.000
FQCBCL	1.737	0.099	17.506	0.000
SOQCBCL	1.478	0.081	18.291	0.000
MQMSHYP	1.413	0.074	19.207	0.000
FQMSHYP	1.245	0.066	18.814	0.000

SOQMSHYP	1.107	0.066	16.713	0.000
F1	0.000	0.000	999.000	999.000
F2	0.000	0.000	999.000	999.000
Variances				
F	1.000	0.000	999.000	999.000
Residual Variances				
MQCBCL	0.187	0.080	2.332	0.020
FQCBCL	0.730	0.094	7.764	0.000
SOQCBCL	0.642	0.092	6.954	0.000
MQMSHYP	0.226	0.094	2.400	0.016
FQMSHYP	0.688	0.098	7.002	0.000
SOQMSHYP	0.784	0.088	8.947	0.000
F1	0.202	0.026	7.643	0.000
F2	0.454	0.043	10.471	0.000

STD Standardization

	Estimate	S.E.	Est./S.E.	Two-Tailed P-Value
F1 BY				
MQCBCL	2.224	0.145	15.286	0.000
FQCBCL	1.318	0.270	4.890	0.000
SOQCBCL	1.469	0.223	6.590	0.000
F2 BY				
MQMSHYP	1.484	0.071	20.943	0.000
FQMSHYP	1.004	0.181	5.530	0.000
SOQMSHYP	0.721	0.157	4.583	0.000
F BY				
F1	0.893	0.015	60.325	0.000
F2	0.739	0.029	25.202	0.000
Means				
F	0.000	0.000	999.000	999.000
Intercepts				
MQCBCL	4.323	0.153	28.299	0.000
FQCBCL	4.410	0.188	23.507	0.000
SOQCBCL	3.631	0.175	20.787	0.000

MQMSHYP	2.383	0.097	24.689	0.000
FQMSHYP	2.238	0.118	18.985	0.000
SOQMSHYP	1.717	0.099	17.323	0.000
F1	0.000	0.000	999.000	999.000
F2	0.000	0.000	999.000	999.000
Variances				
F	1.000	0.000	999.000	999.000
Residual Variances				
MQCBCL	1.136	0.498	2.280	0.023
FQCBCL	4.708	0.581	8.097	0.000
SOQCBCL	3.874	0.552	7.021	0.000
MQMSHYP	0.642	0.307	2.093	0.036
FQMSHYP	2.223	0.287	7.736	0.000
SOQMSHYP	1.885	0.230	8.179	0.000
F1	0.202	0.026	7.643	0.000
F2	0.454	0.043	10.471	0.000

R-SQUARE

Observed Variable	Estimate	S.E.	Est./S.E.	Two-Tailed P-Value
MQCBCL	0.813	0.080	10.157	0.000
FQCBCL	0.270	0.094	2.866	0.004
SOQCBCL	0.358	0.092	3.874	0.000
MQMSHYP	0.774	0.094	8.240	0.000
FQMSHYP	0.312	0.098	3.173	0.002
SOQMSHYP	0.216	0.088	2.464	0.014

Latent Variable	Estimate	S.E.	Est./S.E.	Two-Tailed P-Value
F1	0.798	0.026	30.163	0.000
F2	0.546	0.043	12.601	0.000

```
QUALITY OF NUMERICAL RESULTS

Condition Number for the Information Matrix              0.919E-02
(ratio of smallest to largest eigenvalue)

MODEL MODIFICATION INDICES

NOTE:  Modification indices for direct effects of observed dependent
variables regressed on covariates may not be included.  To include these,
request MODINDICES (ALL).

Minimum M.I. value for printing the modification index     10.000

                                  M.I.     E.P.C.  Std E.P.C.  StdYX E.P.C.

BY Statements

F1       BY MQCBCL               22.361    -2.524     -5.614       -2.276
F2       BY MQMSHYP              22.398    -0.770     -1.143       -0.678

ON/BY Statements

F1       ON F1       /
F1       BY F1                   22.394    -2.526     -2.526       -2.526
F1       ON F2       /
F2       BY F1                   22.392     1.395      0.931        0.931
F2       ON F1       /
F1       BY F2                   22.380     1.394      2.089        2.089
F2       ON F2       /
F2       BY F2                   22.399    -0.770     -0.770       -0.770

WITH Statements

MQMSHYP  WITH MQCBCL             30.797     1.575      1.575        1.844
FQMSHYP  WITH FQCBCL             38.086     1.650      1.650        0.510
FQMSHYP  WITH MQMSHYP            16.908    -0.961     -0.961       -0.804
SOQMSHYP WITH SOQCBCL            43.133     1.444      1.444        0.534
F2       WITH F1                 22.392     1.395      1.395        1.395

Variances/Residual Variances

F1                               22.393    -5.052     -1.021       -1.021
```

F2	22.395	-1.540	-0.699	-0.699

SAMPLE STATISTICS FOR ESTIMATED FACTOR SCORES

SAMPLE STATISTICS

Means

	F1	F1_SE	F2	F2_SE	F
1	0.000	1.012	0.000	0.652	0.000

Means

	F_SE
1	0.554

Covariances

	F1	F1_SE	F2	F2_SE	F
F1	3.782				
F1_SE	0.013	0.108			
F2	2.061	0.003	1.663		
F2_SE	-0.009	0.017	-0.004	0.011	
F	1.589	0.005	0.962	-0.004	0.685
F_SE	0.002	0.029	0.000	0.006	0.001

Covariances

	F_SE
F_SE	0.008

Correlations

	F1	F1_SE	F2	F2_SE	F
F1	1.000				
F1_SE	0.020	1.000			
F2	0.822	0.008	1.000		
F2_SE	-0.045	0.495	-0.032	1.000	

```
 F              0.987         0.017         0.902         -0.043        1.000
 F_SE           0.012         0.990         0.004          0.605        0.010

Correlations
              F_SE
              ________
 F_SE           1.000

SAVEDATA INFORMATION
Save file
    toddlerW4W5adhd.dat

Order and format of variables
    MQCBCL              F10.3
    FQCBCL              F10.3
    SOQCBCL             F10.3
    MQMSHYP             F10.3
    FQMSHYP             F10.3
    SOQMSHYP            F10.3
    F1                  F10.3
    F1_SE               F10.3
    F2                  F10.3
    F2_SE               F10.3
    F                   F10.3
    F_SE                F10.3

Save file format
12F10.3

Save file record length    10000

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Appendix V.

The Peer Interaction Coding System

(PICS)

A Coding Manual for Peer Relations for Children under the Age of Three

Dale F. Hay

Cardiff University

Identifying Social Interaction

Identifying Socially Directed Behaviour

The PICS is designed to capture **episodes of social interaction** between at least two infants or toddlers. Social interaction between the peers is defined as an alternating sequence of each child's peer-directed behaviours. Peer-directed behaviours may be physical, vocal, or verbal, but they must clearly be directed to the peer, as signalled by the actor's **gaze** at the other child, or by words (e.g., calling the other child by name). So the first thing the observer must do is decide whether one child is looking in the direction of the other. With nonverbal children, the direction of looking is our best guide to the intentionality of the action.

In the PICS, observers will try to identify peer-directed behaviours. If one child (**the actor)** directs a behaviour to the other (**the recipient),** and the recipient responds by directing a behaviour back to the actor, an **episode** of social interaction has taken place. An episode must contain at least two moves, but may be much longer.

Alternating Moves

Young children's nonverbal interactions are like conversation, and like games, where players take alternating turns. One person acts, and the other person reacts. In the PICS, we divide social interactions into **moves** by each actor. You can imagine a game of chess in which one person acts and the other person responds to the previous action. That is what infants do in their episodes of peer interaction. Of course, it is also possible that one infant directs an action to the peer, which the peer then ignores. **When coding social interaction, observers must record both the socially directed action and the peer's reaction.**

Moves may contain more than one category of behaviour. For example, one infant may emit a swift sequence of behaviours (e.g., reach toward a toy the peer is holding, contact that toy, and tug that toy out of the peer's hand). The whole sequence of behaviours is coded as one move. If the peer reacts, the combination of behaviours that make up the reaction (e.g., cry and tug back) are coded as the following move. Thus interactions are made up of alternating moves by each participant in the interaction. How do you know when a move has ended? Either the other child has reacted, or there is a pause in the action of 3 seconds or longer. If one of the children then directs another behaviour to the peer, that is coded as another move. How do you know when an episode of social interaction has ended? If there is a pause in the action of 30 seconds or longer, we assume one episode of interaction has ended. If a child then directs a behaviour to the peer, that is coded as the first move of a new episode of interaction.

Actions and Reactions

The PICS is designed to categorise the most common ways in which infants and young children initiate a socially directed behaviour and react to the behaviour of their peers. Thus any interaction you code will consist of actions and reactions. Some categories of behaviour can be used to **initiate** an interaction and to **react** to the peer. Other categories can only be coded as reactions to something that has just happened.

The behavioural categories that we code allow us to define two types of interactions between the peers: (1) **conflict**, when the two children are in dispute over toys or violations of personal space, and (2) **prosocial exchanges,** when the two children are interacting in a peaceful, positive manner, by communicating or sharing toys with each other.

Socially-Directed Actions

The following behaviours can be used to initiate interaction with the peer (i.e., as the first move of an episode of peer interaction), or in reaction to something the peer has just done. To be considered socially directed, the infant's eyes must be on the recipient of the action; you must determine whether the infant is at least facing the peer. These behaviours are categorised and defined as follows:

I. Proximity-Seeking or Proximity-Avoiding

Approach: The actor locomotes (i.e., moves each leg at least once) in a direction toward the peer, when the peer is statonary.

Follow: The actor follows the peer around the room; code the time when the actor stops or goes off in a different direction.

Move away: The actor locomotes (i.e., moves each leg at least once) in a direction away from the peer.

II. Prosocial Gestures:

Point out Object to Peer: The actor points to an object at some distance away from the peer, while looking at the peer's face (e.g., points to a toy at a distance from both children, or to a poster on the wall).

Show Object: The actor holds up an object toward the peer's face, while looking at the peer.

Demonstrate Object: The actor holds up an object toward the peer, while looking at the peer and manipulating the object, thus revealing its properties

Offer/Give Object: The actor extends an object toward the peer's hands or lap, possibly releasing it into the recipient's hand or lap

Add Object to Array: The actor shares by releasing an object into an array of objects in the peer's possession (e.g., the actor adds a shape to an array of shapes that can be put into a shape-sorting box, or a ring to a pile of multi-coloured rings with which the peer is playing)

Push/Roll: Without using force, the actor shares an object by pushing or rolling the object toward the peer (e.g, rolls a ball or a toy that is on wheels toward the peer). This is to be distinguished from throwing an object roughly at the peer.

III. Designs on the Peer's Possessions:

In the PICS, the children are considered to possess portable objects if (a) an object is in a child's hands or lap, or otherwise in physical contact with that child; (b) the object is part of an array of toys with which the child is currently playing, on the floor, but in very close proximity to the child (e.g., a brick from a set of Lego bricks with which the child is playing); or (c) the object has been deposited with the child's parent or caregiver, and is in the caregiver's physical possession. The observer's job is to note whether the object is in the peer's possession, and consider whether the design on the object is expressed with a gesture (point or reach), a gentle touch or a rough tugging on the object.

Point to Peer's Object: The actor points to an object in the peer's physical possession, by extending the hand with pointing index finger toward the object, while looking at another person: code whether the child is looking at the peer or to someone else, e.g., the actor's parent;

Reach to Peer's Object: The actor extends a hand toward an object physically held by the peer, extending the hand with outstretched fingers, as if to grasp the object. **Do not reach if the gesture immediately turns into contact of or tugging on the object.**

Takes Object: The actor picks up an object that is not physically in contact with the peer, but is in the peer's possession; this may be accompanied by looking at the peer, but need not be:

(a) Take from array: The actor picks up or places his or her hands on an object from the peer's array of toys

(b) Take5: The actor picks up an object that the peer has just put down, within the last 5 seconds

(c) Take from parent: The actor picks up an object that is in the peer's parents' lap.

Contacts Object: The actor contacts an object that is in the peer's physical possession, using his or her hands, but not using force.

Tugs on Object: The actor uses physical force to grab onto and pull away an object that is held by the peer, pulling it toward him or herself.

IV. Intrusions on the Peer's Personal Space

In the PICS, the observer codes a set of actions whereby the actor intrudes on the peer's personal space, by gesturing toward or actually touching the peer. The observer's job is to determine (1) whether the intrusion was intentional, or whether the actor simply bumped into the peer accidentally, (2) was physical contact made, and (3) if so, was the physical contact was fairly gentle or quite rough. The following behavioural categories are then used:

Unintentional Physical Contact

Bumps into Peer: Without looking at the peer, the actor makes forceful physical contact with the peer. **Code only if forceful contact is made that appears to the observer to be entirely accidental, and therefore not socially directed.**

Intentional Gestures

Reach toward Peer: The actor extends hands and/or arms toward the peer, while looking at the peer. Code only if the peer is not holding a toy or other object, in which this will be assumed to be reach to peer's object.

Swipe at Peer: The actor roughly swipes at the peer, while looking at the peer, but doesn't actually make contact. Note whether there is a toy in the actor's hand; if so, code **Swipe at Peer with Toy.**

Intentional Physical Contact with the Peer

Touch Peer: The actor gently touches the peer with a hand, without using force, while looking at the peer.

Other Contact of Peer: The actor gently touches the peer with another part of his or her body, e.g., a gentle touch of feet. This would usually be accompanied by looking at the peer, but could include sitting back-to-back.

Gives Affection to Peer: The actor hugs, kisses or otherwise uses conventionally affectionate behaviour toward the peer. Note if this was suggested by the mother or other adult.

Places Object on Peer: Without using force, the actor gently places a toy, item of clothing (e.g., a hat), or other object on the peer's head or limb, or uses implements such as combs and brushes to groom the peer.

Forceful Contact (FC): Pulls on Peer: Using force, the actor pulls on the peer's hair, limbs, or clothes.

Forceful Contact (FC): Pushes/Shoves Peer: Using force with his or her hand, the actor presses down or pushes the peer; this may or may not displace the peer's position in space. When push is used as a reaction to the peer's intrusive behaviour, code as **FC Push Away.**

Forceful Contact (FC): Bites Peer: Using mouth and (presumably) teeth, the actor makes forceful contact of the peer's body.

Forceful Contact (FC): Smacks Peer: Using his or her hand, the actor makes forceful contact of the peer's body. Note if the actor has used a closed fist. Code if but note whether the actor has swung toward the peer, but missed. Use **fc** as modifier.

Forceful Contact (FC): Kicks Peer: Using forceful swings of his or her legs or feet, the actor makes forceful contact of the peer's body. Note whether the actor has kicked toward the peer, but missed.

Throws Object at Peer: Using force, the actor throws a toy or other object toward the actor's face or body. Note whether the object has actually hit the peer.

Forceful Contact of Peer with Object: Using force, the actor strikes the peer with a toy or other object.

V. Non-distressed Vocalisation and Speech

For these behavioural categories, the observer must decide which infant is making sounds, and whether there are discernible words.

Vocalise: The actor emits non-distressed voiced sounds while looking at the peer. The sounds could be purely nonverbal or unintelligible speech.

Speak: The actor directs intelligible speech to the peer. The fact that the peer is the recipient is indicated by direction of the actor's gaze and/or using the peer's name in a way that shows the peer is the intended audience for the remark. Transcribe what the child says as best you can.

Reactions to Actor's Behaviour

The behaviour categories previously described can be used as a way of initiating interaction or as reactions to the peer's behaviour. The following categories are only coded as reactions. **Do not code them as initiations**.

VI. Positive/Neutral Reactions

Accept Object Offered by Peer: The recipient grasps or picks up an object that has just been offered by the peer. **If an offer has just been made, code accept, not take.**

Release Object to the Peer: The recipient releases an object in his or her hands into the peer's possession, in response to the peer's pointing at, reaching toward, contacting, or tugging on the object. Release represents yielding to the peer's design on the object. **Do not code release if a child has simply put down an object on the floor, not in response to the peer's design on that object.**

Copy's Peer's Play Action: The recipient duplicates an action that has just been demonstrated by the peer, which is not otherwise defined in the coding system. This code should be used when the recipient repeats a distinctive, playful action, such as banging on the wall of the room, or shouting into the microphone, or engaging in a distinctive set of movements or gestures, not otherwise defined (e.g., doing a little dance).

Watch: The recipient responds to the peer's socially directed action only by looking at the peer. **Do not code watch except in reaction to a peer-directed action.**

No Discernible Reaction (NR): The recipient shows no discernible response to the peer's action, and is not looking at the peer. **It is always necessary to code 'NR' in order to determine if the initiation has led to an interaction or not.**

VII. **Resistance to the Peer's Actions**

Withdraw physically in response to physical intrusions: The recipient shrinks back from contact with the peer, turning face or body away from the peer's hands or body.

Withdraw object away from peer: The recipient pulls an object toward himself or herself, out of reach of the peer's hands. This is coded in response to the peer's pointing at, reaching for, contacting or tugging on objects.

VIII. Protest against the Peer's Actions

Fuss/whimper: The recipient emits voiced sounds that indicate discomfort, short in duration, or in a whinging tone of voice, in response to peer's action **Do not code as an initiation.**

Cry: The recipient engages in full-blown crying, making a loud, wailing sound, with tears often present, in response to the peer's actions. **Do not code as an initiation.**

Verbal Protest: The recipient says ‘No,’ ‘Don’t,’ or otherwise indicates protest of what the peer has just done. Possession claims (e.g., ‘Mine’) can qualify as verbal protest, although they may also be made as initiations.

Appendix VI RBCS & PICS – Free play session

Time	Participant A	Participant B	Participant C
15.38	START		
17.18		1) **SP** to C “police car that one…H”	
			2) **WATCHES** B
17.20		3) **APPROACHES** C and C’s aeroplane	
			4) **WITHO** plane from B
17.26		5) **SP** to C “I, I want to play with the plane”	
17.28			6) **SP** to B “mine!” and **WITHO** plane from B
17.34		7) **SP** to C “I want to play with you, please!”	
			8) **WITHO** plane from B and **SP** to B “no”
17.41		9) **SP** to C “I want ah ah play with it, please!”	
			10) **WATCHES** B
17.51	11) **CONTACT OBJ** C’s plane		
17.55			12) **SP** to A “no! Mine! Mine! Mine!” and **WITHO** plane from A
18.01	13) **SHOW** man to C (as if to say “all I want to do is put the man in the plane”)		
			14) **NR**
18.18	15) **CONTACT OBJ** C’s plane, to put the man back in it		16) **WATCHES** A
			17) **SP** to everyone “mine!” and touches the plane
18.38			
			19) Places hand firmly on the plane, otherwise **NR**
18.49	18) **CONTACT OBJ** C’s plane		
18.55	20) **SP** to C “look, has stuff in…has stuff in” and **POINTS** to the back door of the plane		21) Closes the back door of the plane
			23) Watches the plane
19.00	22) **CONTACT OBJ** C’s plane again		24) **MA** leaving A to play with the plane
19.20			

Time	Participant A	Participant B	Participant C
20.10			1) **APPROACH** A
20.16	2) **MA** with plane		
22.33	1) **SP** to B and B's mother "what does a lion say?....raaaahhh!"		22.33 Flap without an object. End 22.38
		2) **NR**	
22.44	3) **CONTACT OBJ** B's jigsaw puzzle and **SP** to B and B's mother "what does an elephant say?"		
22.56		4) **SP** to A and his mother "what does a giraffe say"?	
23.48	Both A and B put the jigsaw pieces in the puzzle together. 23.50 Bang toy against toy. End 23.51		
23.51	1) **SP** to B "a monkey go there [unintelligible]", A and B both point at the same jigsaw piece on the puzzle board		
23.56		2) **SP** to mother and A "[unintelligible] go there"	
24.02	3) **SP** to B "it goes there" and **POINTS** to the right spot on the jigsaw puzzle board		
24.06		4) **TUG (2)** puzzle piece from A (it's a bit confusing here because B's mother offers it and both boys go to take it, I think B actually has it first, but he is the one who pulls it away from A, A doesn't really pull)	
24.09	5) **RELEASES** puzzle piece to B 6) **SP** to B "[unintelligible]" (speaks too quietly and the mothers are speaking too loudly)		
24.17		7) **NR**	
24.18	8) **SP** to B "and that one goes there"		
		9) **TUG (2)** puzzle piece from A	

	Participant A	Participant B	Participant C
24.22	10) **RELEASES** puzzle piece to B		
24.25	11) **CONTACT OBJ** B's puzzle piece		
		12) **SP** to A "yes, yes yes!"	
	13) **POINT** out the correct hole for the puzzle piece to B		
		14) Follows A's advice	
24.33	15) **POINT** out the correct hole for the puzzle piece to B and **SP** to B "that's the lion down there"		
		16) Does not follow A's advice	
	17) **POINT** out the correct hole for the puzzle piece to B		
		18) **NR**	
	19) Picks up the piece himself and puts it in the right place **?TAKEARR** (but I'm not sure whether this is now a joint array)		
		20) **CONTACT OBJ** A's jigsaw piece	
	21) **RELEASES** puzzle piece to B and **WATCHES** B		
	22) **SP** to B "and a monkey go in there"		
		23) Puts the monkey in the correct hole	
	24) **SP** to B "and a zebra"		
		25) Finds the zebra	
	26) **REACH** for B's zebra puzzle piece and **SP** to B "it's my turn"		
		27) **SP** to A "look"	
	28) **SP** to B "[unintelligible, too quiet]"		
	25.24 Bang toy against another object. End 25.29		

Time	Participant A	Participant B	Participant C
27.23		1) **SP** shouts to ? “please”	
			2) **SP** to B “I like these, OK, this one” and **SHOWS** safari car to B
27.36		3) **SP** to C “no!”	
27.37	4) **ADD (2)** to B		
27.42		5) **ACCEPTS** from A then throws it at the sofa	
			27.43 Bounce. End 27.46
27.47			6) **ADD (2)** ambulance to B
27.50			
27.53	8) **SP** to everyone “I’ve got an aeroplane”	7) **ACCEPTS** ambulance from C	
28.33			
		1) **SP** to self “[unintelligible] nee-nor, nee-nor”	
28.56			
	3) **WATCHES** B	2) **SP** to A “please can I have it?”	
29.10			
		4) **SP** to ? “but I wanted to share the fire engine”	
29.12			5) **THROW** man at B when it bounced off B C pushed it towards B’s head (not sure what the intention is for this, whether antisocial or pro-social)
	End of peer session		

Appendix VII

The means and standard deviations of all of the tasks assessed in Chapter 7.

	Any repetitive behaviour during the toddler assessment?			
	Yes		No	
	Female	Male	Female	Male
Inhibitory Control Tasks				
Raisin task (BR)*	1.2 (1.39)	1.34 (1.52)	1.5 (1.46)	.97 (1.24)
Farm whisper(BR)**	15.99 (8.82)	12.28 (8.44)	13.32 (7.88)	12.51 (7.87)
Tower planning (CF)***	.38 (.49)	.45 (.50)	.35 (.48)	.31 (.47)
Big Bear Little Bear (CF)****	1.24 (1.64)	.93 (1.34)	1.14 (1.61)	1.31 (1.67)
Behavioural Regulation	***.18 (.96)***	***.01 (1.1)***	***.11 (.98)***	***-.15 (.92)***
Cognitive Flexibility	***.01 (1.07)***	***.07 (.99)***	***-.01 (1.02)***	***-.09 (.93)***
Measures of Activity Levels				
Actigraph measurements	638.68 (350)	721.88 (354)	529.67 (285)	779.13 (440)
ADHD symptom rating	.54 (.07)	.53 (.06)	.54 (.08)	.55 (.08)
Communicative Behaviour				
Mean words spoken (L)	3.97 (2.38)	3.35 (2.34)	1.77 (1.93)	2.97 (2.71)
Proportion moves with. speech (L)	.34 (.74)	.27 (.22)	.20 (.23)	.24 (.25)
Nonverbal offers (O)	1.42 (1.22)	1.15 (1.13)	1.02 (1.21)	.71 (.95)
Pretence offers (O)	.49 (1.20)	1.13 (3.17)	.30 (.91)	.28 (1.06)
Language factor score	***.48 (1.16)***	***.05 (.77)***	***-.36 (.89)***	***.01 (1.01)***
Non-verbal factor score	***.09 (.84)***	***.28 (1.6)***	***.02 (.72)***	***-.21 (.72)***

Note tasks that are associated with behavioural regulation factor score = BR, cognitive flexibility factor score = CF, language factor score = L and offer factor score = O.

* This is the number of times the participant waited for the bell to be rung (range 0-4).

** Higher scores indicative of those who inhibited their voice the most (range 0-30)

*** Rating of whether the participant build the ‘correct’ tower as depicted by experimenter (see Figure 7.3b) (range 0-1)

**** Rating of whether the participant placed the items in the correct (and not conventional) location (range 0-4)

Appendix VIII.

Description of the context surrounding the use of repetitive behaviours

Repetitive behaviours	Descriptive information regarding environment
Bang toy/toy	Two additional peers are present in this free play session. Tom and Cerys are playing closely on the floor. Owen is standing next to this interaction. He sits next to the other children and touches Tom's toy with his own toy. Owen then holds another toy in the other hand and bangs the toys together for an extended period. Whilst doing this Owen looks at the toys. No one interacts with him whilst he bangs; parents continue to chat on the sofa. No other changes or notable factors in the room.
Flap	Two other peers are present in this free play session. Tom gives the cup to the Owen's mum; she pretends to use it and then gives it back to Tom. Tom then walks away whilst holding the cup. Whilst walking away he flaps.
Bounce	Two other peers are present in this free play session. Ffion and Elena are interacting with each other. They are standing together at one end of the room. All of the parents are sitting down, chatting with one another. Ffion bounces up and down a lot and stops when Elena runs over and approaches her.
ABS	One other peer is present in this free play session. Ffion and Elena are standing next to each other, backs against a wall, facing the room. They are not interacting or talking to each other. Ffion bangs against the wall whilst Elena continues to stand in the same position. Parents are still seated, chatting amongst themselves.
Bounce	One other peer is present in this free play session. Tom is standing with Cerys against the wall. They are not interacting. Parents are chatting on the sofa. No changes in environment. Tom bounces up and down several times. Cerys throws himself on the floor, this ends the RB.

Rock	Two additional peers are present in this free play session. All children are playing independently. Cerys is sitting alone at the play mat; she is playing with the plastic food. Tom approaches the mat but not the Cerys directly. Cerys rocks 8 seconds after peer's approach. No other change in the environment.
Flap with object	One other peer is present in this free play session. Harri picks an object up flaps with the object and then looks to Betsi before handing the object to the Betsi. Betsi then walks away.
Rock	Two other peers are present in this free play session. Harri is playing at the play mat, he looks like he is enjoying the play food although he is not holding anything whilst he rocks. There is no change to the environment, the parents are still sitting on the sofas and the other participants are still playing independently at other locations in the room.
Rock	Two other peers are present in this free play session. Harri is sitting next to the Betsi on the floor, at the play mat. They are not interacting. Betsi then lies down. Harri rocks. There were no changes to parental location. Parents were not interacting with Harri.
Flap	One other peer is present in this free play session. Betsi has just finished an interaction Harri. She then decides to approach her parents; she runs over with a smile on her face and flaps. Parents who were originally looking elsewhere are now attending to the Betsi. She stops flapping when she reaches her parents. Harri is not near the participant.
Flap	Two other peers are present in this free play session. All of the children are playing independently. All of the children are near to their parents but not playing directly with them. Amy is standing near to her mother but is not interacting directly with her. She looks at the floor and flaps her arms. Eventually her mother shows

	her a toy and Amy stops flapping.
Flap	Two other peers are present in this free play session. Amy is sitting on the floor at the tea party mat with Jo's parents. She is holding the teapot but it has no lid. Amy's mum asks about the lid and she flaps her arms. Then she gives her the lid and she puts it on the teapot and stops flapping.
Bang toy / toy	Two other peers are present in this free play session. Amy and Jo are playing around the room, mostly around the play mat. The Amy is at the other side of the room with her mother. The mother is holding a teddy bear (large) and Amy is holding a smaller teddy bear. She bangs the teddies against each other whilst looking at her mum. The mum does not respond. Participant holds the small teddy against the big teddy, looks away from the mum and watches some interaction at the sofas chatting to each other & watching the peer interaction.
Bang toy other	Two other peers are present in this free play session. Lloyd is holding the teapot to his face; it looks as though he is trying to mouth it. At the same time, Will is on the floor playing with the toys and Richard is with his mum. The mothers are interacting with each other. Lloyd then bangs the toy to his mouth several times and then stops. Nothing happens at the same time as he stops.
ABS	Two other peers are present in this free play session. Whilst manipulating the plane Lloyd looks at the rest of the people in the room and ABS against the plane. Will is conversing with his mum regarding the bear; other peer is playing with a jigsaw alone on the floor. The parents are conversing. No one is interacting with Lloyd.
Flap	Two other peers are present in this free play session. Lloyd is standing next to his mum who is sat at the picnic mat. They are discussing the teddy bears. Will and Richard are also sat and the picnic mat, playing with the toys. Lloyd is not looking at Will or Richard. Whilst talking to the mum about the teddies Lloyd flaps

	his arms.
Flap	Two other peers are present in this free play session. Richard is sitting next to the mum and the mum attending to him, reading a book on the sofa. Richard flaps his arms whilst looking at the book and the mum continues to read.
Bounce	Two other peers are present in this free play session. Linda has been building a Duplo tower with her dad. The tower in on the coffee table. Linda picks it up to show others, she then carries on playing with the tower. All peers are playing independently. Linda plays alone and quietly with the tower. Parents are conversing with one another. Linda bounces and then carries on with independent play.
Rock	Two other peers are present in this free play session. Linda takes a cake from the plate that is located between her parents. She pretends to eat it and rocks back and forth at the same time. She seems to be making eating sounds. Whilst doing this Stuart watches Linda. Immediately after the rock, dad tells Linda to get something and she goes to retrieve it.
Rock	One other peer is present in this free play session. Diana is sitting on the beanbag chair facing the room; she doesn't seem to be watching anyone in particular. Caroline then runs behind her and stands in the corner of the room, also facing out towards everyone. Diana rocks and directs her gaze towards Caroline. She then gets up from the chair to face Caroline and then they interact around the bean bag chairs
Rock	One other peer is present in this free play session. Malc is playing on his own at the coffee table, his mum puts the party hat on his head but he does not like it. Participant pulls it off and then gives it to his mum. Malc then rocks a few times whilst kneeling on the floor. He is looking at the toy that is next to him. Malc's mum then tells him to give the hat to Gill and he stops rocking at the same time.
Bang toy/ other	One other peer is present in this free play session. Gill is sitting on the floor next to Malc; they are both playing with the toy cars. Gill keeps

	lifting hers up to the air and puts it back down. Eventually she bangs toy without looking at anyone and then carries on playing with the car. The parents are chatting. Gill looks at the toys whilst banging.
Bounce	One other peer is present in this free play session. Alex is sitting on the sofa drinking, looking at Kay who is conversing with her mum. Alex bounces 3 times. There are no changes to the environment.
Rock	One other peer is present in this free play session. Alex is leaning on sofa next to his mum. He is not talking to anyone. All other peers are playing independently on the floor, Alex is watching them. SHe rocks 4 times and then stops with no other interruptions. There is no conversations in the room
Rock	One other peer is present in this free play session. Alex is leaning against the sofa with his sibling and their mum is also on the sofa. The mum tells Alex something but it is hard to hear what she says because of other noises in the room. Alex throws the toy that was in his hand and rocks against the sofa. He stops without direction.

Note A random selection of repetitive behaviours was selected for the description.