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PARS ING OF SUB J ECT–VERB AGRE EMENT IN THE ACQUI S I T ION OF CATALAN AND GERMAN

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Diese Doktorarbeit widme ich meiner Mutter, die mir beigebracht hat, mit Ausdauer den schweren Weg zu gehen und niemals aufzugeben. Ihre Unterstützung und ihr Glaube an mich waren stets eine Quelle der Motivation und Inspiration.

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ABSTRACT

This dissertation delves into the understanding of the early parsing of subject-verb agreement in children and infants, approached through the lens of offline and online methodologies. In study 1, I present two experiments. Experiment 1 replicates the study by Pérez-Leroux (2005), focusing on the comprehension of number (singular, plural) and sentences with overt and null subjects among Catalan-speaking children. A total of 111 children (age range: 2;4–6;9) and 62 adults participated in a sentence-picture matching task. Results showed that performance was above chance for all conditions except the singular, null subject where children were at chance. Experiment 2 introduced a numeral distractor to the same experimental items. Performance was above chance for all conditions and age groups. These results corroborate the impact of methodological differences on the parsing of subject-verb agreement, as noted by Brandt-Kobele & Höhle (2010) and Gonzalez-Gomez et al. (2017). The findings suggest that the observed delays in agreement comprehension are not due to language-specific properties but rather methodological artifacts. Study 2 includes two experiments employing the Preferential Looking Paradigm to analyze the early acquisition of subject-verb agreement in infants. Experiment 1 measured gaze duration while infants listened to sentences with full DP and null-subjects in Catalan. The results showed a significant looking preference for the target, indicating that infants as young as 19.3 months can effectively parse subject-verb agreement in Catalan. Experiment 2 extended this paradigm to German; sentences with full DP and pronominal subjects; pronominal subjects introduced ambiguity through the pronoun *sie* 'she/they', forcing infants to rely on the verb to identify the subject. Again, gaze duration analysis revealed significantly longer looks at the target in the Full-DP and the pronominal conditions. These findings demonstrate that infants exhibit early syntactic competence in parsing subject-verb agreement. The results show that the overall trajectory of agreement acquisition is similar across languages, whether infants are acquiring a null-subject or a non-null subject grammar.

RESUM

Aquesta tesi explora la concordança subjecte-verb en nens i infants, abordada mitjançant metodologies offline i online. A l'estudi 1, presento dos experiments. L'experiment 1 reprodueix l'estudi de Pérez-Leroux (2005), que se centra en l'anàlisi implícita (*parsing*) del nombre (singular, plural) i oracions amb subjectes explícits i nuls entre els nens catalanoparlants. Un total de 111 nens (edats: 2;4–6;9) i 62 adults van participar en una tasca de correspondència oració-imatge. Els resultats mostren que els nivells d'anàlisi adulta estan per sobre de l'atzar en totes les condicions excepte en la condició de subjecte nul singular, on els nens tenien un comportament a nivell de l'atzar. L'experiment 2 introdueix un distractor numèric als mateixos ítems experimentals. El comportament va ser superior a l'atzar en totes les condicions i grups d'edat. Aquests resultats corroboren l'impacte de les diferències metodològiques en l'anàlisi de la concordança subjecte-verb, tal com van notar Brandt-Kobele & Höhle (2010) i Gonzalez-Gomez et al. (2017). Els resultats suggereixen que els retards observats en la concordança no es deuen a propietats específiques de la llengua, sinó que són artefactes metodològics. L'estudi 2 inclou dos experiments que utilitzen el Paradigma de Mirada Preferencial per analitzar l'adquisició primerenca de la concordança subjecte-verb en infants. L'experiment 1 mesura la durada de la mirada durant l'audició d'oracions amb SD ple i subjectes nuls en català. Els resultats mostren una preferència significativa de mirada cap a l'objectiu i, per tant, indica que els infants a partir dels 19.3 mesos poden analitzar correctament la concordança subjecte-verb en català. L'experiment 2 estén aquest paradigma a l'alemany. Inclou frases amb SD complet i subjectes pronominals en què els subjectes pronominals introdueixen ambigüitat a través del pronom *sie* 'ella/ells' i forcen els infants a confiar en el verb per identificar el subjecte. L'anàlisi de la durada de la mirada va revelar de nou mirades significativament més llargues cap a l'objectiu en les condicions de SD ple i pronominal. Aquestes resultats demostren que els infants manifesten una competència sintàctica primerenca en l'anàlisi implícita de la concordança subjecte-verb, tant si adquireixen una llengua de subjecte nul com si adquireixen una llengua que no sigui de subjecte nul.

ZUSAMMENFASSUNG

Diese Doktorarbeit untersucht das frühe kognitive Verarbeiten der Subjekt-Verb-Kongruenz bei Kindern und Kleinkindern, analysiert durch Offline- und Online-Methoden. In Studie 1 präsentiere ich zwei Experimente. Experiment 1 repliziert die Studie von Pérez-Leroux (2005), die sich auf das Verständnis von Numerus (Singular, Plural) sowie auf Sätze mit expliziten und Nullsubjekten bei katalanischsprachigen Kindern konzentriert. Insgesamt nahmen 111 Kinder im Alter von 2;4 bis 6;9 Jahren und 62 Erwachsene an einer Satz-Bild-Zuordnungsaufgabe teil. Die Ergebnisse zeigten, dass die Leistung in allen Bedingungen über dem Zufallsniveau lag, außer bei Singular-Sätzen mit Nullsubjekten, wo die Kinder auf Zufallsniveau lagen. Experiment 2 führte einen numerischen Distraktor in dieselben experimentellen Items ein. Die Leistung lag in allen Bedingungen und Altersgruppen über dem Zufallsniveau. Diese Ergebnisse bestätigen den Einfluss methodologischer Unterschiede auf das Parsing der Subjekt-Verb-Kongruenz, wie von Brandt-Kobele & Höhle (2010) und Gonzalez-Gomez et al. (2017) festgestellt. Die Befunde legen nahe, dass die beobachteten Verzögerungen im Verständnis der Kongruenz nicht auf sprachspezifische Eigenschaften, sondern auf methodologische Artefakte zurückzuführen sind. Studie 2 umfasst zwei Experimente, die das Preferential-Looking-Paradigma verwenden, um den frühen Erwerb der Subjekt-Verb-Kongruenz bei Babys zu analysieren. Experiment 1 maß die Blickdauer, während Kleinkinder Sätze mit vollem Determinierer-Phrase (DP) und Nullsubjekten im Katalanischen hörten. Die Ergebnisse zeigten eine signifikante Blickpräferenz für das Ziel, was darauf hinweist, dass Kleinkinder bereits im Alter von 19,3 Monaten die Subjekt-Verb-Kongruenz im Katalanischen effektiv parsen können. Experiment 2 erweiterte dieses Paradigma auf das Deutsche, mit Sätzen, die sowohl volle Determinierer-Phrasen als auch pronominale Subjekte beinhalteten. In den pronominalen Subjekten führte das Pronomen *sie* ('sie/Sie') zu Ambiguität und zwang die Kleinkinder, sich auf das Verb zu verlassen, um das Subjekt zu identifizieren. Auch hier zeigte die Analyse der Blickdauer signifikant längere Blicke auf das Ziel in den Bedingungen mit vollem Determinierer-Phrase und den pronominalen Bedingungen. Diese Befunde zeigen, dass Kleinkinder früh syntaktische Kompetenz im Parsing der Subjekt-Verb-Kongruenz aufweisen. Die Ergebnisse legen nahe, dass die allgemeine Trajektorie des Erwerbs der Kongruenz in verschiedenen Sprachen ähnlich ist, unabhängig davon, ob die Kleinkinder eine Grammatik mit oder ohne Nullsubjekt erwerben.

RESUMEN

Esta tesis profundiza en la comprensión del análisis temprano de la concordancia sujeto-verbo (SV) en niños y bebés, utilizando metodologías tanto offline como online. En el Estudio 1, presento dos experimentos. El Experimento 1 replica el estudio de Pérez-Leroux (2005), centrándose en la comprensión del número (singular, plural) y las oraciones con sujetos explícitos y nulos entre niños hablantes de catalán. Participaron un total de 111 niños (rango de edad: 2;4-6;9) y 62 adultos en una tarea de emparejamiento oración-imagen. Los resultados mostraron que la proporción de la respuesta correcta fue significativamente superior al azar en todas las condiciones, excepto en la condición de singular con sujeto nulo, donde el desempeño de los niños no superó el nivel de azar. El Experimento 2 introdujo un distractor numeral en los mismos ítems experimentales. El desempeño fue significativamente superior al azar en todas las condiciones y grupos de edad. Estos resultados corroboran el impacto de las diferencias metodológicas en el análisis de la concordancia sujeto-verbo, como se ha señalado en estudios previos (Brandt-Kobele y Höhle, 2010; Gonzalez-Gomez et al., 2017). Los hallazgos sugieren que los retrasos observados en la comprensión de la concordancia no se deben a propiedades específicas del idioma, sino más bien a artefactos metodológicos. El Estudio 2 incluye dos experimentos que emplean el Paradigma de Preferencia de Mirada para analizar la adquisición temprana de la concordancia sujeto-verbo en infantes. El Experimento 1 midió la duración de la mirada mientras los infantes escuchaban oraciones con sujeto pleno y sujeto nulo en catalán. Los resultados mostraron una preferencia significativa de mirada hacia el objetivo, indicando que los infantes de tan solo 19,3 meses pueden procesar efectivamente la concordancia sujeto-verbo en catalán. El Experimento 2 extendió este paradigma al alemán; oraciones con sujetos plenos y sujetos pronominales; los sujetos pronominales introducían ambigüedad a través del pronombre "sie" (‘ella/ellos’), forzando a los infantes a depender del verbo para identificar al sujeto. Nuevamente, el análisis de la duración de la mirada reveló miradas significativamente más largas hacia el objetivo en las condiciones de sujeto pleno y pronominal. Estos hallazgos demuestran que los infantes exhiben una competencia sintáctica temprana en el análisis de la concordancia SV. Los resultados muestran que la trayectoria general de la adquisición de la concordancia es similar en todos los idiomas, independientemente de si los infantes están adquiriendo una gramática de sujeto nulo o de sujeto no nulo.

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ETHICAL CONSIDERATIONS

The experimental work presented in this thesis was conducted following the principles of the Declaration of Helsinki. Furthermore, ethical approval for the experiments on the early acquisition of agreement in Chapters 3 and 4 was obtained from the Comissió d'Ètica en l'Experimentació Animal i Humana of the Universitat Autònoma de Barcelona (CEEAH approval number 6467).

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ACRONYMS

ACC Anterior cingulate cortex

CP Complementizer Phrase

DLPFC dorsolateral prefrontal cortex

DPBE Delay of Principle B Effect

ECM Exceptional Case Marking

FL Faculty of Language

fMRI Functional magnetic resonance imaging

GB Government and Binding model

HAS High-amplitude sucking

HPP Head-turn preference procedure

IPLP Intermodal Preferential Looking Paradigm

LF Logical Form

LWL Looking-while-listening

MAE Mainstream American English

MLU Mean length of utterance

MP Minimalist Program

OI Optional Infinitive

OM Object agreement

PF Phonological Form

PLP The Preferential Looking Paradigm

PS Picture selection tasks

pSTG Posterior superior temporal gyrus

RI Root Infinitive

ROI Region of Interest

SM Subject morpheme

SD Standard deviation

T Tense

TP Tense Phrase

TW Time window

UG Universal Grammar

vP vPhrase

1

INTRODUCTION

The logical problem of poverty of stimulus, or Plato's problem (Chomsky, 1965), poses a fundamental question in linguistics and cognitive science. It investigates how children can acquire complex and abstract language systems with apparent ease and speed despite receiving limited and often imperfect linguistic input. Noam Chomsky has been pivotal in formulating this argument, suggesting that an innate linguistic structure must be part of human cognition to account for such rapid language acquisition despite insufficient input (Chomsky, 1965). This idea is also supported by empirical research on language development, which highlights the inadequacy of environmental input alone to explain the linguistic capabilities observed in young children (Pinker, 1994).

The debate surrounding Plato's problem extends to various theoretical perspectives, including connectionist models, which attempt to explain language acquisition through general cognitive processes rather than specialized linguistic modules (Rumelhart et al., 1986). However, critics argue that these models fail to account for the speed and uniformity of language acquisition observed across different languages and cultures (Fodor, 2008). This ongoing discussion underscores the complexity of understanding human language acquisition and the need for further interdisciplinary research to unravel the intricacies of Plato's problem (Jackendoff, 2002).

This paradox of rapid language acquisition and proficiency suggests that the linguistic input available to children is insufficient to fully explain their extensive linguistic competence (Chomsky, 1980). Despite being exposed to incomplete and potentially erroneous linguistic data, such as fragmented sentences and grammatical inconsistencies, children rapidly and efficiently learn their native language and grasp its intricate grammatical structures (Chomsky, 1965). The input received by language learners is insufficient for mastering fully-fledged grammar. Children encounter adult utterances, not abstract grammatical structures, yet they successfully acquire a hierarchically organized system of categories and rules (Chomsky, 1981).

Children are exposed to a finite number of utterances, yet they can produce and comprehend an infinite number of sentences (Chomsky, 1965, 1972). This ability demonstrates an understanding of language that far surpasses the apparently limited input (Pinker, 1994). Moreover, children develop a grasp of what is not possible in their language, often without explicit correction or instruction (Chomsky, 1965, 1972). This shows a nuanced comprehension of language that goes beyond their immediate experiences

(Pinker, 1994). Such capacity suggests that children possess some form of internal knowledge or mechanism that aids them in navigating the complexities of their native language (Lenneberg et al., 1967).

The poverty of stimulus argument provides a way to explain why observable input alone is insufficient to account for the linguistic competence that children exhibit. They do not merely reproduce language; they also extrapolate beyond the language experiences directly accessible to them (Chomsky, 1980; Pinker, 1994). Baker and MacCarthy (1981) summarizes this argument, highlighting its critical role in understanding language acquisition:

a. *Rich Linguistic Knowledge from Finite Input*: Children develop extensive linguistic knowledge that includes a potentially infinite number of sentences despite their exposure to a finite set of sentences. This observation supports the concept of an innate linguistic capacity, indicating that children's linguistic competence exceeds their direct linguistic experiences.

b. *No Linguistic Instructions*: The primary linguistic data for children consist of positive evidence, including grammatical sentences in their language. This reliance implies that children infer grammatical rules and structures without explicit instruction on what constitutes ungrammaticality. Without explicit instruction, children establish which sentences are ill-formed or what interpretations are not possible in their language.

c. *Selective Error Patterns in Language Acquisition*: The errors that children make in language learning reveal much about their innate grammatical understanding. Unlike what might be expected if they were merely extrapolating from the examples they hear, children's mistakes do not usually mirror the potential grammatical errors present in their input. For instance, after being exposed to question forms like "Who do you want to come?", they seldom produce malformed questions such as "Who do you wanna come?". This avoidance of certain types of errors suggests children operate within an innate linguistic framework, which guides them away from certain ungrammatical constructions. Their ability to navigate around these pitfalls, even without being explicitly corrected, points to a deeper, intuitive grasp of language rules that goes beyond mere imitation of heard speech.

Building on this understanding of the complexities of language acquisition, it has been shown that it takes place in a specific time period, the critical period (Lenneberg et al., 1967). Lenneberg's critical period hypothesis posits that language acquisition takes place between early childhood and puberty. This timeframe is marked by heightened neural plasticity, which is essential for the optimal organization and absorption of language. Accord-

ing to Lenneberg et al. (1967), the biological foundations of language acquisition are most effectively established during this critical period, facilitating a more profound and efficient mastery of language skills. Failing to acquire language within this sensitive window can result in permanent deficits, underscoring the importance of appropriate environmental exposure during this phase (Curtiss, 1977). This exposure is crucial to activate the innate language faculties proposed by theorists like Chomsky, emphasizing the natural, biologically predetermined aspects of language acquisition while also acknowledging the limited, but necessary role of environmental input.

Following the exploration of the poverty of the stimulus argument and the critical period hypothesis, it becomes evident that these concepts lay a foundational theoretical framework supporting the innatism perspective. The rapid and robust nature of language acquisition, observed even in the face of limited and imperfect linguistic input, points to the existence of an innate linguistic capacity within children. There are studies on which infants' linguistic preference can be tested, as shown in Figure 1 just 20 hours post-birth, an infant participates in a procedure where the act of sucking is shown to relate to speech sounds heard through headphones.

Figure 1: High Amplitude Sucking (HAS) technique (Moon et al., 2013).

According to Moon et al. (2013) the exposure to the ambient language in utero begins to influence the fetuses' phonetic perception of their native language, which can be observed soon after birth through their differing responses to familiar versus unfamiliar vowels. The remarkable linguistic competencies observed in infants highlight their ability to discriminate be-

tween different languages based on rhythmic patterns shortly after birth, underscoring an innate sensitivity to linguistic structures (Mehler et al., 1988). Such findings not only affirm the concept of Universal Grammar but also demonstrate the specialized nature of linguistic cognition, distinct from other cognitive abilities. To illustrate, a study conducted by Mehler et al. (1988) examined the ability of newborns to differentiate between languages based on their rhythmic properties. The researchers hypothesized that infants are born with an innate sensitivity to the prosodic features of language, which enables them to discriminate between different linguistic inputs even before they have acquired any specific language knowledge. To test this hypothesis, Nazzi and colleagues designed a series of experiments involving newborns, typically only a few days old. They used the High-amplitude sucking (HAS) paradigm shown in Figure 1, a common method in infant research that measures changes in an infant's sucking behaviour in response to auditory stimuli. In these experiments, infants were exposed to sentences from different languages that varied in rhythmic class—specifically, stress-timed (e.g., English), syllable-timed (e.g., Spanish), and mora-timed [1] (e.g., Japanese) languages. The findings revealed that infants exhibited different sucking patterns when exposed to sentences from different rhythmic classes, indicating that they could distinguish between languages based on their rhythmic properties. For instance, infants could discriminate between English and Japanese or between Spanish and Japanese, but found it more challenging to distinguish between languages within the same rhythmic class, such as English and Dutch. This demonstrated that the infants' sensitivity was specifically tuned to the rhythmic patterns of language. Nazzi et al.'s study provided compelling evidence for the notion that the ability to process rhythmic patterns in language is present from birth, suggesting that this sensitivity is an innate component of the human language faculty. Nazzi et al.'s study reinforces this idea by demonstrating that infants have an inherent ability to discriminate between languages based on rhythmic cues, despite having minimal exposure to linguistic input. This innate sensitivity to linguistic structures provides a foundation for language acquisition that cannot be fully explained by environmental input alone. Furthermore, the study highlighted infants' ability to discriminate between languages based on rhythmic patterns indicates that linguistic processing operates differently from other cognitive abilities. This specialization suggests that the human brain is equipped with distinct neural mechanisms dedicated to language

1 A mora-timed language is a language in which the rhythm and timing of speech are organized around moras, with each mora representing a unit of sound that takes approximately equal time to articulate. Japanese serves as a prime example of such a language. This timing mechanism contrasts with syllable-timed languages, where rhythm is based on syllable duration, and stress-timed languages, where rhythm is based on the interval between stressed syllables ((Ladefoged & Johnson, 2011; Tsujimura, 2007)

acquisition and processing, separate from those used for other types of auditory or cognitive tasks.

This capacity, deeply embedded within the human cognitive architecture, aligns with Noam Chomsky's Universal Grammar (UG)—a set of prewired grammatical rules and structures that guide the language learning process from an early age (Chomsky, 1965, 1986b). The evidence for innatism, bolstered by the foundational theories of the poverty of the stimulus and the critical period, is further examined through empirical research. Studies conducted by Berwick and Chomsky (2011) and Crain and Pietroski (2005), among others, offer compelling insights into how children's innate linguistic predispositions interact with environmental inputs to foster language development. Berwick and Chomsky (2011) argue that the linguistic input available to children is insufficient to account for the rich and complex linguistic knowledge they eventually attain. They propose that children must possess an innate linguistic framework or universal grammar that allows them to infer the rules of their language from limited and often imperfect input. Their studies build on various linguistic phenomena, such as syntactic structures and hierarchical sentence formation, demonstrating that children can grasp these complex rules without explicit instruction or sufficient examples in their environment. This innate capacity is seen as evidence of a biologically endowed language faculty that is triggered by exposure to linguistic input. Crain and Pietroski (2005) further supports the innatist perspective by examining how children interpret sentences which are ambiguous. They conducted experiments showing that, even at a young age, children can disambiguate sentences based on innate syntactic principles rather than relying solely on contextual clues or frequency of occurrence in their linguistic environment. For instance, they explored children's understanding of scope ambiguity in sentences with quantifiers and negation, such as "Every boy didn't climb a tree." Their findings revealed that children's interpretations align with innate grammatical principles, suggesting that their linguistic knowledge is significantly shaped by innate cognitive structures.

However, individuals who miss this crucial window, the critical period, such as late learners of a second language or individuals with delayed exposure to their first language, often struggle to achieve the same level of proficiency, underscoring the interplay between biological timing and linguistic input. As we transition into the next section, we will delve deeper into how generativism address these foundational questions of language acquisition, examining the mechanisms to achieve fluent linguistic performance.

1.1 A GENERATIVE APPROACH TO LANGUAGE ACQUISITION

This thesis is rooted in the generativist framework, which addresses the complex challenges of early language acquisition. Situated at the conver-

gence of linguistics, cognitive science, and developmental psychology, this research aims to unravel the innate mechanisms underlying infants' language capacities—a pivotal inquiry for comprehending the intricacies of human cognitive architecture. The concept of UG developed by Chomsky has revolutionized our understanding of language's innate structures. Chomsky proposed that all human languages share a set of structural rules, genetically encoded and universally present irrespective of cultural context (Chomsky, 1972). This universal grammar is crucial for explaining how children, even with limited and noisy linguistic input, as discussed in Chapter 1, can develop complex linguistic systems (Chomsky, 1965, 1981). According to Chomsky, the capacity to acquire language is an innate faculty of the brain, pre-configured to recognize grammatical structures common across all languages (Berwick & Chomsky, 2015). Generativism posits that the fundamental architecture of language learning is predicated on an innate linguistic framework. This theoretical framework, stemming from Chomsky's work, focuses on describing the implicit knowledge that speakers of a language possess about its structure (Chomsky, 1972). This knowledge, which is not explicitly taught, allows individuals to generate an infinite number of sentences from a finite set of rules and vocabulary (Chomsky, 1965, 1972). Generativist linguistics aims to identify and formalize these underlying grammatical rules that are universally shared among all human languages (Chomsky, 1981). This idea emerged as a response to the inadequacies of behaviorist theories of language acquisition, which could not sufficiently explain the rapid and uniform development of language among children (Chomsky, 1959; Skinner, 1957).

Chomsky proposed that UG consists of a set of syntactic principles that are applicable across all languages (Chomsky, 1965, 1981). One key principle is the concept of hierarchical structure, which posits that sentences are organized into nested layers of phrases, each with its own internal structure (Chomsky, 1965). This hierarchical organization allows for the construction of complex sentences from simpler ones. Another fundamental principle is recursion, the ability to embed structures within similar structures, enabling the creation of infinitely long sentences (Chomsky, 1965, 1972). To this basic system, the idea has been put forward that particular linguistic domains may be subject to variation; these are the so-called parameters (Chomsky, 1981), discussed in Chapter 2. Parameters are like switches that can be turned on or off based on linguistic experience. For example, the null subject parameter determines whether a language allows sentences without an explicit subject. In languages like Italian or Spanish, the parameter is set to allow null subjects, whereas in English, the parameter is set to require explicit subjects (Rizzi, 1982). While the core principles of UG are universal, the specific settings of these parameters account for the variations observed across different languages (Chomsky, 1981). These parameters influence var-

ious aspects of language, including word order, inflection, and agreement (Chomsky, 1981). For example, one parameter might determine the typical order of the verb and object in a sentence (verb-object versus object-verb order). Another parameter might govern the presence and placement of inflectional morphemes that mark tense, aspect. Similarly, parameters can affect how languages handle agreement features, such as gender, number, and person. When children are exposed to a particular language, they use the linguistic input to set these parameters accordingly, allowing them to acquire the specific rules of that language while still adhering to the universal principles of UG (Chomsky, 1981). This parameter-setting model explains how children can learn any language to which they are exposed, despite the diversity of linguistic systems (Chomsky, 1981). It suggests that all languages are variations on a common theme, shaped by the same underlying grammatical framework (Chomsky, 1981).

Steven Pinker builds upon Chomsky's ideas, arguing that the "language instinct" is an evolutionary adaptation that equips humans with a unique set of abilities for processing linguistic information (Pinker, 1994). The language faculty refers to the innate biological mechanisms that enable humans to acquire and use language (Chomsky, 1981). According to Chomsky's theory, this faculty consists of a set of linguistic principles and parameters that are hard-wired into the human brain. These principles are universal, applying to all human languages, while the parameters allow for variation between languages, enabling the diversity observed in linguistic structures worldwide (Chomsky, 1981, 1995). The concept of the language faculty posits that children can interpret and generate the linguistic input they receive. For instance, the principle of structure dependence suggests that syntactic rules depend on hierarchical structures rather than linear sequences of words. This principle helps explain why children can correctly form complex sentences even when exposed to relatively simple linguistic input (Chomsky, 1986a). One fundamental aspect of this theory is parameter-setting.

Studies on the critical period have shown that the timing of exposure to linguistic input significantly affects the ease and success of language acquisition, further highlighting the importance of this interaction (Lenneberg et al., 1967). Furthermore, research by Fodor and Carin (1990) and Wexler (1996) has demonstrated that children's language development follows predictable patterns, which are consistent with the notion of UG and parameter-setting. These studies show that children across different languages make similar types of grammatical errors, which are systematically corrected as they mature, suggesting that they are actively setting parameters based on their linguistic environment.

Furthermore, advancements in neurobiological research have begun to pinpoint specific brain structures involved in language processing. Functional magnetic resonance imaging (fMRI) studies have identified areas such as

Broca's and Wernicke's as biologically predisposed for their roles in language, supporting the generative assertion that language capabilities are hard-wired into the brain (Friederici et al., 2011). Generativism not only elucidates how children overcome the poverty of the stimulus but also highlights the universal patterns of language acquisition observed across diverse cultures and linguistic environments. This perspective fundamentally contests and expands upon prior empiricist views by positing innate biological readiness as central to language development. From a nativist perspective, linguistic knowledge acquisition is regarded as stemming from an innate endowment. This innate framework, while not a fixed set of detailed linguistic rules, acts as a flexible template that is refined through exposure to specific linguistic environments (Jackendoff, 2002). This idea presents a sophisticated interplay between innate mechanisms and environmental interaction, suggesting that while universal grammar provides the cognitive scaffolding for language acquisition, its actualization is profoundly influenced by linguistic experience (Chomsky, 1981; Pinker, 1994). The theoretical underpinnings of generativism suggest that children begin their language learning journey with an intrinsic understanding of grammatical rules common to all human languages. Chomsky's pioneering work posits that this capability is rooted in a set of biologically shared principles, challenging the view that language acquisition is solely driven by environmental factors (Chomsky, 1965, 1972).

The empirical sections of this thesis explore early agreement parsing in children and infants, investigating how specific language exposure activates and refines the innate grammatical structures posited by universal grammar.

1.2 THE EVOLUTION OF LANGUAGE SKILLS

Understanding how children seamlessly acquire language and universally progress through similar developmental stages has long intrigued scholars, drawing parallels to the innate acquisition of physical abilities such as walking (Brown, 1973; Hart & Risley, 1995; Lenneberg et al., 1967). Just as children around the world learn to walk at roughly the same age and follow a predictable sequence of developmental milestones, they also acquire language in a remarkably uniform manner (Brown, 1973; Lenneberg et al., 1967).

The research indicates that children everywhere typically pass through similar stages of language development: from babbling to single words, to two-word phrases, and eventually to complex sentences. This sequence is observed across diverse linguistic and cultural contexts, implying the existence of a universal developmental trajectory in language acquisition (Brown, 1973). For instance, Brown's seminal work on language development documented that children progress through specific stages, regardless

of the language they are learning, highlighting the predictability and universality of this process (Brown, 1973). The uniformity of language acquisition stages has led researchers to draw parallels with other innate developmental processes. For example, Lenneberg proposed that language development, like motor skills, is a biologically timed process, closely tied to the maturation of the brain and nervous system (Lenneberg et al., 1967). He suggested that just as children are genetically programmed to develop the ability to walk, they are also preprogrammed to acquire language, provided they receive adequate linguistic input during the critical period. The concept of a "critical period" for language acquisition is a central topic in neurolinguistics and developmental psychology. As already mentioned, this concept posits a specific window during early human development when the capacity to acquire language is maximally facilitated. Originally proposed by Eric Lenneberg (1967), the critical period hypothesis asserts that maturational constraints within the human brain significantly enable language learning from early infancy until approximately puberty. Lenneberg emphasized that beyond this pivotal phase, language acquisition not only becomes challenging but also is unlikely to result in full native-like proficiency (Lenneberg et al., 1967). Lenneberg et al. (1967) reviewed cases of children who had been deprived of linguistic input due to circumstances such as social isolation (e.g., feral children) and those with hearing impairments who received delayed exposure to language (Lenneberg et al., 1967). By comparing their language acquisition capabilities with those of children who had normal linguistic exposure, he identified significant delays and deficits in those deprived of early language input. Additionally, Lenneberg et al. (1967) analyzed recovery patterns of language abilities in individuals who suffered brain injuries at different ages. His observations revealed that younger individuals exhibited a higher likelihood of regaining language functions, whereas older individuals showed diminished recovery potential (Lenneberg et al., 1967). Furthermore, Lenneberg investigated second language acquisition, noting that individuals who began learning a second language after puberty often struggled to achieve native-like fluency. This observation was supported by empirical studies demonstrating that the timing of exposure to a new language critically affected the level of proficiency attained. He based his conclusions on various sources: longitudinal studies, cross-sectional analyses, and case studies. These diverse methodological approaches allowed Lenneberg to triangulate evidence from multiple sources, reinforcing the idea that there is a biologically determined period during which language acquisition occurs most naturally and effectively. This hypothesis profoundly impacts our understanding of both the intrinsic nature of language and its intricate relationship with brain development. The interaction between language acquisition and neurological development during early childhood highlights a critical phase during which the brain's

linguistic capacities are formed and solidified. This interplay suggests that the brain's structure is influenced not only by genetic factors but also significantly shaped by the linguistic environment during the critical period (Lenneberg et al., 1967). The theory suggests that if a child does not receive adequate linguistic input during this critical period, typically ending around puberty, the ability to acquire and utilize language in a typical manner may be permanently impaired. Researchers have further explored the critical period's implications, highlighting that the brain exhibits heightened receptivity to specific environmental stimuli during early development. This period is crucial for establishing the foundational linguistic structures that children will use throughout their lives, marking a unique synergy between natural learning abilities and environmental interaction (Lakshmanan, 1995).

Empirical support for this hypothesis is illustrated through studies of feral children. The case of Genie, a young girl found in 1970 who had experienced extreme social isolation and abuse from a very young age, underscores the consequences when a child is deprived of linguistic exposure during the critical period. Linguistic assessments conducted by Susan Curtiss in the 1970s demonstrated that despite substantial rehabilitation efforts, Genie failed to fully acquire a first language, supporting the hypothesis that the critical period is crucial for normal language development (Curtiss, 1977). Another pertinent example is Victor of Aveyron, a French feral child discovered in the late 18th century. The extensive work undertaken by Jean Marc Gaspard Itard, a pioneering French doctor, with Victor further highlights the challenges of language acquisition outside the critical period. Itard's rigorous educational attempts revealed only minimal success in language development, illustrating the critical period's boundaries and the long-term consequences of its miss (Lane, 1976). These cases have significantly influenced the ongoing debate over nature versus nurture in language development, reinforcing the theory that regular human interaction and early linguistic exposure are foundational to typical language development. Moreover, they exemplify the potential permanence of language deficits arising from inadequate early exposure, as posited by Lenneberg et al. (1967) and Curtiss (1977).

The critical period hypothesis continues to be a subject of dynamic research, with contemporary studies exploring its limits and the degree of flexibility it may possess. Recent neuroscientific research suggests that while the critical period does impose significant constraints, individual neuroplasticity may allow for some degree of language learning success even beyond this period, though typically with less efficacy (Newport et al., 2001). Recent research by Dehorter and del Pino (2020) has expanded our understanding of critical periods, traditionally viewed as finite windows of heightened developmental plasticity. Their findings suggest that interventions during these periods could potentially redirect abnormal developmental trajecto-

ries, particularly in the context of neurological and neuropsychiatric disorders. This indicates a broader potential for intervention and influence beyond the previously understood scope. Dehorter and del Pino (2020) emphasize that critical periods in brain development are epochs of heightened plasticity influenced by environmental factors. This perspective aligns with the concept of the critical period in language acquisition, wherein the brain exhibits a heightened ability to absorb and process linguistic information. In addition to these insights, the research conducted by Peña et al. (2012) challenges the assumption that earlier speech exposure in infants necessarily accelerates language acquisition. Their study on full-term and preterm infants indicates that brain maturation, rather than merely the duration of exposure to speech, is critical in shaping phonological representations in early childhood. This finding highlights the interplay between biological development and environmental exposure during the critical period for language acquisition, emphasizing the complexity of factors that contribute to language development. Furthermore, the ethical considerations emerging from the study and rehabilitation of feral children like Genie and Victor of Aveyron are profound. These considerations encompass debates about the appropriate treatment methods and the ethical limits of attempting to rehabilitate individuals after extended periods of neglect (Rymer, 1994; Singerman, 1981). The modern psychological and special educational approaches increasingly advocate for personalized educational therapies that consider the complex emotional, social, and cognitive needs tailored to the unique developmental histories of each individual (Koluchova, 1976; Spitz, 1945).

Recent neurological research provides additional support for the validity of the critical period hypothesis. Studies have shown that synaptic plasticity, which refers to the brain's ability to form and reorganize synaptic connections in response to learning or experience, is particularly active during early developmental stages. This neuroplasticity includes processes such as synaptic pruning, which refines neural connections by reducing the number of unnecessary synapses. The rate of synaptic pruning declines significantly after childhood, suggesting a neurobiological basis for the increasing difficulty of language learning as one ages (Huttenlocher, 1974).

Central to this discussion are several brain regions involved in language processing, each playing a critical role in the acquisition and development of linguistic capabilities during the critical period. Broca's area plays a crucial role in language processing by coordinating various aspects of speech production, integrating multimodal information, and facilitating the formation of syntactic structures (Hagoort, 2005). However, its function involves a complex network of cortical and subcortical regions essential for effective communication (Friederici et al., 2011). Broca's area, located in the frontal lobe, is instrumental in language production and sentence structuring (Brodmann, 1909). Its function is paramount during early language development,

facilitating the formation of coherent syntactic structures necessary for effective communication. Recent studies have redefined the role of Broca's area, showing it mediates the cascade of activation from sensory representations of words in the temporal cortex to their corresponding articulatory gestures in the motor cortex, rather than participating directly in the articulation itself (Flinker et al., 2015a). Additionally, it has been proposed that Broca's area (including subregions such as BA44 and BA45), is involved in different aspects of language processing. Damage to these areas does not necessarily result in classical Broca's aphasia unless the lesions extend to surrounding regions, indicating a broader network involvement in language production (Ardila et al., 2016). Moreover, Broca's area is also jointly activated during speech and gesture production, highlighting its role in integrating multimodal aspects of communication (Brown & Yuan, 2018). Studies using functional MRI have shown that the subregions of Broca's area, such as pars triangularis (BA45) and pars opercularis (BA44), are involved in different language functions, including phonological and syntactic processing (Zhang et al., 2018).

The synaptic activity in Broca's area during the critical period supports complex linguistic functions, and there are studies that indicate that damage or underdevelopment in this region can lead to Broca's aphasia, characterized by halting and effortful speech and selective syntactic impairment (Grodzinsky, 2000). Similarly, Wernicke's area, situated in the temporal lobe, is crucial for the comprehension of spoken language. The effective connectivity between Wernicke's area and other language-related regions, such as Broca's area, is essential for the seamless translation of language comprehension into speech production. The susceptibility of Wernicke's area to synaptic pruning during early development optimizes language processing capabilities, highlighting the importance of this period for linguistic maturation (Binder, 2017; Mesulam et al., 2015; Wang et al., 2015). The auditory cortex also plays a foundational role in language development by processing basic sound inputs. This area's maturation is crucial for recognizing and differentiating phonetic elements, laying the groundwork for more advanced language skills. The development of the auditory cortex during the critical period facilitates the early acquisition of phonetic distinctions that are essential for the later development of fluent language skills (Kuhl, 2000; Tallal, 2004).

The areas shown in Figure 2 illustrate the areas involved in language. The brain's heightened plasticity during the critical period not only enables the robust development of language-related neural pathways. Failure to receive adequate linguistic stimulation during this critical period can lead to permanent deficits in language development, supporting the hypothesis that both innate biological predispositions and environmental factors are crucial for language acquisition (Kuhl, 2004; Lenneberg et al., 1967).

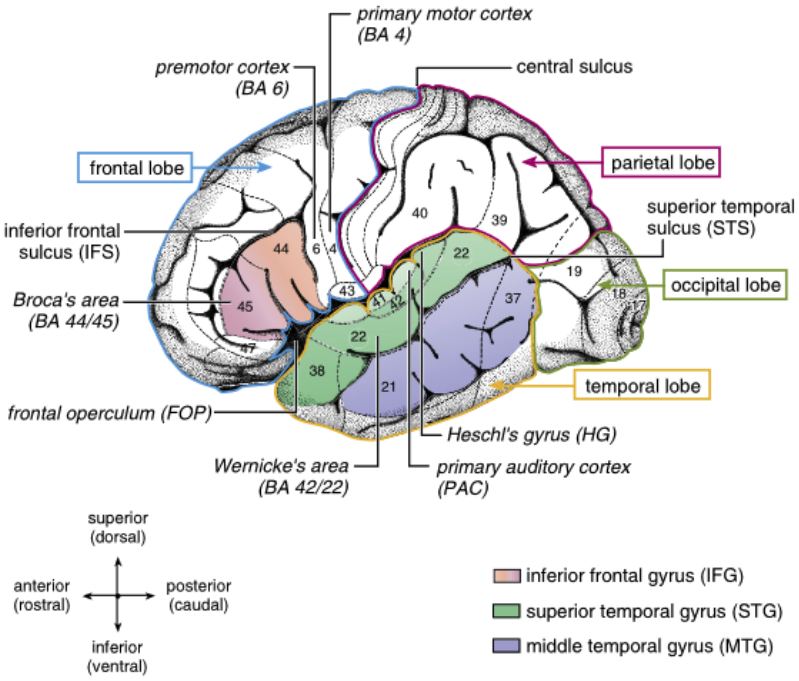


Figure 2: Anatomical and cytoarchitectonic details of the left hemisphere, highlighting lobes, major gyri, and language-relevant Brodmann Areas by Friederici et al. (2011)

This aligns with empirical findings from second-language acquisition research, such as studies by Newport and Aslin (2004), which indicate that individuals who begin learning a language during the critical period are more likely to achieve near-native proficiency compared to those who start later in life (Newport & Aslin, 2004). Figure 3, by Werker and Hensch (2015) graphically represents the evolution of language skills in infants and children, correlated with age in months. This representation relates the critical period with the dynamic contours of developmental plasticity.

From birth to approximately six months, the nascent phase is characterized by a pronounced adaptability in language discrimination, signifying the ability to discern distinct linguistic sounds. This plasticity, peaking after birth, rapidly declines in the ensuing months. Sequentially, a period emerges for the establishment of native phonetic categories, signifying a pivotal phase where infants acclimatize to the phonemic nuances of their native language. Progressing to the 6 to 14-month stage, infants develop heightened sensitivity towards word forms, marking a critical phase in the discernment of unique word sounds and structures. Early word production begins as infants transition from babbling to producing their first recognizable words around 10 to 12 months of age, with the ability to produce syntactic sequences by 18 months. This developmental milestone is supported by the infants' ability to segment continuous speech into distinct phonological units, a skill that emerges from birth and is refined through exposure to

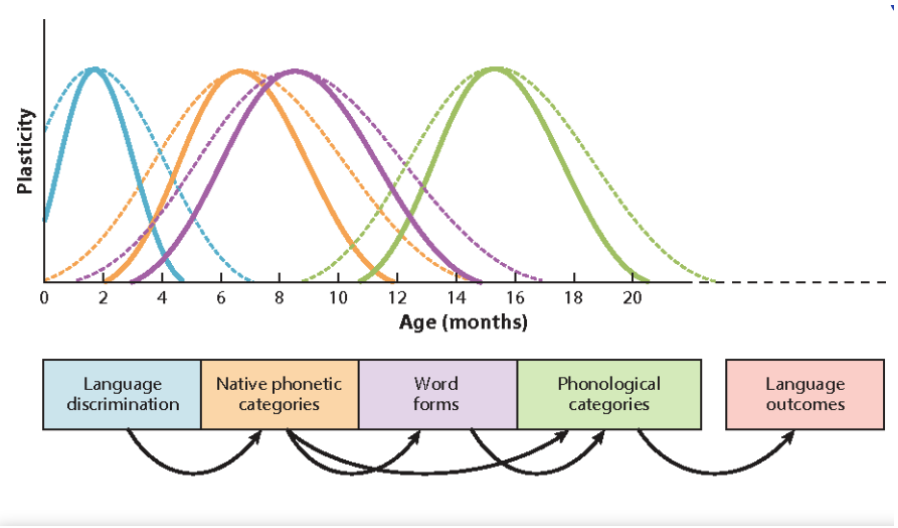


Figure 3: Evolution of language skills Werker and Hensch (2015)

spoken language. Research by Huttenlocher (1974), and Oviatt (1980) provides foundational insights into these early stages of language development. These studies emphasize the significance of phonological development and the infants' capacity for prosodic and segmental discrimination, which facilitates the early association of sounds with their meanings. Notably, by the age of 4 to 6 months, infants begin to recognize their names and establish initial word-object associations, highlighting the rapidity and efficiency of lexical acquisition even in the first year of life (Bergelson & Swingley, 2017; Tincoff & Jusczyk, 1999).

Lexical knowledge encompasses an individual's understanding and use of vocabulary, including the ability to recognize and produce words. The period between 18 to 24 months is characterized by a significant increase in vocabulary size, often described as a "vocabulary spurt" (Bates & Goodman, 1997; Fenson et al., 1994). Measures of vocabulary growth typically rely on caregiver reports, though these can sometimes overestimate lexical knowledge. Experimental approaches, such as the preferential-looking paradigm and reaction time analyses in word identification tasks, offer more objective insights into children's lexical abilities (Fernald et al., 2008; Golinkoff et al., 1987).

Phonological bootstrapping refers to the process by which infants leverage phonological cues to segment speech and identify words. This ability plays a crucial role in early language acquisition, enabling children to extract lexical items from the speech stream and begin analyzing their syntactic and semantic properties. Research by Christophe et al. (1997) and further studies have shown that infants can use prosodic and phonological patterns to discern word boundaries and build prelexical representations. This skill underpins the development of more advanced linguistic abilities, including

the recognition of word categories and the analysis of morphosyntactic features (Christophe et al., 1997; Gervain & Werker, 2013).

While alternative theories, such as the usage-based account of language acquisition (Tomasello, 2003), propose explanations rooted in domain-general cognitive processes and environmental interactions, the evidence presented in this chapter suggests a narrower window during early development when the ability to learn language is at its peak and does not remain active in the way that general cognitive development does.

1.3 A METHODOLOGICAL APPROACH TO EXAMINE LANGUAGE ACQUISITION

In this thesis, I adopt a multifaceted approach to explore language acquisition among children and infants exposed to Catalan and German. This diverse methodology is necessitated by the varying capabilities of the age groups tested, demanding a tailored approach to effectively cater to their respective developmental stages.

For children, I utilize the picture selection method to assess their linguistic abilities. This method is particularly suited for those who have attained the requisite cognitive and motor skills to interact with visual stimuli. Specifically, this approach is employed to examine agreement phenomena in Catalan. As expounded by Crain and Fodor (1987), this method entails presenting children with a series of images, prompting them to select the one that aligns with a given sentence or phrase, thereby evaluating their grasp of linguistic stimuli. The work by Crain and Pietroski (2005) on the child's lexical competence lays a foundational framework for understanding how such interactive methodologies adeptly capture the nuanced linguistic navigation of children through their developing linguistic landscape. Conversely, for infants at 17 months—a phase marked by emerging linguistic abilities but a constrained capacity for complex linguistic engagement—I turn to the preferential-looking paradigm. This method is selected based on the insights from Hirsh-Pasek and Golinkoff (1985), who highlight its effectiveness in early language assessment. Despite the infants' limited linguistic productive abilities, they demonstrate a significant ability to engage with visual stimuli and process linguistic information. This paradigm is thus utilized to probe parsing of agreement in both Catalan and German. Analyzing infants' gaze patterns in response to various linguistic structures offers valuable insights into their early language development.

Employing these distinct methods—picture selection for children and preferential-looking for infants—I endeavor to compile a comprehensive depiction of language development from infancy through childhood. This methodological plurality, inspired by landmark works in the field, facilitates a detailed examination of the evolution of language skills from early infancy

to later childhood. In what follows I present in some more detail the methods used.

The Picture Selection Paradigm in child language comprehension studies

The Picture Selection Paradigm is recognized as a versatile and child-centric methodology that significantly enhances our understanding of language processing in children, especially due to its non-reliance on verbal responses. This approach is crucial for evaluating language comprehension in individuals with emerging reading or writing abilities, including young children and those encountering developmental challenges (Hoff, 2009).

In this paradigm, auditory stimuli, typically sentences, are presented to the participant. These stimuli, either voiced by the researcher or through recordings, are carefully tailored to match research objectives, including vocabulary, and grammar. Concurrently, children are shown a set of representational images, including a target image that visually represents the spoken sentence's meaning, alongside one or several distractor images. The task requires children to identify the image that aligns with the auditory information, often through pointing or interactive methods such as touchscreen inputs (Snedeker & Trueswell, 2004). This exercise assesses the child's capacity to link spoken language with visual representation and is notably beneficial for children with verbal communication difficulties (Justice & Pence, 2005). The "learning criterion" in Picture Selection tasks refers to a predefined accuracy level or comprehension that participants must achieve to be considered as having successfully understood the target sentence. Achieving this criterion often means accurately identifying spoken sentences' corresponding images across a significant majority of trials, showcasing a robust grasp of the language concepts being tested (Fenson et al., 2007). Research by Köder and Falkum (2020) reveals that children aged 3 to 8 years show enhanced performance in picture selection tasks for understanding metonymy compared to children under the age of 3, indicating the paradigm's particular effectiveness and appropriateness for this age group. Additionally, Krist and Krüger (2012) discovered that even children as young as two years could meet the learning criterion in Picture Selection tasks, proving the paradigm's value for toddlers and indicating its widespread utility for language comprehension studies across the early stages of childhood Krist and Krüger (2012).

The Preferential Looking Paradigm

The The Preferential Looking Paradigm (PLP) and its variant, the Intermodal Preferential Looking Paradigm (IPLP) (Cauley et al., 1989; Golinkoff et al., 1987; Hirsh-Pasek & Golinkoff, 1996b), have been central to the field of in-

fant research, providing critical insights into early development (Golinkoff et al., 2013). The PLP operates on the principle that infants and older individuals tend to look longer at stimuli that capture their interest, that they recognize as familiar, or that match the spoken stimuli they are hearing. This behaviour is used to infer their cognitive and perceptual processes (Hamlin, 2014). In typical PLP studies, infants are shown two visual stimuli simultaneously, usually side-by-side, ranging from simple patterns to complex scenes. The duration of the infant's gaze at each stimulus is measured, with the assumption that longer looking times indicate preference or recognition (Stone & Bosworth, 2019). This paradigm has been instrumental in exploring the infants' ability to discriminate between stimuli, preferences for certain patterns or faces, and the development of visual attention (Golinkoff et al., 2013; Hamlin, 2014). The IPLP extends the PLP by incorporating auditory stimuli, using sound to direct the infant's attention to one of the visual displays. This method allows for more nuanced insights into not only visual but also auditory processing and the integration of these sensory modalities in early development. Researchers typically record infants' eye movements with cameras and analyze this data to measure how long they look at each display. Studies using IPLP have shown that infants often look preferentially toward the display that corresponds to the word or sentence they hear, a finding that has been foundational in language development research (Golinkoff et al., 2013; Tafreshi et al., 2014).

The very first study using the IPLP demonstrated that 17-month-old children could comprehend a range of nouns (e.g., boat, shoe) and verbs (e.g., dance, wave) (Golinkoff et al., 1987). The IPLP presents children with a choice between two visual stimuli shown simultaneously, where only one of the visual stimuli matches an accompanying linguistic stimulus. If infants comprehend the linguistic stimuli, they are predicted to look longer at the matching display than at the non-matching display. This method, therefore, differs from visual fixation paradigms such as habituation, which relies on the perception of novelty. Instead, the IPLP and its offshoots, including the Interactive IPLP, PLP, and the Looking-while-listening (LWL) procedure, are based on infants' ability to interpret what they hear to find a matching display (Hirsh-Pasek & Golinkoff, 1985; Hollich et al., 2000).

In the preferential-looking paradigm, infants are typically seated on a caregiver's lap while visual stimuli are presented on screens positioned to their left and right (details shown in Figure 4). The experiment measures where and for how long the infant looks at each stimulus. Modern implementations often use eye-tracking technology to provide precise data on gaze direction and duration. This technology records eye movements and can differentiate between looks directed at each stimulus, allowing researchers to infer the infant's preferences based on gaze patterns (Stone & Bosworth, 2019).

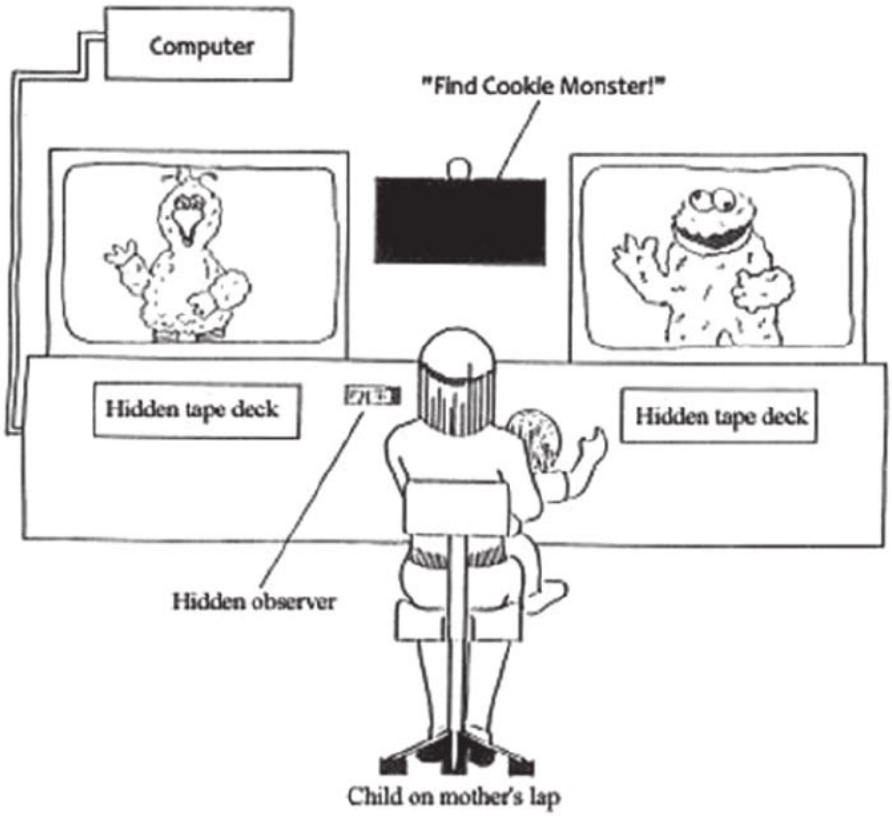


Figure 4: Procedure of the Intermodal Preferential Looking Paradigm Hirsh-Pasek and Golinkoff (1996b)

The procedure involves several key components. Infants are presented with pairs of stimuli, such as a familiar pattern versus a novel one. The stimuli can range from simple geometric shapes to complex social scenes or faces. The primary dependent variable is the duration of gaze directed at each stimulus. Researchers assume that longer looking times indicate greater interest or recognition. Data is analyzed to determine preferences. For example, if an infant consistently looks longer at a novel stimulus compared to a familiar one, it suggests recognition and interest in novelty (Hamlin, 2014).

The IPLP adds an auditory component, where infants are exposed to sounds that are synchronized with visual stimuli. For instance, a word might be played while the corresponding object is displayed on one side of the screen. The infant's gaze is then tracked to see if they look longer at the matching visual stimulus when they hear the word, indicating an understanding of the word-object association (Golinkoff et al., 2013). These paradigms have demonstrated that even very young infants have sophisticated perceptual and cognitive abilities. They provide a non-invasive and effective means to study these abilities before infants have developed the motor skills and language necessary for more interactive forms of testing. The preferential-looking paradigms thus offer a window into the preverbal mind (Hamlin, 2014). Furthermore, studies employing the IPLP have highlighted

the importance of controlling for factors such as parental awareness, as this can influence infant-looking behavior and potentially alter conclusions in word learning studies (Alcock et al., 2020). This underscores the complexity and the need for meticulous experimental design in infant research using these paradigms (Stone & Bosworth, 2019; Tafreshi et al., 2014).

1.4 RESEARCH AIMS AND THESIS OUTLINE

This research investigates how pre-verbal infants and children process syntactic agreement in null and non-null languages with rich morphological. The dissertation unfolds over five chapters, focusisng on the acquisition of subject-verb agreement parsing within the generative grammar tradition, with a special focus on Catalan and German.

After this first chapter, chapter 2 presents the theoretical framework that anchors the study. It starts with an analysis of the impact of parameter setting, particularly the null-subject parameter, and its ramifications during the optional infinitive stage of child language development. Progressing into the minimalist framework, the chapter emphasizes the significance of agreement in syntactic theory. The focal point of this discourse is the operation of Agree, laying the groundwork for empirical inquiries to follow. Chapter 3 presents the literature on children's mastery of subject-verb agreement through offline methods. It documents two empirical studies, focusing on Catalan-speaking children; the original experiments include conditions such as full-DP and null-subject, and finish with a discussion on the implications of these findings for our understanding of language acquisition. Chapter 4 progresses the empirical analysis, turning to online methodologies to evaluate the early parsing abilities of infants. This chapter examines the parsing ability of subject-verb agreement in Catalan and German infants. The concluding chapter, Chapter 5, synthesizes the theoretical and empirical findings of the dissertation. It revisits and critically analyzes the discrepancies observed in previous work between comprehension and production. The chapter also delineates future research avenues.

2

BACKGROUND

Within the generative approach to language acquisition, agreement and parameter setting emerge as critical aspects for breaking-down how children discern and choose between binary syntactic options that their linguistic environments propose. This contrast is starkly evident between languages such as Catalan and German—the two languages to which this thesis is devoted.

This chapter begins with an introduction to the key theoretical constructs within the generative approach, emphasizing the importance of parameter setting and agreement. Following this introduction, the chapter delves into the specifics of parameter setting in language acquisition and its manifestation in the distinction between null-subject and non-null-subject languages (Hyams, 1986). Following this, the chapter explores the null-subject parameter, and how children acquire this parameter, discussing how this stage reflects children's developing syntactic knowledge and its significance for understanding the acquisition of tense and agreement features (Hoekstra & Hyams, 1998; Wexler, 1994a). A final section is devoted to a detailed analysis on the verbal domain of Catalan and German, examining the specific syntactic properties and the verbal paradigm of these languages.

2.1 CORE OPERATIONS IN THE MINIMALIST PROGRAM

Minimalist Program (MP), conceived by Noam Chomsky in the early 1990s, represents a radical streamlining of earlier syntactic theories within generative grammar (Chomsky, 1995). Its primary goal is to simplify the complex rules and transformations characteristic of earlier frameworks by reducing them to a minimal set of principles necessary to generate natural language sentences (Chomsky, 1995; Pires, 2006). The MP seeks not only to explain how languages are structured but also why they are structured that way by focusing on the most economical ways to satisfy syntactic constraints (Chomsky, 1972, 1995). Before the advent of Minimalism, the field of generative syntax was dominated by the Government and Binding model (GB), itself an extension of the earlier Transformational Grammar (Chomsky, 1981). The GB framework, characterized by a set of syntactic principles and levels of representation (like D-structure and S-structure), aimed to account for the syntactic phenomena of a wide variety of languages through a modular approach to syntax (Chomsky, 1981, 1998).

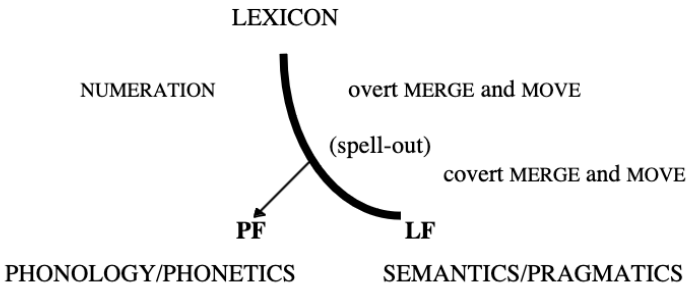


Figure 5: Architecture of the syntactic derivation, taken from Kennedy (2002)

As discussed by Hornstein (2009) and Lasnik and Lohndal (2010), while the GB theory has been highly influential within the field of generative grammar, it has faced criticism for its complexity and lack of explanatory elegance. Explanatory elegance refers to a theory's ability to provide simple, intuitive, and insightful explanations for a wide range of phenomena using a minimal set of principles and rules (Chomsky, 1995). GB theory, characterized by its multiple levels of syntactic representation, often appeared overburdened and lacking transparency, leading to critiques of its explanatory power (Newmeyer, 1980). Critics argued that while GB described linguistic phenomena in great detail, it fell short in offering deeper theoretical insights into the fundamental principles governing language structure (Newmeyer, 2005). The shift towards the MP, initiated by Chomsky, aimed to address these shortcomings by focusing on core computational principles underlying language (Chomsky, 1995). The transition from GB to MP marked a significant paradigm shift, focusing on streamlining the syntactic theory into a more parsimonious model. This shift is notably discussed in works by Chomsky (1995) and later refined in Chomsky (2000b), where Chomsky introduced key concepts such as Merge and Agree.

In the MP, the focus shifts towards understanding language as an optimal solution to communicative needs, constrained by cognitive capacities. The MP posits that the language faculty is composed of an optimal, efficient system that aims to meet the needs of semantic interpretation and phonetic realization. This framework is based on the hypothesis of an "optimal solution to design specifications" for the Faculty of Language (FL), as theorized by Chomsky (1998). At the heart of the MP are two pivotal levels: Logical Form (LF) and Phonological Form (PF). These interfaces play crucial roles in the bridge between syntax and other cognitive domains, thus facilitating simplified language processing and comprehension (Boeckx, 2005; Uriagereka, 2000). Figure 5 represents the architecture of a linguistic derivation.

A syntactic derivation begins with the lexicon, where elements are selected to form a numeration. These elements undergo overt syntactic oper-

ations such as Merge and Move, which are conducted before the derivation reaches the Spell-Out stage. At Spell-Out, the derivation splits into two paths: one leading to the PF interface, which handles the phonetic and phonological aspects of language, and the other to the LF interface, which deals with semantic and pragmatic interpretation. Covert syntactic operations, also involving Merge and Move, occur post-Spell-Out, ensuring that the structures are properly aligned with both PF and LF requirements (Chomsky, 1995, 2000b).

The MP aims to reduce the syntactic theory to its bare essentials, focusing on the minimal necessary conditions for language structure and processing. This approach provides a more streamlined, efficient framework for exploring complex linguistic phenomena, thereby enhancing our understanding of the human language faculty (Chomsky, 1995). Subsequent developments and elaborations of the theory of Chomsky (2000b, 2001) further emphasize its cognitive alignment, suggesting that linguistic processes adhere to principles of economy and optimal design (Chomsky, 2000b). These insights are supported by empirical research that explores how these minimalist syntactic structures are processed cognitively (Berwick & Chomsky, 2011), thereby affirming the program's significance in linking syntactic theory with psycholinguistic reality.

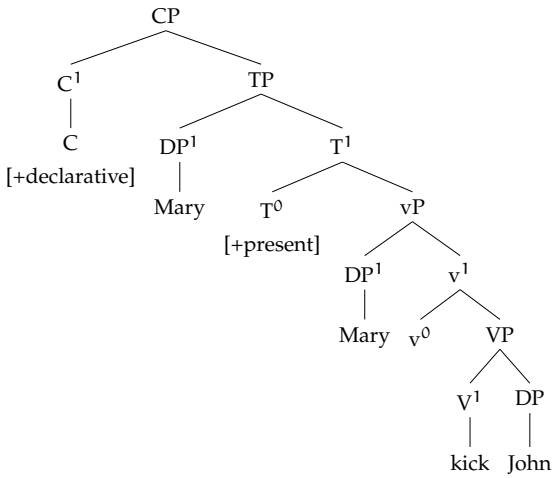
One of the fundamental operations in MP is Merge, which combines two syntactic objects into a single new object, forming the basic building blocks of syntactic structures (Chomsky, 1995). Merge is responsible for the hierarchical nature of syntactic trees and underpins the recursive nature of language. Another critical operation is Agree, which handles the checking and valuation of features between elements in a syntactic structure. Agree simplifies the mechanisms of feature checking introduced in GB theory by providing a more direct means of establishing syntactic dependencies (Chomsky, 2000b). Additionally, Chomsky introduced the concept of stages to account for locality constraints in syntax. stages, such as vPhrase (vP) and Complementizer Phrase (CP), serve as units of syntactic computation, where operations like Spell-Out and movement are constrained to occur within these stages. This helps to explain why certain syntactic dependencies are limited in scope.

Merge manifests into two primary forms (Chomsky, 2000a, 2001):

- **External Merge**: This operation combines two distinct syntactic elements to create a new syntactic unit. It is fundamental in building basic syntactic structures and pivotal in the initial stages of syntactic analysis. External Merge is essential for the assembly of lexical items into phrase structures, a process that underlies all syntactic tree construction (Chomsky, 1995).

- **Internal Merge**: Often referred to as "Move," this form involves relocating an existing element within the syntactic structure. Internal Merge is crucial for deriving complex sentence constructions and allows for phenomena such as wh-movement and topicalization. These operations are integral to the formation of interrogative and focus structures in various languages, amongst others (Chomsky, 1995, 2001).

The following tree diagram (2.1) shows how Merge operates in these two fundamental forms for a sentence in English: External Merge and Internal Merge. External Merge is employed to combine discrete syntactic elements, such as merging kick with John to form an initial verb-object structure, and subsequently integrating these with other elements like Mary. This operation is essential for building the foundational syntactic configurations of the sentence. At the apex of the syntactic structure lies the Complementizer Phrase CP, which encapsulates the entire sentence with the feature [+declarative] indicating a declarative statement. Below the CP is the Tense Phrase Tense Phrase (TP), housing the tense marker T [+present]. The v Phrase vP introduces the verb and encodes transitivity and agentivity, introducing Mary as the agent. This highlights Internal Merge, crucial for case checking. Nested within the vP combines the verb kick with its direct object John, forming the predicate where Mary performs the action of kicking John. In the particular case of English, the subject Mary is internally merged to the specifier of TP.



The operation known as Agree is essential for syntactic feature checking (Chomsky, 2000a). This operation requires a syntactic probe, typically a verb or an auxiliary, to match its grammatical features, such as number and person, with those of a corresponding goal, e.g. the subject. The concept of Agree simplified syntactic analysis significantly, shifting away from a multitude of specific transformational rules towards a more uniform and systematic feature-checking mechanism across different linguistic contexts (Chomsky, 2001). Chomsky moved away from traditional spec-head configuration to a model where the crucial syntactic relationship for agreement is

determined by nearest c-command. The revised notion of agreement facilitated by the operation known as Agree is defined by Chomsky as follows:

> "The ϕ-set we can think of as a probe that seeks a goal, namely 'matching' features that establish agreement. [...] Upon locating this goal, the probe erases under matching. [...] The erasure of uninterpretable features of both probe and goal constitutes the operation we call Agree. [...] Matching is a relationship that must hold between a probe P and a goal G for Agree to occur. Not every matching pair induces Agree. For this to happen, G must (at least) be within the domain D(P) of P and must satisfy specific locality conditions. More broadly, uninterpretable features render the goal active, enabling it to engage in operations. Both Agree and Move require a goal that is local and active" (Chomsky, 2000a, p. 122).

The ϕ features that the quote alludes to are a subset of the features that characterize lexical items. Formal features are those that are relevant for syntactic computation and, amongt those, ϕ features refer to gender, number and person features (valued, for example, as +plural, +3 person).

Chomsky (2001) integrates the notion of Agree into a model known as Abstract Feature Transfer, proposing that Agree entails the transfer of abstract features between different elements of a sentence. This mechanism facilitates a feature-checking process that does not require physical movement, thereby simplifying the syntactic operations necessary for establishing agreement. This is evident in instances such as the agreement between a verb and its subject, where features like gender, number, or person are aligned to ensure the grammatical integrity of the sentence, so that abstract features can be checked and matched without necessitating the movement of the elements involved. This operation minimizes the computational demands of syntax by ensuring that features such as number, person, and gender are checked within a constrained local domain, rather than across complex configurational distance (Chomsky, 2001).

In general terms, agreement in linguistic theory typically denotes a consistent relationship between an attribute of one element and a structural attribute of another (Corbett, 2006). Subject-verb agreement, where the verb in a sentence must agree in number (and often in person) with its subject, is one of the most studied aspects of syntactic agreement (Corbett, 2006), and is found to vary across languages (Aoun & Li, 2003). Concord refers to the alignment of morphosyntactic features between nouns and their associated adjectives, determiners, or pronouns. This type of agreement is especially prominent in languages with rich case systems, such as Russian or German. Theoretical models addressing case agreement often explore the mechanisms through which syntactic structures accommodate multiple case

markings, influenced by the syntactic positions of the agreeing elements. Studies by Baker (2008b) have shown that case agreement depends on both syntactic configuration and morphological rules specific to each language, suggesting a complex interplay between syntax, morphology, and the lexicon.

2.2 LINGUISTIC VARIATION

Principles are universal and absolute, applicable to every language that exhibits the relevant linguistic components, such as syntactic categories, phrase structure rules, and morphological processes (Chomsky, 1995). These principles form the foundation of the UG theory, which posits that all human languages share a common underlying structure. For example, syntactic rules and constraints that govern sentence structure—such as feature matching, hierarchical phrase organization, and movement operations—are common to all languages, illustrating the universality of these principles (Chomsky, 1995). Since pre-minimalist syntax, linguistic variation has been approached as a result of parametric variation: variation along well-defined limits, first explored by Rizzi in his work on the null subject languages. Central to this theory is the concept of parameter setting; parametric approaches suggest that children begin with a default value for a given linguistic parameter. If this initial value does not match the one used in their target language, children adjust the parameter based on their linguistic experience. These approaches are compelling because they argue that children can achieve adult-like grammar through positive evidence alone, without requiring additional developmental mechanisms (Chien, 1992; Chomsky, 1981). According to the Principles-and-Parameters (P&P) model, learning a language involves setting specific parameters based on linguistic input. These parameters are binary switches that adjust the universal principles of UGto the specifics of the language being acquired (Chomsky, 1981, 1986a). To illustrate this, Chomsky (2000) provides a metaphor:

> When the switches are set one way, we have Swahili; when they are set another way, we have Japanese (Chomsky, 2000a, p. 8).

Experience with a particular language (e.g., examples of words, phrases, and sentences produced by native speakers in context) serves as input to the child. If the acquisition of grammatical competence is controlled by a genetically endowed language faculty incorporating a theory of UG, it follows that certain aspects of child (and adult) competence are known without experience. But there are also language-specific aspects of grammar that children must learn. Grammatical learning is confined to parametrized aspects of grammar—those aspects that vary from one language to another. To determine what aspects of their native language grammar children need to learn,

we must examine the range of parametric variation found in different natural languages (Chomsky, 1981, 1986a).

Consider the following utterances produced by a young child named Jem at age twenty months, with head verbs italicized in (1) and head prepositions in (2), and their complements in non-italic print (Radford, 1990):

(1) *Touch heads. Cuddle book. Want crayons. Want malteser. Open door. Want biscuit. Bang bottom. See cats. Sit down.*

(2) *On Mummy. To lady. Without shoe. With potty. In keyhole. In school. On carpet. On box. With crayons. To mummy.*

The consistent positioning of heads before their complements from the earliest multiword utterances suggests that children like Jem do not use different orders for different words of the same type or for different types of words (Radford, 2004). This consistency supports the P&P model, suggesting that learning the relative order of heads and complements involves setting a binary parameter based on minimal linguistic experience.

The Verb-Movement parameter

As with the facts in (1) and (2), the placement of verbs is also known to be an early acquisition. Pollock (1989) introduced head-movement as a mechanism to account for certain peculiarities in the behavior of verbs in French. Specifically, finite (tensed) verbs always appear before the primary negative morpheme, *pas*. Conversely, nonfinite (untensed) verbs consistently appear after *pas*. See example (3).

(3) a. Jean (n') aime **PAS** Henri
Jean likes not Henri
'Jean doesn't like Henri'

b. Ne **PAS** sembler heureux...
Not to seem happy...
'To not seem happy'

The proposal was made for the Verb-Movement Parameter. This parameter affects the position of the verb in relation to other elements in the sentence, such as adverbs and negation (Haeberli & Ihsane, 2016). In languages like French, verbs move to a higher position within the sentence structure, often preceding adverbs, as shown in the following example.

(4) Jean aime souvent Marie.
Jean loves often Marie
'Jean often loves Marie.'

This movement is typically to the Tense (T) position, which is higher than the positions of adverbs and negation within the clause structure (Ayoun, 1999). The historical development of English was towards the loss of this

parameter value in English (Haeberli & Ihsane, 2016). In English verbs generally remain in their base-generated position within the vP, not moving to T or any higher functional projection. As a result, adverbs and negation appear before the verb:

(5) John often loves Mary.

Pierce (1989) conducted a comprehensive analysis of several transcripts of French children's speech, provided by Lightbown (cf. Lightbown, 1977). Pierce pursued a detailed examination, focusing on the correlation between word order and finiteness in the children's language productions, particularly in the context of verb and negative particle placement in French. Pierce's findings revealed that children of approximately two years of age exhibited a remarkably accurate correlation between word order and finiteness. This prompted further investigation into the children's use of infinitival forms and the placement of the negative particle *pas*. Pierce observed infinitival main verbs, with *pas* appearing before the infinitival form. Conversely, finite verbs produced by the same children showed *pas* positioned after the verb. This pattern indicated an early acquisition of syntactic rules governing the placement of *pas* relative to verb finiteness.

The following examples from Pierce (1992a, 1992b) illustrate this phenomenon:

(6) Untensed verbs vs. tensed verbs

a. Pas manger la poupée
   Not to eat the doll

b. Pas attraper une fleur
   Not to catch a flower

c. Patsy est pas là-bas
   Patsy is not down there

d. Marche pas
   Walks not

These results indicate that the Verb-Movement Parameter has been correctly set at this early age by French-speaking children. Likewise, Poeppel and Wexler (1993) examined whether young children have the full set of functional syntactic categories, particularly focusing on the inflectional and complementizer systems. The authors analyzed natural production data from a 25-month-old German child, Andreas. The analysis included multiword utterances that were unique, spontaneous, and understandable for a native German speaker. Imperatives and questions were excluded, focusing solely on indicative declarative sentences. This resulted in a sample of 282 utterances. Poeppel and Wexler showed that the child aged 25 months systematically distinguished between finite and nonfinite verbs, with finite

verbs appearing in the second position (V2) and nonfinite verbs in the final position of the clause. This distribution suggests the early presence of functional categories TP and CP. This matches the adult grammar of German, a V2 language.

The statistical analysis revealed a significant contingency between finiteness and verb position, illustrated in the examples below, with only 7.8% counterexamples in the 282 utterances ($\chi^2 = 155.93$, $p < 0.0001$).

(7) Ich hab-e ein doss-en Ball.
I have-1SG a big-ACC ball
'I have a big ball.'

(8) Ich mach-e das nich.
I do-1SG that not
'I do not do that.'

(9) Thorsten Caesar haben.
Thorsten Caesar have
'Thorsten has Caesar.'

(10) Du das haben.
You that have
'You have that.'

Putting aside the presence of sentences with infinitival verbs, to which we turn shortly, errors in verbal morphology were mostly observed with plural subjects, where singular verb forms are incorrectly used. The data shows seven errors out of 231 finite verbs, all with plural subjects. This suggests that the agreement system is almost fully developed at this stage.

(11) Alle Tiere liegt da.
All animals lie-3SG there
'All animals lie there.'

The V2 phenomenon, where the finite verb appears in the second position and a non-subject (object or adverb) may occupy the first position, is evident in the child's utterances. This further supports the presence of a UG system in early grammar. Approximately 28% of the sentences show non-subjects in the initial position, consistent with the V2 structure typical of adult German grammar; this phenomenon is illustrated in the following examples.

(12) Kahehabahn fahr-e ich.
Toy_race_car drive-1SG I
'I drive the toy race car.'

(13) Da bin ich.
There am I
'There I am.'

(14) Eine Fase hab-e ich.
A vase have-1SG I
'I have a vase.'

Table 1: Distribution of Verbs in V1/V2 Position vs. Vfinal Position in Dutch

	V1/V2	**Vfinal**
Finite	1953 (99%)	11 (2%)
Non-finite	20 (1%)	606 (98%)

(15) So macht der.
So does he
'So he does.'

The same findings have been obtained for Dutch, another V2 language. Table 1 shows the distribution of verbs depending on finiteness.

This data is remarkably consistent. Out of about 2,600 utterances, only 31 (roughly 1%) deviate from the prediction. The statistical significance of this correlation between word order and finiteness is very strong. The result is almost categorical. We can assume the small number of errors are production mistakes, not part of the child's linguistic system.

The Null Subject parameter

The null subject parameter characterizes certain languages, such as Italian and Spanish, which permit sentences without explicit subjects, while others, like English, require them. Languages vary in whether they allow the subject of a sentence to be omitted if it can be inferred from the verb's inflectional morphology or not. The presence of null subjects in various languages presents a challenge to the simplicity of the original parameter-setting concept. Early theories suggested that languages either had or did not have null subjects based on a single parameter (Biberauer et al., 2009). However, variations in how null subjects function across different languages indicate that this phenomenon cannot be fully explained by a single parameter (Valian, 1990). For example, the behavior of null subjects in Romance languages significantly differs from that in East Asian languages (Huang, 1995).

Empirical studies (e.g., Bloom and Capatides (1991)) have shown that children learning English often omit subjects in their early speech. Common examples include utterances (16a) to (16d). This occurs typically until around the age of three.

(16) a. Drop bean.
b. Fix Mommy shoe.
c. Helping Mommy.
d. Want go get it.

Interestingly, despite being a highly inflected language, unlike English, German does not allow subject omission, requiring the subject to be explic-

itly stated in sentences (Weiss, 2018). This contrasts with languages like Italian and Spanish, where rich verb conjugations provide enough information to infer the subject, leading to the frequent omission of the explicit subject in spoken and written forms.

Children acquiring Catalan initially adopt a parameter setting that permits null subjects, consistent with their exposure to the language's syntactic structure (Grinstead, 2004).

Table 2: Overt vs. null subjects in the early and later stages (Grinstead, 2004)

Child	**Verbs with null subjects**	**Verbs with overt subjects**
Laura I (1;7–2;2)	145 (100%)	0 (0%)
Laura II (2;4–2;11)	747 (89%)	96 (11%)
Pep I (1;0–1;8)	48 (100%)	0 (0%)
Pep II (1;10–2;4)	305 (88%)	41 (12%)
Guillem I (1;0–1;9)	56 (100%)	0 (0%)
Guillem II (1;11–2;7)	484 (82%)	104 (18%)
Gisela I (1;7–1;11)	31 (100%)	0 (0%)
Gisela II (2;1–2;9)	301 (70%)	125 (30%)
Spanish		
Juan I (1;7–1;9)	25 (100%)	0 (0%)
Juan II (2;0–2;1)	29 (90%)	3 (10%)

Table 2 includes the total number of verbs which occur with null subjects, while the third column includes the total number of verbs which occur with overt subjects. Each child has one row for their early stage and another row for their later stage. The Spanish data (on Juan) is sparse in the early stage and further data collection is necessary. The data on the four Catalan-speaking children is from the Serra-Solé corpus (2001). The data collection sessions on the children whose transcripts were studied lasted 30–45 minutes and the children were recorded approximately once a month. Having noticed that there was an early stage without overt subjects, (Grinstead, 2004) examined roughly equal amounts of data, measured in number of files and months before and after the point at which the first overt subject was used. The files before the onset of the first overt subject in each child's data are called the early stage and the files after this point are called the later stage. The point of segmenting the data in this way was to abstract away from chronological differences in grammatical development. While it is true that some of the early stage files contain no verbal utterances, it is also true that all of the children examined had a significant period of time/number of files in which they did produce verbal utterances before they produced an overt subject. Guillem had 12 files per stage, Pep had nine

files per stage, Laura had six files per stage, Gisela had six files per stage, and Juan, the Spanish-speaking child, had two files per stage. Many utterances were produced in the early stage, none of which carry overt subjects. All overt subjects that co-occurred with a verb were counted, excluding repetitions of immediately preceding utterances, lexically-learned utterances, lexicalized tags, and unclear utterances. A large portion of the verb forms in the early stage occur in present tense and imperative forms. Imperatives were removed from the count because the pragmatic and grammatical licensing factors for overt subjects which occur with imperatives appear to differ from those which occur with non-imperative verbs. That is, since imperatives license null subjects even in overt subject languages, it is likely that mechanisms beyond those that license declarative null subjects are at work.

If there is such a thing as an adult norm for overt subject use in null subject languages, it may be about 30% overt subject use. The adult Spanish speakers reported in Silva-Corvalan (1977) used overt subjects an average of 39% of the time (501 overt subjects out of 1284 possible). Similarly, in the utterances produced in four files by Juan's father, an adult native speaker of Spanish, overt subjects were used 23% of the time (109 overt subjects out of 464 possible). Thus, the children's overt subject production in the later stage, which averages 20%, begins to come close to adult proportions by the end of the later stage.

In German, the omission of the subject results in an ungrammatical sentence, and in other Germanic languages such as Danish. The research indicates a difference in how frequently subjects and objects are omitted. Null subjects appear to be confined to a certain developmental period, with a notable drop-off around the age of 2.5 to 3 years (Hamann & Plunkett, 1998). This pattern is illustrated by Hamann's data on Danish children (Figure 6).

Hyams (1986) proposed that children might initially have parameters incorrectly set to values suitable for certain languages (e.g., Italian) and must reset these parameters based on their specific linguistic input (e.g., English). This resetting process is triggered by exposure to data that contradict the pre-set parameter values. For instance, encountering expletive subjects like *it* or *there* in English would prompt the child to reset the null subject parameter. This proposal was soon abandoned due to its shortcomings in two respects. First, the hypothesis that children start by speaking a null-subject language like Italian raises the subset problem. Following the subset principle (Berwick, 1985), if children started with the broader Italian-like setting that allows null subjects in a wider range of contexts, they would need to learn to restrict their use of null subjects based on English (or German or Danish) input. This would necessitate negative evidence, which is not available to children. Other objections to Hyams' proposal are empirical. In Italian, null subjects can appear in embedded finite clauses and finite root

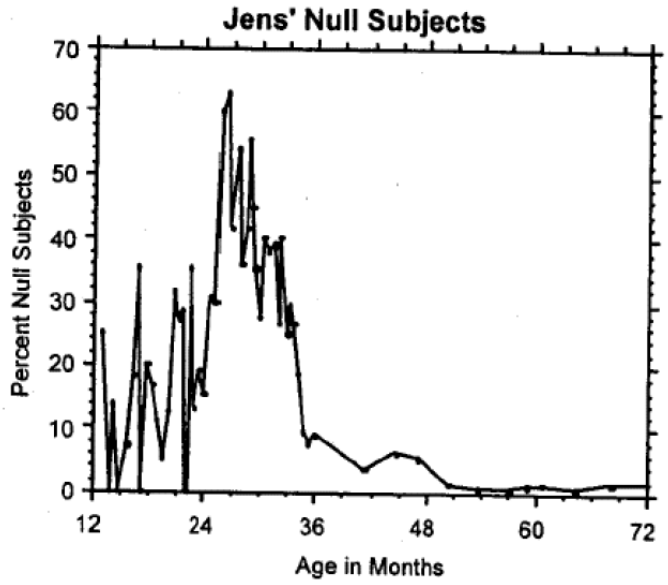


Figure 6: Percentage of null subjects over time in Danish children. Adapted from Hamann (1998).

questions, but this is not observed in English child speech. For instance, Italian allows null subjects in contexts such as:

(17) a. Io so che [lui] è partito.
I know that [he] has left.

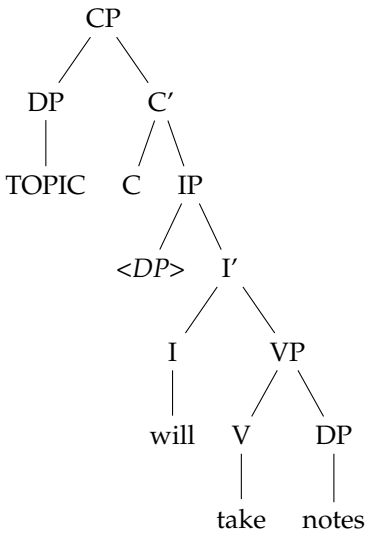
b. Che cosa ha comprato [lui]?
What has [he] bought?

In contrast, English-speaking children do not produce null subjects in such environments (Rizzi, 1993; Valian, 1990).

As an alternative to the hypothesis that English-speaking children might initially treat English as a null-subject language similar to Italian or Chinese, Bromberg and Wexler (1995) propose that null subjects with finite verbs may arise from a kind of topic drop, similar to diary drop in adult English:

(18) a. Went to the store. Bought milk.

They suggest that children might sometimes misinterpret not-Very Strong Topics as Very Strong Topics, leading to pragmatic errors and the omission of subjects. In this view, null subjects are allowed by virtue of topicalization, with topics moving to SpecCP in the syntactic structure. The following syntactic tree illustrates this process:



This hypothesis predicts that null subjects will be more frequent with nonfinite verbs due to the availability of both PRO and topic drop mechanisms. Data supports this prediction, showing that null subjects are more common with nonfinite verbs. For instance, Bromberg and Wexler (1995) found that, in child language, null subjects occur significantly more with nonfinite verbs than with finite verbs.

Additionally, the pragmatic approach to explaining null subjects in child language aligns with observations that children's errors often involve overgeneralization of pragmatic rules rather than purely syntactic ones. This pragmatic error aligns with findings that children also overuse other pragmatic devices, such as definite determiners, where adults would use indefinite ones (Speas, 1990). In sum, the evidence suggests that the presence of null subjects in child English is better explained by a combination of syntactic and pragmatic factors rather than a misset parameter. The high frequency of null subjects with nonfinite verbs and the restricted environments in which they appear argue against the idea that children start with a null-subject parameter set to "on" and later reset it.

Another hypothesis posits that children's early speech is shaped by processing limitations. According to this view, young children have limited cognitive resources, which influence their ability to produce and process language. Consequently, children tend to produce shorter sentences, often moving through identifiable stages such as the one-word stage, two-word stage, and multi-word stage (Hamann & Plunkett, 1998). The Mean length of utterance (MLU) is a commonly used metric to measure this linguistic development, providing insight into the complexity of children's speech as they grow older. This processing limitations hypothesis suggests that children might omit subjects to reduce the cognitive load associated with sentence production, especially when attempting to construct more complex sentences within their limited processing capacity (Bloom & Capatides, 1991). Bloom and Capatides (1991) found that sentences with subjects were

generally shorter than those without, indicating that subject omission might be a strategy to manage processing demands. However, this hypothesis is not consistent with the fact that null subjects are found more often with nonfinite verbs than finite verbs and some of the other findings reported. It may still apply to very young children. For children above a certain MLU threshold, the null subject parameter appears to be set as in the adult grammar.

2.3 THE OPTIONAL INFINITIVE STAGE

As already seen, children frequently use infinitive verb forms where adults would use finite verbs, potentially licensing null subjects in these sentences; this has illustrated above for French and German. This 'Optional Infinitive' Optional Infinitive (OI) stage is a phase in young children's language development characterized by the coexistence of utterances that omit inflection and those that are fully inflected. Introduced by Wexler in his pioneering work (1994a, 1994b), the concept of the OI stage has been found from multiple languages. Figure 7 summarizes the frequent vs. infrequent occurrence of optional infinitives in several languages, with the age in months of each child group shown above each bar. We turn to this crosslinguistic variation shortly.

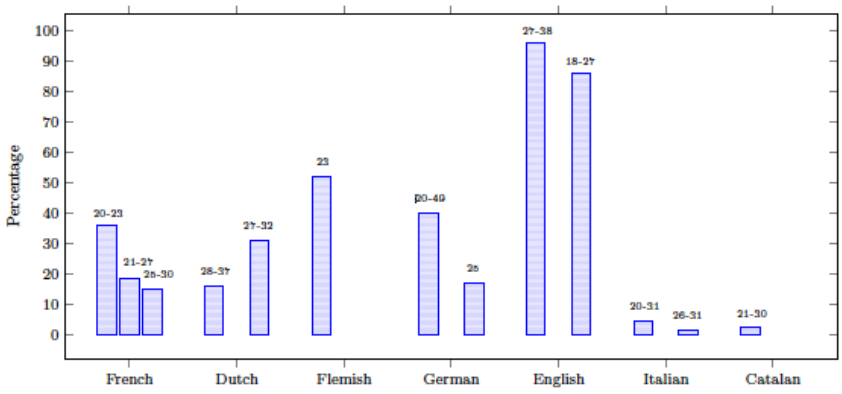


Figure 7: Percentage of Root Infinitives by Age shown in Guasti (2002)

The OI stage is supported by quantitative studies on verb forms (finite or nonfinite), as shown in Table 3. Based on Wexler (1998), Table 3 summarizes which languages have been documented as exhibiting an OI stage or not, and the crucial finding is that they correspond to the non-null subject and null-subject languages respectively.

This phenomenon could explain the high incidence of null subjects in early child speech (Wexler, 1994a). The data shows that null subjects are more common with nonfinite verbs (Table 4) (See also Rizzi (1993)).

Table 3: Languages Exhibiting the OI Stage and Non-OI Stage

OI Languages	**Studies**
Danish	Jonas (1995a, 1995b)
Dutch	Wexler (1990, 1994)
English	Wexler (1990, 1994)
Faroese	Jonas (1995a, 1995b)
Icelandic	Sigurjonsdottir (1992)
Norwegian	Wexler (1990, 1994)
Swedish	Wexler (1990, 1994)
French	Pierce (1989); Weissenborn (1991)
Irish	Wexler (1995, based on data in Hickey, 1990; see also Guilfoyle, 1996)
Russian	Bar-Shalom and Snyder (1997)
Brazilian Portuguese	Wexler and Secco (in preparation)
Czech	Moucka and Wexler (in preparation)
Non-OI Languages	**Studies**
Italian	Wexler (1992, 1994, based on Schaeffer, 1990 data); Guasti (1994)
Spanish	Grinstead (1994); Torrens (1995)
Catalan	Torrens (1995)
Tamil	Sarma (1995)
Polish	Klepper (1996)

Table 4: Finiteness of null/pronominal subjects in Adam's wh-questions (Bromberg & Wexler, 1995)

	Finite	**Nonfinite**
Null	2	118
Pronoun	117	131

One of the key findings from Wexler's early 1990s papers was the observation that children who produced OI followed the grammatical constraints that applied to finite and nonfinite forms in their target language, and that therefore OI aligned with the adult in at least some respects. This has been shown above for the placement of negation in child French and the V2 phenomenon in child German.

The incidence of OI is limited in time. Table 5 details the proportion of OIs out of all main verbs in Dutch. From Wexler (2011) with 47 TD children, ages 1;7 to 3;7 (10–13 children in each age group).

Table 5: P:OI Percentage of Optional Infinitives (OIs) by Age Group

Age Group	Percentage of OIs	Number of OIs	Total Verbs
1;07–2;00	83%	126	152
2;01–2;06	64%	126	198
2;07–3;00	23%	57	253
3;01–3;07	7%	29	415

These results revealed that the youngest children, aged 1;7 to 2;0, used non-finite verb forms, or Optional Infinitives, in 83% of their verb-related utterances. As children grow older, there is a noticeable decrease in the use of Optional Infinitives. By the age of 2;1 to 2;6, the proportion of non-finite verbs drops to 64%. This trend continues with children aged 2;7 to 3;0, where the use of Optional Infinitives further declines to 23%. Finally, in the oldest group, aged 3;1 to 3;7, the frequency of non-finite verb usage is reduced to just 7%. Blom and Wijnen (2000) suggest that at the initial stages of verb production in Dutch, there are nearly 100% OIs. This observation aligns with Wexler (1994b) findings.

Wexler's characterization of the OI stage includes the following properties:

1. The properties of the OI stage are as follows:
   (a) Root infinitives (non-finite verbs) are considered grammatical sentences for children in this stage.
   (b) These infinitives exist alongside finite forms.
   (c) Despite this, children understand the relevant grammatical principles and have set the necessary parameters correctly.

Three further observations about the OI are relevant. First, as noted by Newport et al. (1977), most of the input to the child is finite. This argument is supported by an empirical study by Blom and Wijnen (2000), which shows that the large majority of verbs in the input to young Dutch children are finite. This pattern indicates that the OI stage is driven by the child's linguistic system, not by learning or environmental input. Second, surface "simplicity" does not account for the existence of OIs. For instance, the Dutch infinitive *werken* 'to work' is more complex to pronounce than the first singular present form *werk* 'work', yet children produce *werken* instead of *werk*. To date, no evidence suggests that phonetic or morphological simplicity causes

the OI effect (Wexler, 2011). Third, there is evidence for knowledge of agreement morphology in children at the OI stage. Poeppel and Wexler (1993) challenged the assumption that young German children don't understand agreement, suggesting they do understand that 3rd person singular *t* is 3rd person singular. Similarly, data from Wexler (2004), summarized in Table 6 report the percentage of agreement errors (i.e., subject does not agree with the finite verbal inflection) for each present tense finite morpheme on main verbs in Dutch (*-o* is 1st singular, *t* is 2nd/3rd singular, *en* is plural).

Table 6: Percentage of Non-agreeing Subjects for Each of 3 Present Tense Morphemes in Dutch

MLU	-o	-t	-en	Total (%)	Total (Ratio)
1	15%	0%	5%	9%	5/58
	4/27	0/9	1/22		
2	5%	2%	0%	2%	12/256
	10/185	2/54	0/17		
3	2%	3%	0%	2%	8/378
	6/273	2/73	0/32		
4	2%	6%	0%	3%	18/615
	11/449	7/114	0/52		
5	3%	15%	0%	5%	7/137
	3/97	4/26	0/14		

These data are grouped by MLU level rather than age, but recall that the 47 children are evenly distributed across age range 1;7–3;7, meaning many are younger than 2 or 2;6. At no age is there a large proportion of agreement errors, with percentages being very low. Only at MLU level 1 do the least developed children exhibit more than 9% errors. For example, at MLU 2, *t* is correctly used for 2nd or 3rd singular subjects in 52 out of 54 uses. The same children use *o* correctly for 1st singular subjects 175 out of 185 times. Some errors are expected as children learn the phonetic forms for agreement features. Similarly, Wexler (1994b) found that when OI-stage English-speaking children used the 3rd singular inflection *s*, they rarely produced first singular subjects. It is generally accepted that the OI stage involves only a small percentage of agreement errors.

The studies by Clahsen (1990, 1993) investigate the grammatical development in early child German [1]. Clahsen's work provides examples of finite and OI forms in child language production, particularly noted in ages 2;2 to 2;10 and ages 2;9 to 3;1, where children frequently use nonfinite forms

1 The reported data by (Clahsen, 1990) belongs to extensive longitudinal production data from monolingual German-speaking children.

in contexts that require finite verbs. This use diminishes as they progress to ages 3;0 to 3;1, where finite verb usage becomes more consistent. Examples of child productions during different stages illustrate the use of finite and OI forms, along with the ages at which these forms are produced:

The examples below (19) to (20c) are organized by age.

(19) a. Füße waschen
feet wash-INF
'to wash (my) feet'
(1;8-2;0)

b. Löffel rausholen gehn.
spoon to.fetch go-n
'(I) am going to fetch a spoon.'
(1;8-2;0)

Examples (20) to (20c) show production examples of nonfinite verbs placed at the end of the clause, consistent with the underlying SOV structure of German. In (20b), the child uses a finite verb *weint* (cries), in the verb-second (V2) position.

(20) a. Auto fahren
car drive-INF
'to drive a car'
(1;11)

b. weint die Katze.
cry-3Sg the cat
'The cat is crying.'
(2;0-2;4)

c. fällt um
falls over
'falls over'
(2;2)

In (20a), the child uses the infinitive verb *fahren* 'to drive'. In (20b), the finite verb *weint* 'cries' is correctly used in the verb-second position. Example (20c) demonstrates the child's correct use of the finite verb *fällt* 'falls'.

Considering the high level of knowledge of agreement among OI-stage children and their nearly perfect knowledge of the finiteness/word order correlation, we must ask why the requirement for finite root clauses is often violated at young ages. The explanations that have been put forward rely on maturational factors (Rizzi, 2006; Wexler, 1998) affecting the computational system; (see Wexler 2011 for a review). The only non-maturational account, Legate and Yang (2007) [2], encounters numerous conceptual and empirical

2 Legate and Yang (2007) approach suggests that the Root Infinitive Root Infinitive (RI) phenomenon in child language can be explained through the interaction between morphological learning and syntactic development, rather than through maturational processes. This account

problems. Considering these options and others in the literature is beyond the scope of this thesis.

Agreement in a non-OI language: Catalan

In the domain of inflection production in Catalan, Torrens' (1995) work is the most relevant study to date. Torrens' study aims to determine whether children between the ages of 1;6 and 2;6 demonstrate evidence of inflection in their language production. The primary goal is to assess children's mastery of finite verb morphology and their ability to distinguish between finite and nonfinite verbs in Spanish and Catalan. The data were collected longitudinally from four children (three boys and one girl) in Barcelona, including both monolingual and bilingual speakers. The age ranges were: Martí (1;9.21–2;5.5), Guillem (1;9.24–2;6.10), Josep (1;9.22–2;6.3), and Gisela (1;10.6–2;6.23). These children produced a total of 524 utterances containing a finite verb. Among these, 515 utterances featured adult subject-verb agreement, while 9 contained incorrect agreement, accounting for 1.72% of the utterances.

All productions with finite verbs were analyzed to determine if children produce correct agreement. Verbs in the present, past, and imperative tenses were examined; however, there was a high proportion of verbs in the present tense. Table 7, presents the results for subject-verb agreement.

Table 7: Number of Productions for All Children with Correct and Incorrect Subject-Verb Agreement

Child	Correct	Error	% Error
Martí	177	1	0.56%
Guillem	126	3	2.32%
Josep	132	4	2.94%
Gisela	80	1	1.23%
Total	**515**	**9**	**1.72%**

Torrens (1995) states that for a first age interval, Martí does not produce any errors; Guillem produces 3 errors, accounting for 5.56% of the productions; Josep produces 4 errors, representing 7.55% of the productions; and Gisela produces 1 error, which is 3.12% of the productions. For a second age interval, Guillem, Josep, and Gisela produce no errors; Martí produces

proposes that the presence of RI reflects a grammar that does not manifest tense marking, akin to Chinese. The gradual elimination of this non-tense-marking grammar occurs as children learn the morphosyntactic system of their target language. This perspective contrasts with maturational models, which attribute changes in RI usage to internal biological maturation processes rather than to the learning mechanisms responsive to the linguistic environment.

Table 8: Number of Verbs for All Conjugations and All Children in Catalan

Child	1st Conjugation	2nd Conjugation	3rd Conjugation
Martí	45	24	7
Guillem	65	43	17
Josep	32	5	5
Gisela	32	43	5
Total	**174**	**115**	**34**

1 error, which is 1.1% of the productions. The number of errors is not significant for any of the age intervals. At both age intervals, children distinguish correctly among verbs of different person and number, thereby fulfilling the productivity criteria.

Table 9: Number of Productions with Correct and Incorrect Subject-Verb Agreement (First and Second Intervals)

Child	Correct	Error
First Interval		
Martí (1;9.21–2;2.11)	88	0
Guillem (1;9.24–2;2.28)	51	3
Josep (1;9.22–2;1.27)	49	4
Gisela (1;10.6–2;2.6)	31	1
Total	**219**	**8**
Second Interval		
Martí (2;3.24–2;5.5)	89	1
Guillem (2;3.12–2;6.10)	75	0
Josep (2;3.17–2;6.3)	83	0
Gisela (2;4.20–2;6.23)	49	0
Total	**296**	**1**

To ascertain if verbs are productive forms in children's grammars, Torrens (1995) observed whether children correctly produce verbs in different person-number combinations -see Table 10- and different conjugations –see Table 8.

Torrens observed the production of first and third person singular agreement by Martí:

(21) a. jo agafo
I take-1s

Table 10: Frequencies of Subject-Verb Agreement for Person and Number

Child	1s	2s	3s	1p	2p	3p
Martí	21	37	104	13	0	2
Guillem	19	40	64	2	1	0
Josep	13	50	56	12	0	1
Gisela	14	21	43	0	0	2

Table 11: Number of Verbs for All Conjugations and All Children in Catalan

Child	1st Conjugation	2nd Conjugation	3rd Conjugation
Martí	45	24	7
Guillem	65	43	17
Josep	32	5	5
Gisela	32	43	5
Total	**174**	**115**	**34**

'I take' (M 2;3,24)

b. no plora
not cries
's/he does not cry' (M 2;1,22)

He also observed similar patterns in other children. For instance, Guillem produced verbs in the first-person singular, second-person singular (including imperative forms), and third-person singular.

(22) a. t'agafo
to-you catch-1s Yoya
'I catch you' (Gu 1;11,13)

b. no arriba!
not arrives
's/he does not arrive!' (Gu 2;4,24)

Similarly, Josep and Gisela also produced verbs of different persons and numbers correctly, further supporting the argument that subject-verb agreement is productive in their grammars. Torrens (1995) also investigates whether children can distinguish between finite and nonfinite verbs by examining their production in different contexts. The contexts examined include "infinitive in a main sentence," "infinitive after preposition," and "fragment."

The context called *infinitive in a main sentence* is the only non-grammatical context for nonfinite verbs, and is exemplified below. For the context called

Table 12: Contexts for Nonfinite Verbs

	INF Main Sen.	Gov. INF - Fin. V.	INF + Prep.	Frag.
Martí	2	5	5	3
Guillem	2	6	3	1
Josep	1	7	3	0
Gisela	0	3	1	0
Total	**5**	**19**	**11**	**4**

infinitive after preposition, some numbers have been included in parentheses; these values refer to cases where a nonfinite verb is produced without a preposition but in a discourse context where adults produce a preposition. Gerken (1991) proposes that children omit non-stressed syllables at the beginning of an utterance; this is because non-stressed syllables are assimilated into the next stressed syllable, and this may be the case here. The context called *fragment* is for productions that have grammatically incomplete ellipsis but receive a full meaning from the verbal context. From the data, we can conclude that there is not an *optional infinitive stage* in Catalan, as predicted by Wexler (1994a, 1994b).

(23) a. tirar l'aigua
throw-INF the water
'let's throw the water'

2.4 THE VERBAL INFLECTIONAL SYSTEMS OF CATALAN AND GERMAN

Catalan, as a null subject language with a relatively flexible word order, demonstrates how rich inflectional morphology and clitics can provide syntactic information that allows for variable surface structures (Picallo, 1991; Rizzi, 1982). German, on the other hand, as a non-null subject language with a more rigid word order in main clauses and a distinct SOV order in subordinate clauses, exemplifies the verb-second (V2) phenomenon (Haider, 2010; Hinterholzl, 2006). On the other hand, the verbal inflectional systems of the two languages are both rich.

The Catalan inflectional paradigm

According to the *Gramàtica essencial de la llengua catalana* 2022, the Catalan verb is formed by a stem to which inflectional markers corresponding to person, number, tense, aspect, mood, and conjugation are added. Finite verbal forms consist of the stem, the conjugation morpheme, and the verbal inflections, which include tense (with aspect and mood markers if present)

and person (including number). Non-finite verbal forms do not have tense, mood, or person morphemes. They include -r for the infinitive (*cantar* 'to sing'), -nt for the gerund (*cantant* 'singing'), and -d-/-t for the participle, which has gender and number markers (*cantat* 'sung', *cantada* 'sung' (feminine), *cantats* 'sung' (plural), *cantades* 'sung' (feminine plural)). The verbal paradigm of a regular Catalan verb in the indicative mood is illustrated in Table 13, while the subjunctive, conditional, and imperative moods are shown in Table 14, non personal forms are shown in Table 15. For the verb *cantar* 'to sing'. Person and number, always expressed in a single morpheme, indicate the agreement between the subject and the verb. The six verbal forms are: first (1sg), second (2sg), and third (3sg) person singular, and first (1pl), second (2pl), and third (3pl) person plural. The forms (*vós*, *vostè*, and *vostès*) establish formal agreement with the verb that does not coincide with sense agreement. Conjugation classifies verbs by specific inflectional patterns. The first conjugation includes verbs with an infinitive ending in -ar (*saltar*), the most numerous and productive group. The second conjugation includes verbs with an infinitive ending in unstressed -re or -er (*perdre*, *esprémer*, *córrer*), some with stressed -er (*haver*, *saber*) and -r (*dir*, *dur*, *fer*). This group is not very productive and includes many irregular verbs. The third conjugation includes verbs with an infinitive ending in -ir (*dormir*, *servir*), divided into pure conjugation and inchoative conjugation (with stem increment in some present forms). Morphologically, verbs are regular or irregular. Regular verbs follow predictable morphological patterns: first conjugation (e.g., *cantar*), second conjugation (e.g., *batre*, *témer*), third conjugation pure (e.g., *dormir*), and third conjugation inchoative (e.g., *servir*). Regular verbs maintain a consistent stem across all forms, subject only to phonetic changes from regular phonological processes like accent shifts. Regular verbs adhere to systematic patterns, as shown by the conjugation of *cantar* (to sing) in the present tense: *jo canto* (I sing), *tu cantes* (you sing), *ell/ella canta* (he/she sings), *nosaltres cantem* (we sing), *vosaltres canteu* (you all sing), *ells/elles canten* (they sing).

For the purposes of this thesis, only regular verbs of Central Catalan are described, omitting irregular verbs and dialectal variations.

Table 13: Catalan Verb Conjugation - Indicative mood

	Present	**Perfet**	**Imperfet**	**Plusquamperfet**	**Passat Simple**	**Passat Anterior**	**Passat Perifràstic**	**Passat Anterior Perifràstic**	**Futur**
1st sg	canto	he cantat	cantava	havia cantat	cantí	haguí cantat	vaig cantar	vaig haver cantat	cantaré
2nd sg	cantes	has cantat	cantaves	havies cantat	cantares	hagueres cantat	vas (vares) cantar	vas (vares) haver cantat	cantaràs
3rd sg	canta	ha cantat	cantava	havia cantat	cantà	hagué cantat	va cantar	va haver cantat	cantarà
1st pl	cantem	hem (havem) cantat	cantàvem	havíem cantat	cantàrem	haguérem cantat	vam (vàrem) cantar	vam (vàrem) haver cantat	cantarem
2nd pl	canteu	heu (haveu) cantat	cantàveu	havíeu cantat	cantàreu	haguéreu cantat	vau (vàreu) cantar	vau (vàreu) haver cantat	cantareu
3rd pl	canten	han cantat	cantaven	havien cantat	cantaren	hagueren cantat	van (varen) cantar	van (varen) haver cantat	cantaran

	Futur Perfet	**Condicional**	**Condicional Perfet**	**Present Subjunctive**	**Perfet Subjunctive**	**Imperfet Subjunctive**	**Plusquamperfet Subjunctive**	**Imperative**
1st sg	hauré cantat	cantaria	hauria cantat	canti	hagi cantat	cantés	hagués cantat	canta
2nd sg	hauràs cantat	cantaries	hauries cantat	cantis	hagis cantat	cantessis	haguessis cantat	canti
3rd sg	haurà cantat	cantaria	hauria cantat	canti	hagi cantat	cantés	hagués cantat	canti
1st pl	haurem cantat	cantaríem	hauríem cantat	cantem	hàgim cantat	cantéssim	haguéssim cantat	cantem
2nd pl	haureu cantat	cantaríeu	hauríeu cantat	canteu	hàgiu cantat	cantéssiu	haguéssiu cantat	canteu
3rd pl	hauran cantat	cantarien	haurien cantat	cantin	hagin cantat	cantessin	haguessin cantat	cantin

Table 14: Catalan Verb Conjugation - Subjunctive, Conditional, and Imperative Moods

		Subjunctive		
	Present	**Perfet**	**Imperfet**	**Plusquamperfet**
1st sg	canti	hagi cantat	cantés	hagués cantat
2nd sg	cantis	hagis cantat	cantessis	haguessis cantat
3rd sg	canti	hagi cantat	cantés	hagués cantat
1st pl	cantem	hàgim cantat	cantéssim	haguéssim cantat
2nd pl	canteu	hàgiu cantat	cantéssiu	haguéssiu cantat
3rd pl	cantin	hagin cantat	cantessin	haguessin cantat
		Conditional		
	Condicional	**Condicional Perfet**		
1st sg	cantaria	hauria (haguera) cantat		
2nd sg	cantaries	hauries (hagueres) cantat		
3rd sg	cantaria	hauria (haguera) cantat		
1st pl	cantaríem	hauríem (haguérem) cantat		
2nd pl	cantaríeu	hauríeu (haguéreu) cantat		
3rd pl	cantarien	haurien (hagueren) cantat		
		Imperative		
2nd sg			canta	
3rd sg			canti	
1st pl			cantem	
2nd pl			canteu	
3rd pl			cantin	

Table 15: Non-Personal Forms in Catalan

Infinitiu	**Gerundi**	**Participi**
cantar	cantant	cantat, cantada, cantats, cantades

The German inflectional paradigm

Verbs in German are inflected to indicate tense, mood, person, and number. As delineated by Buscha and Helbig (2001) and corroborated by Durrell et al. (2017), German verbs exhibit six primary tenses: present (*Präsens*), present perfect (*Perfekt*), simple past (*Präteritum*), past perfect (*Plusquamperfekt*), future (*Futur I*), and future perfect (*Futur II*). These tenses are employed to express various temporal aspects and nuances. The mood of a verb can

be indicative (*Indikativ*), subjunctive (*Konjunktiv*), or imperative (*Imperativ*). German verbs are also conjugated for person (first, second, third) and number (singular, plural). Regular verbs follow predictable conjugation patterns, whereas irregular verbs require memorization due to their non-standard forms. Regular verbs adhere to systematic patterns, as illustrated by the conjugation of *machen* (to do/make) in the present tense: *ich mache* (I make), *du machst* (you make), *er/sie/es macht* (he/she/it makes), *wir machen* (we make), *ihr macht* (you all make), *sie machen* (they make). In contrast, irregular verbs exhibit unique conjugation forms that deviate from these patterns, necessitating additional study and memorization. The regukar verbal paradigm of German verbs is illustrated in the following tables.

Table 16: Inflectional System in German: Indicative Mood

	Present	**Perfekt**	**Imperfekt**	**Plusquamperfekt**	**Präteritum**	**Futur I**
1st sg	singe	habe gesungen	sang	hatte gesungen	sang	werde singen
2nd sg	singst	hast gesungen	sangst	hattest gesungen	sangst	du wirst singen
3rd sg	singt	hat gesungen	sang	hatte gesungen	sang	wird singen
1st pl	singen	haben gesungen	sangen	hatten gesungen	sangen	werden singen
2nd pl	singt	habt gesungen	sangt	hattet gesungen	sangt	werdet singen
3rd pl	singen	haben gesungen	sangen	hatten gesungen	sangen	werden singen

Table 17: Other Tenses in German: Indicative Mood

	Futur II	**Konjunktiv I**	**Konjunktiv II**	**Perfekt Konjunktiv I**	**Perfekt Konjunktiv II**	**Passiv**
1st sg	werde gesungen haben	singe	sänge	habe gesungen	hätte gesungen	werde gesungen
2nd sg	wirst gesungen haben	singest	sängest	habest gesungen	hättest gesungen	wirst gesungen
3rd sg	wird gesungen haben	singe	sänge	habe gesungen	hätte gesungen	wird gesungen
1st pl	werden gesungen haben	singen	sängen	hätten gesungen	hätten gesungen	werden gesungen
2nd pl	werdet gesungen haben	singet	sänget	habet gesungen	hättet gesungen	werdet gesungen
3rd pl	werden gesungen haben	singen	sängen	haben gesungen	hätten gesungen	werden gesungen

Table 18: Subjunctive Mood in German

	Present Subjunctive	**Past Subjunctive**	**Perfect Subjunctive**	**Plusquamperfekt Subjunctive**
1st sg	singe	sänge	habe gesungen	hätte gesungen
2nd sg	singest	sängest	habest gesungen	hättest gesungen
3rd sg	singe	sänge	habe gesungen	hätte gesungen
1st pl	singen	sängen	haben gesungen	hätten gesungen
2nd pl	singet	sänget	habet gesungen	hättet gesungen
3rd pl	singen	sängen	haben gesungen	hätten gesungen

Table 19: Imperative Mood in German

	Imperative
2nd sg	singe (du)
2nd pl	singt (ihr)
3rd sg formal	singen Sie (er/sie/es)
3rd pl formal	singen Sie (sie)

3

CHILDREN'S MASTERY OF SUBJECT-VERB AGREEMENT

The generative perspective on language development intricately maps the journey from a child's initial comprehension of linguistic structures to their eventual capability for production. This transition from passive understanding to active verbalization is a testament to the sophisticated nature of the language faculty. Central to this view is the concept of universal grammar, as articulated by Noam Chomsky, which posits that children are born with an inherent set of linguistic principles that span all human languages (Chomsky, 1965, 1972). This inborn framework is believed to equip children with the means to decode complex grammatical structures well before they can produce them themselves, indicating a natural predisposition towards language that is activated and sculpted through linguistic interaction (Berwick & Chomsky, 2015; Pinker, 1994). Here, the role of linguistic environments is pivotal; it acts as a key that unlocks the child's latent linguistic potential, guiding them from mere comprehension to active linguistic production. This process, underpinned by the internalization of grammatical rules and structures encountered in the surrounding language, is refined through the child's linguistic experience. The early dominance of comprehension over production highlights the deep-rooted complexity within the language faculty, marking a crucial period in the acquisition process where a deeper understanding precedes the ability to express complex ideas grammatically (Hirsh-Pasek & Golinkoff, 1996a; Legate et al., 2013). The emphasis on the biological foundations of language underscores a pivotal developmental sequence. This sequence prioritizes comprehension of linguistic structures before their active application in communication. Insights from Lenneberg et al. (1967) highlight the role of innate linguistic capabilities, suggesting that specific linguistic features are pre-configured within the brain, poised for activation through engagement with language. This proposition aligns with broader research findings which affirm that the internalization of language rules and structures is not merely a byproduct of environmental interaction but is significantly influenced by biological predispositions (Kuhl, 2004; Pinker, 1994).

Studies indicate that children understand syntactic and morphological rules before utilizing these rules in speech generation, suggesting that comprehension of language structures lays the groundwork for later production (Brown, 1973; Crain & Fodor, 1987). This observation underscores that language acquisition transcends mere imitation or reinforcement, embodying a complex cognitive process unfolding from the interplay between in-

nate capabilities and environmental stimuli (Guasti, 2002; Wexler, 1998). Understanding this sequence—wherein comprehension precedes production—sets the stage for an exploration of how children master specific grammatical constructs, such as subject-verb agreement.

Goldin-Meadow's pioneer research into gesture systems developed by deaf children without formal sign language instruction provides evidence for the innate capacity for structured communication, highlighting the universality and spontaneity of language development processes (Goldberg, 1995; Goldin-Meadow et al., 1976). In line with the generative tradition, the innate capacity for language, unfolding through exposure, is further examined in different areas emphasizing on grammatical knowledge enabling children to parse and interpret language from an early age (Huttenlocher et al., 1991; Huttenlocher, 1974). In a study by Benedict (1979), the interaction between grammatical knowledge and linguistic input was investigated, demonstrating that early language acquisition is driven by both inherent structures and exposure to language. The researchers examined this by comparing the first 50 words comprehended and produced by eight infants aged 9 to 18 months. The findings demonstrated that comprehension development began earlier, around 9 months, and reached the 50-word level by 13 months. In contrast, production development started at 12 months and reached the same milestone by 18 months. The rate of word acquisition for comprehension was twice that of production, confirming that comprehension precedes production in lexical development. Huttenlocher et al. (1991) conducted a pivotal study examining the relationship between early vocabulary growth and parental language input in children aged 14 to 26 months. The researchers found a significant positive correlation between the quantity of maternal speech and the rate of vocabulary acquisition, demonstrating that children who received more verbal input from their mothers exhibited faster vocabulary growth. Slobin (1985) examined how children navigate between understanding language and its active use, revealing that the developmental pathway from comprehension to production is not linear but is mediated by cognitive and neurological maturation. During this period, children seem to develop the ability to parse and understand linguistic input accurately while simultaneously honing the motor skills required for speech production.

Language production is demonstrably more complex than language comprehension from both physiological and neurological perspectives. This complexity arises from the intricate coordination and significant cognitive effort required for effective speech production. From a motor skill perspective, speech production necessitates the precise coordination of multiple physical systems. These include the respiratory system for breath control, the vocal cords for phonation, and various articulators such as the lips, tongue, and jaw. Such coordination is essential for producing the diverse sounds that con-

stitute human speech (McClean & Tasko, 2002; Simonyan & Horwitz, 2011). The process begins with the respiratory system, which supplies the necessary airflow for phonation. The lungs, diaphragm, and intercostal muscles work together to regulate the pressure and flow of air, which is then modulated by the vocal cords in the larynx. The vocal cords vibrate to produce sound, which is subsequently shaped by the articulators in the vocal tract. These articulators, including the tongue, lips, jaw, and soft palate, adjust their positions to refine the sound, producing distinct phonetic elements of speech (Bailly et al., 2012; Honda, 2008).

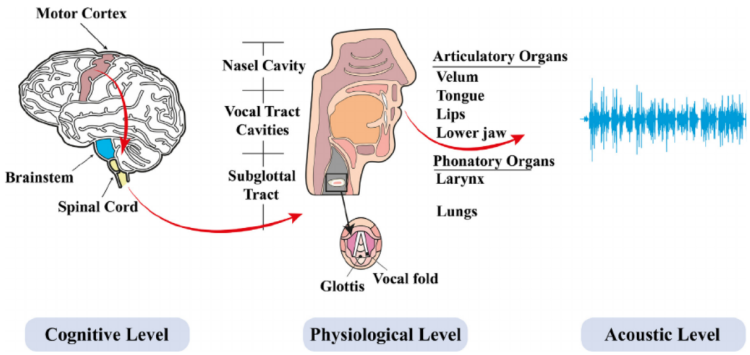


Figure 8: Production: cognitive planning, muscle coordination, and sound generation Almaghrabi et al. (2023)

Figure 8, illustrates the speech production process and the acoustic theory of voice production. This process starts at the cognitive level, where the brain's motor cortex formulates the intended message and plans the necessary phonetic and prosodic details. These neural signals are transmitted through the brainstem and spinal cord to the muscles involved in speech production (Almaghrabi et al., 2023). At the physiological level, the vocal tract—including the nasal cavity, vocal tract cavities, and subglottal tract—operates in conjunction with the articulatory organs such as the velum, tongue, lips, and lower jaw, as well as the phonatory organs like the larynx and vocal folds. The lungs provide the essential airflow for speech, while the vocal folds vibrate to create sound waves. These sound waves are then modulated by the vocal tract to produce distinct speech sounds. Finally, at the acoustic level, these modulated sound waves are radiated from the lips and captured as acoustic signals, depicted as a waveform in the image. This complex process demonstrates the coordination between cognitive planning, muscular actions, and sound generation, resulting in human speech (Almaghrabi et al., 2023).

From a neurological standpoint, the brain plays a pivotal role in orchestrating these physical movements. The primary motor cortex, including the laryngeal motor cortex, is responsible for initiating and controlling the fine motor actions of the articulators (Simonyan & Horwitz, 2011). Additionally, the brainstem and various subcortical structures coordinate with corti-

cal regions to ensure smooth and precise muscle movements. This involves complex feedback loops where sensory information from the articulators is sent back to the brain to adjust movements in real-time, maintaining the accuracy of speech production, as shown in Figure 8. Furthermore, the neural pathways involved in speech production are highly interconnected with those responsible for other cognitive functions, such as auditory processing and language comprehension. This interconnectedness allows for the integration of auditory feedback, enabling individuals to monitor and correct their speech output based on what they hear. Studies have shown that the auditory cortex is actively engaged during speech production, highlighting its role in providing feedback and ensuring intelligibility (Simonyan & Horwitz, 2011).

Neurologically, speech production and comprehension involve a sophisticated network of brain regions, many of which share functional responsibilities (Flinker et al., 2015b). Traditional emphasis has been placed on Broca's area in the frontal lobe for its critical role in speech production, including the planning and execution of speech. However, contemporary neuroscientific research presents a more complex interplay among various brain areas (Nishitani et al., 2005). Language processing emerges from the dynamic interactions between multiple regions, not limited to Broca's area but also incorporating Wernicke's area and beyond, creating a comprehensive network that supports a range of linguistic functions (Hickok & Poeppel, 2007; Price, 2012). These areas do not function in isolation but are interconnected components of a complex system that integrates both the production and comprehension of language (Dronkers & Fadiga, 2004; Flinker et al., 2015b). Broca's area is not just instrumental in linguistic planning—selecting and arranging words and grammatical structures—but also in motor planning, which involves the coordination of speech muscles to produce sounds (Dronkers & Fadiga, 2004; Fadiga et al., 2002). Significant advances have been made in investigating the brain's role in language. Researchers such as (Friederici, 2012; Gallardo et al., 2023; Grodzinsky, 2000; Hagoort, 2014) have extensively examined Broca's area. Hagoort (2014) has shown that within Broca's area and beyond, there exist both language-selective regions and domain-general areas that contribute to the multifaceted demands of language production. Specifically, Hagoort identifies regions within Broca's area that are highly specialized for processing syntactic structures and constructing grammatical sentences. In addition, domain-general areas, such as the dorsolateral prefrontal cortex (DLPFC) and Anterior cingulate cortex (ACC), are involved in managing executive functions like working memory, cognitive control, and attentional processes. These domain-general regions are crucial for integrating linguistic information with other cognitive tasks, facilitating fluent speech and effective communication. This intricate network underscores the

complexity of language production, involving a collaborative effort between specialized language centers and broader cognitive systems.

Domain-general areas are broader brain regions not exclusively dedicated to language but involved in various cognitive functions that support language production. Examples of these regions include the DLPFC and the ACC. These areas are instrumental in executive functions such as working memory, cognitive control, and attention. Working memory is essential for holding information temporarily for processing; cognitive control manages thoughts and actions to achieve goals; and attention focuses on relevant information while ignoring distractions emphasizing on the impermanence of these regions in integrating cognitive functions with linguistic tasks (Duncan, 2010; Miller & Cohen, 2001).

Broca's area, located in the left inferior frontal gyrus and encompassing Brodmann Areas 44 (BA44) and 45 (BA45), is crucial for language processing. This area is particularly significant for its role in syntactic operations. BA44, in particular, is divided into posterior and anterior regions that support different language functions. The posterior region of BA44 is primarily associated with syntactic processing, while the anterior region is involved in semantic processing. This functional division underscores the complexity and specialization of Broca's area in handling different aspects of language (Friederici et al., 2017). The study by Friederici et al. (2017) highlights the extensive connectivity of Broca's area with other brain regions, particularly the Posterior superior temporal gyrus (pSTG), facilitated by both dorsal and ventral pathways. The dorsal pathway, which includes the arcuate fascicle, is particularly critical for syntactic processing. This connectivity is not just structural but also functional, allowing for the efficient processing of complex syntactic structures. Additionally, Broca's area exhibits leftward volumetric asymmetry, a feature that develops during early childhood and aligns with critical periods of language acquisition. This asymmetry is crucial for the efficient functioning of language networks (Friederici et al., 2017). One of the significant contributions of this study is its insight into how Broca's area handles hierarchical processing in syntax. The activation of Broca's area varies with the syntactic complexity of language input, indicating its sensitivity to hierarchical structures. The study discusses the Merge operation. This operation predominantly activates BA44, highlighting its role in building complex syntactic hierarchies. This hierarchical processing is essential for understanding and producing grammatical sentences, thereby impacting cognitive load during language production (Friederici et al., 2017). The syntactic processing demands placed on Broca's area contribute to cognitive load during language production. Efficient processing of these demands is essential for fluent and accurate language use. The structural and functional connectivity of Broca's area with other language-related regions helps mitigate cognitive load by facilitating the rapid and efficient integration of

syntactic and semantic information (Friederici et al., 2017). Grodzinsky's research has substantially advanced our understanding of the brain regions implicated in language and logic processing. In his 2000 Grodzinsky, delved into the neural correlates of logical negation, a sophisticated cognitive function intricately tied to linguistic processing. Utilizing functional MRI, the study successfully disentangled the elements of logic from language and numerosity, identifying a distinct cluster of brain activity in the left anterior insula, located ventromedially to Broca's region. This area appears to mediate interactions between language and reasoning regions, shedding light on how the brain manages logical negation as a separate entity from other linguistic and numerical functions. In subsequent research, Grodzinsky et al. (2021), further explored the stable brain loci involved in the processing of complex syntax, underscoring the vital contributions of Broca's region and other related areas. Through a comprehensive retrospective review of fMRI studies, this research pinpointed the left Broca's region as the primary locus for syntactic displacement operations (Internal Merge), which are crucial for the comprehension and production of complex sentence structures. Moreover, the study revealed significant involvement of the left superior temporal sulcus and superior temporal gyrus, regions well-known for their roles in integrating syntactic and semantic information.

The process of language production extends beyond these areas, invoking a broader assembly of neural networks involved in motor planning and execution. This phase requires the brain to send signals to the speech muscles, activating them in a precise sequence and timing, making it more complex than comprehension (Pulvermüller, 2002). Language production imposes a higher cognitive load compared to comprehension. It demands the selection of appropriate words from an extensive mental lexicon, organizing these words into grammatically accurate and semantically meaningful sentences, and planning the physical act of speaking (Smith & Jones, 2023). This multifaceted process requires complex decision-making and strategic planning under real-time constraints, highlighting the cognitive complexity inherent in language production (Levelt & Vijver, 2004). Unlike production, comprehension primarily involves the recognition and interpretation of incoming linguistic signals—a process that, while intricate, does not necessitate the immediate, coordinated motor output characteristic of production (Hagoort, 2014). Additionally, speakers must monitor their spoken output for errors and make real-time adjustments, a process known as self-monitoring and error correction (Nooteboom & Quené, 2017). This aspect of language production adds another layer of complexity, as it requires constant feedback and adjustments to ensure communicative effectiveness. Listeners may also detect errors or ambiguities in speech during comprehension but are not required to correct these errors in real time as part of the comprehension process (Postma, 2000).

The developmental trajectory of language acquisition in children begins with understanding the language used by their surroundings before they start to express it verbally. This sequence, where comprehension precedes production, is characterized by an initial phase where children listen and internalize the language nuances around them prior to engaging in spoken communication (Hirsh-Pasek & Golinkoff, 1996b). Furthermore, linguistic research has consistently shown that young children's abilities to comprehend are often more developed than their abilities to produce language. For instance, they are capable of understanding complex sentences and grasping grammatical rules well before these elements are reflected in their speech (Bates & MacWhinney, 1989). This pattern underscores a pivotal aspect of early language development, emphasizing that the capacity to comprehend linguistic structures forms the foundation upon which speech production is later built. There seems to be a general consensus that comprehension precedes active production (Bates & MacWhinney, 1988; Vygotsky, 1978). Yet, research has pinpointed certain grammatical phenomena where this developmental sequence seems to reverse. A notable example of such a phenomenon is the use of pronouns.

The Delay of Principle B effect

Binding Theory, introduced by Chomsky (1981), outlines principles governing the syntactic relationships necessary for interpreting anaphors (reflexives), pronouns, and lexical noun phrases. Principle B specifically states that pronouns must be free in their governing category, meaning they cannot have a co-referential antecedent within the same domain. Research on children's comprehension of Principle B has revealed significant insights into language acquisition. Early studies by Crain and McKee (1985), Jakubowicz (1984), and Wexler and Chien (1985) showed that, while children generally understand reflexives correctly, they often struggle with pronouns in certain contexts. For instance, in sentences like "Luke Skywalker washed him," children frequently interpret the pronoun to refer back to the subject, a phenomenon known as the Delay of Principle B Effect (DPBE).

Chien and Wexler (1990) used a Truth Value Judgment Task to show that children rarely misinterpret sentences like "Every bear is touching her," suggesting they follow Principle B.In sentences withour quantifiers, however, children allowed a correferential interpretation of the pronoun.

(24) a. John_i saw himself_i/*himself_j/*herself_i.
b. John_i saw him_j/*him_i.
c. John_i/he_i saw John_j.

Children's comprehension of pronouns lags behind their comprehension of reflexives, suggesting additional cognitive factors may be involved.

Grodzinsky and Reinhart (1993) argued that the pragmatic principle preventing a pronoun from co-referring with an antecedent is not applied at an early age.

Cross-linguistic studies have added further complexity into this picture. For example, McKee (1992) and other studies found that Romance languages using clitic pronouns do not exhibit a DPBE. Further research addressed further syntactic contexts, like ECM-constructions in sentences such as "The girl sees her dance," in which the DPBE is visible even in the Romance languages with clitics. Researchers like Philip and Coopmans (1996) and Baauw and Cuetos (2003) contributed to understanding these effects, favoring pragmatic accounts. Using a Picture Choice Task, Ruigendijk (2008) found that German children aged 4-6 years correctly interpreted 94% of simple sentences with reflexives and 95.1% with pronouns, similar to French or Spanish children. However, like Romance children, they performed 95.5% adult-like in ECM cases with reflexives but only 77.3% adult-like in Exceptional Case Marking (ECM) cases with pronouns. Following Hamann (2002), Ruigendijk suggested that German weak pronouns in the Wackernagel position (high in the clause's left periphery) resemble clitics:

(25) High Position:

a. dass ihn/'n der Junge gesehen hat
that him.ACC the.NOM boy.NOM seen has
that the boy saw him

b. Sieht ihn/'n der Junge?
sees him.ACC the.NOM boy.NOM
Does the boy see him?

Table 20 summarizes cross-linguistic results on the interpretation of pronouns in Principle B environments, Chain Condition contexts, and the comparison of strong and weak positions or forms, based on adult responses from children aged between 4 and 6 years. The data is categorized by language, experiment, lexical and quantified antecedent percentages, and various conditions and comparisons. Languages included in the study are Dutch, English, Russian, Norwegian, German, Italian, French, Spanish, and Greek. Each language section references specific studies, indicating the researchers and publication years. The Lexical Antecedent column shows the percentage of correct pronoun interpretations when the antecedent is a lexical noun phrase, while the Quantified Antecedent column shows the percentage of correct pronoun interpretations when the antecedent is a quantified noun phrase. The Chain Condition column refers to specific syntactic environments, such as ECM [1] and Anti-subject Contexts, which impact pronoun interpretation. The Strong/Weak Comparisons column indicates

1 Exceptional Case Marking (ECM) is a syntactic phenomenon where a verb in the main clause assigns accusative case to the subject of an embedded infinitival clause. This occurs in specific

experiments comparing strong versus weak positions, such as 50% vs. 50%, and whether the differences were significant.

syntactic environments and impacts pronoun interpretation and syntactic structure. In ECM constructions, the subject of the infinitival clause appears to receive its case from the main verb, which is not typical for embedded clause subjects Chomsky (1981) and Lasnik (1981)

Table 20: Cross-linguistic results on pronoun interpretation in Principle B environments

Language	Experiment	Lexical antecedent (%)	Quantified antecedent (%)	Chain condition	Strong/weak
Dutch	Sigurjónsdóttir and Coopmans (1996)	17	-	-	-
Dutch	Philip and Coopmans (1996)	33	53	ECM: 10%	-
Dutch	Baauw and Cuetos (2003)	-	-	-	50% vs. 50%
English	Chien and Wexler (1990)	50	80	-	-
English	McKee (1992)	50	-	-	-
English	Conroy et al. (2009)	89	86	-	-
Russian	Avrutin and Wexler (1992)	48	83	-	48% vs. 66% (not signif.)
Norwegian	Hestvik and Philip (1999/2000)	90	99	Anti-subject Contexts 39%	-
German	Hamann and Ruigendijk (2009)	94	-	ECM	95% vs. 95%
German		-	-	Low 60%	Both:low
Italian	McKee (1992)	90	-	High 30%	-
French	Jakubowicz (1989)	80	80	-	-
French	Hamann et al. (1997)	90	80	ECM: 51%	-
Spanish	Baauw et al. (1997)	90	90	ECM: 64% Mean age: 5;6	-
Greek	Varlakosta (2000)	95	-	-	87% vs. 95%

The acquisition of pronominal reference involves a complex interplay of syntactic, pragmatic, and processing factors. This is an extensive field of research; see Conroy et al. (2009) and Hendriks et al. (2007) for significant contributions. What is relevant for our purposes is that the DPBE is a comprehension phenomenon, since children never revert to a pronoun instead of a reflexive in production. This serves, therefore, as an example of production-before-comprehension, most unusual in language acquisition.

3.1 AGREEMENT THROUGH OFFLINE METHODS

The literature on the acquisition of subject-verb agreement presents one additional case of production-before-comprehension. In a study by Johnson et al. (2005), the comprehension of the third-person marker as an agreement marker was investigated in a group of English-speaking children aged three to six years. The sample comprised 62 children within this age range. This study employed a picture selection task where verb inflections were the sole cue to the subject number; to hide number agreement in the subject, verbs beginning with an *-s* cluster (such as *swim* and *see*), which co-articulated with the plural *-s* on the noun, were used as stimuli. Only regularly inflected nouns were employed as subjects. The stimulus set consisted of five stimuli with third person singular marking *-s* and five stimuli with a Øinflection for plural. An experimental set is represented in examples (26) and (27) for singular and plural respectively:

(26) The duck swims on the pond.

(27) The ducks swim on the pond.

The session began with three warm-up trials, six copula/auxiliary trials, and overt subjects. During the experimental session, two scenarios were presented for each sentence within a single figure, with each scenario depicting two actor sets engaging in the same action associated with the verb, positioned on opposite sides of the figure. For example, Figure 9 displayed two pictures of ducks performing the same action, in one card two ducks and on the other card only one duck. The experimenter then posed a question to the participant:

(28) 'Show me the picture where **the duck swims** in the water.'

(29) 'Show me the picture where **the ducks swim** in the water.'

The results of this study show that participants did not perform well until the ages of five to six years. As shown in Table 21, the accuracy means and standard deviations were grouped by age. The older children demonstrated a high performance in all conditions. The plural condition seemed particularly challenging, in contrast, the singular condition showed better performance than the plural condition.

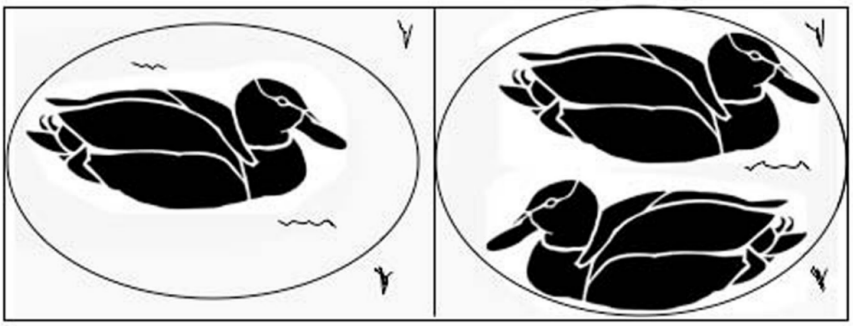


Figure 9: Visual stimuli used by Johnson et al. (2005)

Table 21: Mean % accuracy per age and condition Johnson et al. (2005)

Age		Singular	Plural
3	mean	52.38	41.90
	SD	22.34	21.82
4	mean	64.44	46.67
	SD	21.86	28.28
5	mean	78.67	61.33
	SD	27.74	35.33
6	mean	78.89	53.33
	SD	27.84	34.30

The findings led Johnson et al. (2005) to conclude that the third-person singular *-s* inflection in English does not clearly indicate subject number agreement for children aged 3 to 4 years. They suggested that the limited inflectional morphology of English, where only the third-person singular form is explicitly marked, may obscure the role of the *-s* ending in signaling number agreement. The study reported that while Mainstream American English (MAE) speakers begin to consistently use *s* in production by approximately 3 years and 5 months, they do not reliably use it to infer subject number in comprehension tasks until around 5 to 6 years of age. The authors noted a potential oversight in previous research on the comprehension of the third-person *-s* as a cue for number agreement (Soderstrom et al., 2002). They proposed that the complexities of the English present tense system, where *-s* denotes third-person singular but is not used for the singular in the first or second person, might complicate the acquisition process.

In research conducted by Pérez-Leroux (2005), the experimental design of Johnson et al. (2005) was replicated to address the case of comprehension in a morphologically rich language. Therefore, the primary goal was to investigate whether children exhibit similar challenges in a morphologically rich language like Spanish. By replicating Johnson et al.'s experiment in Spanish, Pérez-Leroux (2005) aims to explore if the observed asymmetry between production and comprehension is a universal phenomenon or influenced by language-specific factors. Notably, although Spanish has a robust agreement system, the dialect studied exhibits reliable agreement only on the verb and not on the noun: she tested Caribbean Spanish, particularly Dominican Spanish, where the syllable-final *-s* marker often undergoes aspiration or deletion. Aspiration transforms the *-s* into an [h]-like sound, while deletion results in the complete omission of the *-s* sound. For instance, *los gatos* 'the cats' can be pronounced as [loh 'gatos] with aspiration or [lo'gatos] with deletion. These variations affect how plural forms are identified, with speakers relying more on other grammatical cues like verb agreement. This phenomenon is widespread across Caribbean Spanish dialects (Poplack, 1980). This fact mask the number information in the article as it was designed in (Johnson et al., 2005) making the only cue of number available in the verb.

To examine this, Pérez-Leroux (2005) tested 23 children aged three to six years. The visual material, as depicted in Figure (10), differed in terms of coloring and drawing style compared to that used by Johnson et al. (2005), but the experimental design was identical.

To avoid the interference of nominal inflection, null subject sentences were utilized by Pérez-Leroux (2005). Spanish, being a pro-drop language, allows these even without a full-DP subject. This is exemplified in examples (30) and (31), where the verb ending is the only indicator of number. A full-DP condition, both in singular and plural, was also included, as shown in examples (32) and (33). The experimental set consisted of four conditions: full-DP

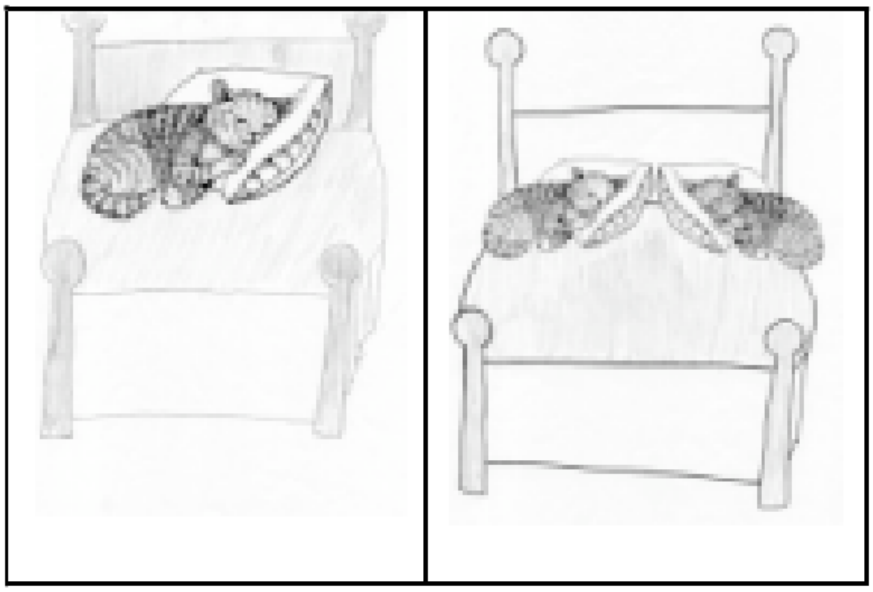


Figure 10: Visual stimuli used by Pérez-Leroux (2005)

singular (30) and plural (31), and null subject singular (32) and plural (33). In total, 16 verbs were used, yielding 64 items.

(30) El gato duerme.
the.M.SG cat.M.SG sleep.3SG
'The cat sleeps.'

(31) Los gatos duermen.
the.PL cat.M.PL sleep.3PL
'The cats sleep.'

(32) Duerme.
sleep.3SG
'(The cat) sleeps.'

(33) Duermen.
sleep.3PL
'(The cats) sleep.'

The results showed that, although children seemed to perform slightly better in the plural condition compared to the study of Johnson et al. (2005), their overall performance was low. Tables 22 present the comprehension results of Spanish-speaking children, which are remarkably similar to those of English-speaking children in Table 21. The results indicated a significant effect of age, with older children demonstrating higher accuracy in the picture selection task than younger children ($F_{1,21} = 5.913$, $p = .024$). No other significant effects involving sentence type or number marking were found. Notably, children performed better with lexical subjects, particularly the older group, who also showed greater accuracy with plural forms These findings

do not support the notion that the lack of robust verb morphology in English is the reason for the results reported by Johnson et al. (2005).

Table 22: Mean accuracy for SG and PL (Spanish) Pérez-Leroux (2005).

Full- DP	**Age range**	**SG**	**PL**
Younger	3;2-4;5	52%	45%
Older	4;8-6;6	67%	79%
Pro-drop	**Age range**	**SG**	**PL**
Younger	3;2-4;5	52%	45%
Older	4;8-6;6	50%	67%

Pérez-Leroux (2005) argued that the apparent syntactic delay may be explained by theories that treat distribution and syntax-semantics mapping as separate layers of development. The author suggests that the source of difficulty with numbers lies at the syntax/semantic interface, meaning that children may master the morphology and syntactic distribution of number marking without fully understanding its semantic distribution. The present study indicates that a developmental gap in understanding number also exists in Spanish. This suggests that acquiring a language with a uniform verbal paradigm does not improve the use of number marking in comprehension for children. The lack of morphological uniformity in the verbal paradigm cannot be the source of the comprehension difficulty, as children perform equally poorly in a language with robust verbal morphology (Gerth et al., 2017). The results also indicate that target performance appears first for the marked form (the plural)) rather than for the member of the paradigm expressed by zero morphology (the singular). This raises the query of whether the root cause of issues with number comprehension lies in morphological factors, syntax, or semantic considerations (like number neutralization). If i is the latter, children may interpret sentences in a generic manner and what evolves over time is their capacity to refine the sentence's meaning to denote specific instances rather than general categories.

As a follow up study to the English study Gxilishe et al. (2009) designed an experimental study to investigate Xhosa-speaking children's sensitivity to subject and object number information encoded in verb morphology. Xhosa is a Bantu language which exhibits complex morphology. The verb structure allows for the insertion of grammatical morphemes in nine distinct positions, enabling the agreement with both subject and object noun classes (Plessis & Visser, 1998). This feature allows Xhosa verbs to convey extensive grammatical information, often without the need for overt arguments. The study involved two primary tests: one assessing subject agreement and the other, object agreement. Each test utilized a set of picture pairs representing

singular and plural forms, accompanied by sentences that either contained a lexical subject/object or relied solely on the morphological markers for number information. The participant group consisted of 38 children aged 4 to 5 from daycare centers around Cape Town. The experimental stimuli were carefully selected to reflect common singular-plural agreement pairs in Xhosa, ensuring cultural and linguistic relevance for the child participants.

Xhosa nouns are categorized into fifteen classes, each marked by a unique noun prefix. These classes include eight singular and seven plural forms (Plessis, 1997). For example, the singular form *um-ntu* ('person') becomes *aba-ntu* ('people') in the plural, and *u-sisi* ('sister') becomes *oo-sisi* ('sisters'). Each noun class affects the verb morphology, necessitating appropriate agreement markers on the verb for both the subject and the object (Gxilishe et al., 2009). For instance, the sentence in (34) shows how the subject marker *ba-* corresponds with the noun class of *oomama* (mothers).

(34) Oomama ba-thetha efonini.
mothers SM.CL2-talk on.the.phone
"The mothers talk on the phone."

The agreement markers on Xhosa verbs are not straightforward copies of the noun prefixes. Instead, they vary according to the noun class, making the agreement system more complex. For example, in the sentence (35), the subject marker (sm) *ba-* agrees with the noun class of *oo-sisi* (sisters).

(35) Oo-sisi ba-hlala phezu kwesofa.
sisters SM.CL2-sit on the.sofa
"The sisters sit on the sofa."

Similarly, in sentence (36), the subject marker *zi-* corresponds with the noun class of *izinja* 'dogs'.

(36) Izi-nja zi-hlala phezu kwesofa.
dogs SM.CL10-sit on the.sofa
"The dogs sit on the sofa."

The question the child was asked was 'show the picture where…'. The responses were evaluated based on two criteria. First, accuracy was assessed by counting the number of correct responses. More importantly, the children's sensitivity was measured, which involved determining whether the child selected the singular picture exclusively when the singular sentence was presented. This measure accounts for any bias, such as a tendency to consistently prefer singular or plural pictures. Sensitivity was calculated as the ratio of the number of times singular pictures were chosen when singulars were presented to the total number of singular presentations, and similarly for plural pictures. A sensitivity of 0.5 indicates chance performance. For the Subject morpheme (SM) on the verb, the average sensitivity remained around chance level, as depicted in Figure 11. Although there was a significant increase in sensitivity to singular forms between the ages of four

and five, performance at each age did not exceed a level of 0.5 according to a single-sample t-test. This finding was consistent for both singular and plural forms. Figure 12 illustrates the performance levels on Object agreement (OM) information. Sensitivity to both singular and plural forms did not surpass chance levels for any age group, and there was no age-related difference in performance for either index. However, it is noteworthy that the reported results do not fully explain the performance of the 4-year-old group in the OM plural condition, where their performance appears higher than that of the older 5-year-old group. The data suggest that some children could perform the task while others could not.

The authors suggest that the insensitivity to morphological markers of number in both subjects and objects among Xhosa-speaking children is related to the late acquisition of these features, influenced by factors beyond mere exposure to rich morphological systems. The Xhosa-speaking children's data resemble those from English-speaking children as reported in Johnson et al. (2005) or Spanish by Pérez-Leroux (2005), showing no sensitivity to the morphemes that carry number agreement with the subject. Spontaneous speech data suggest Xhosa-speaking children produce correct number agreements early (de Villiers & Gxilishe, 2009), reversing the usual comprehension-production gap. This warrants further investigation.

To investigate the parsing of agreement in children, both Gonzalez-Gómez et al. (2017) and Legendre et al. (2006) conducted studies examining the task demands of experiments administered to them. Although Gonzalez-Gómez et al. (2017) builds upon the groundwork laid by Legendre et al. (2006), this section focuses on offline methods, while the methodology used by Legendre et al. (2006) is online. Therefore, the study by Legendre et al. (2006) will be presented in the next section chapter 4. The study by Gonzalez-Gómez et al. (2017) investigates whether simplifying task demands enhances the parsing of subject-verb agreement in Spanish at an earlier stage. The authors carried out two experiments with the same setup and instructions for both experiments. The visual materials in both experiments, exemplified in Figure 13, consisted of two videos presented side by side to each participant and played simultaneously. These materials corresponded to those used in the study by Legendre et al. (2014) in each video, two boys appear. In the singular condition, one boy executes an action alone while the other remains stationary beside him. In the plural condition, both boys perform the action together. For the singular and plural conditions of each action, different unfamiliar objects were utilized, totaling sixteen in number. Consequently, the same action was performed on different objects either by one boy (singular video) or by both boys simultaneously (plural video). Each video sequence had a duration of 6 seconds.

In both experiments children were tested individually, each child was seated in front of a touchscreen monitor and instructed to touch one of the

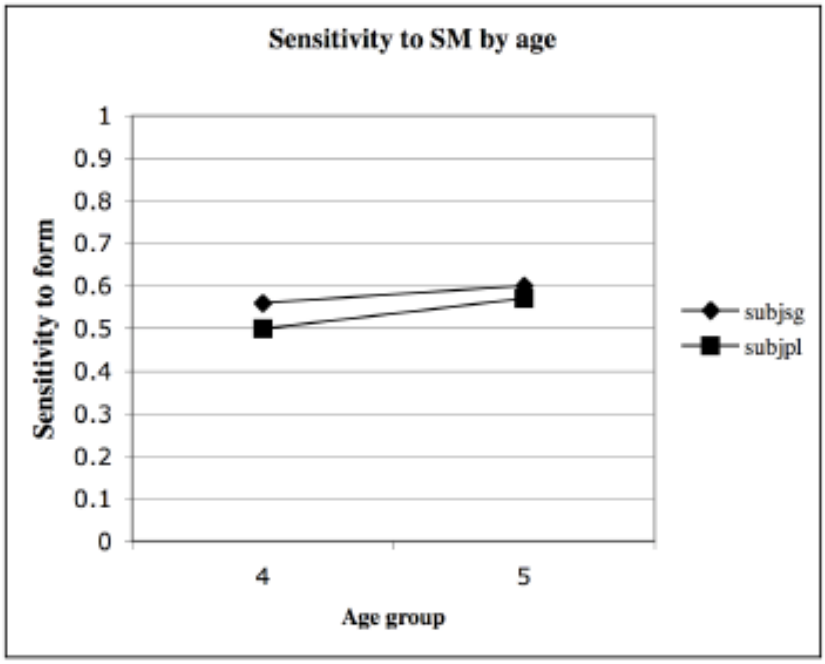


Figure 11: Sensitivity to subject marking by age, Xhosa

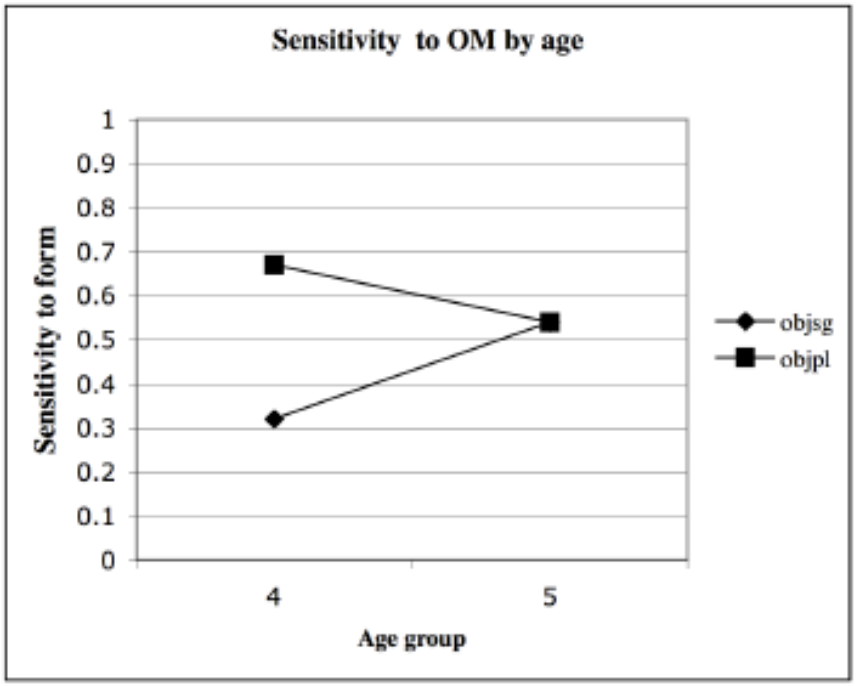


Figure 12: Sensitivity to object marking by age, Xhosa.

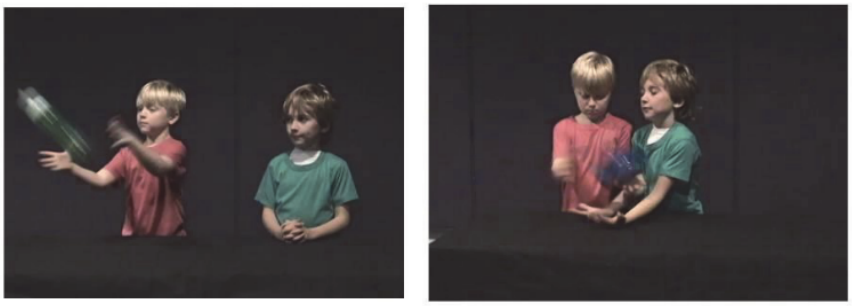


Figure 13: Visual stimuli used by Gonzalez-Gómez et al. (2017).

images shown on the screen. The session began with four training trials using familiar objects to ensure the children understood the task. During the test phase, the two videos were displayed simultaneously while the experimenter asked the child to point to the video that matched the verbal stimulus. The child's touch response was recorded, and feedback was given by changing the screen color.

In Experiment 1, forty monolingual Mexican Spanish-speaking children participated (mean age = 50 months; range: 38-64 months; 22 girls, 18 boys). The verbal stimuli consisted of short null subject sentences structured as transitive verb + determiner + pseudo-noun (e.g., 37 and 38). The verbs used were *amarrar* 'tie', *agarrar* 'catch', *besar* 'kiss', *quitar* 'remove', *limpiar* 'wipe', *parar* 'stop', *llevar* 'carry', and *sacar* 'take out'. The pseudo-nouns used were *lipe*, *pliro*, *napo*, *duco*, *leto*, *miso*, *trude*, and *jaldo*.

(37) Agarra el miso.
grab-3SG D-M-SG /pseudonoun/
'(He) grabs the miso.'

(38) Agarran el miso.
grab-3PL D-M-PL /pseudonoun/
'(They) grab the miso.'

Forty monolingual Mexican Spanish-speaking children participated in Experiment 2 (mean age = 51 months; range: 41-61 months; 16 girls, 24 boys). The visual stimuli were the same sixteen videos used in Experiment 1. The key difference between the two experiments was in the verbal stimuli. In Experiment 2, the verbal stimuli consisted of short null subject sentences structured as transitive verb + determiner + familiar noun *objeto* 'object', as exemplified in (39) and (40). The same eight verbs used in Experiment 1 were used in this experiment.

(39) Agarra el objeto.
grab-3SG D-M-SG object
'(He) grabs the object.'

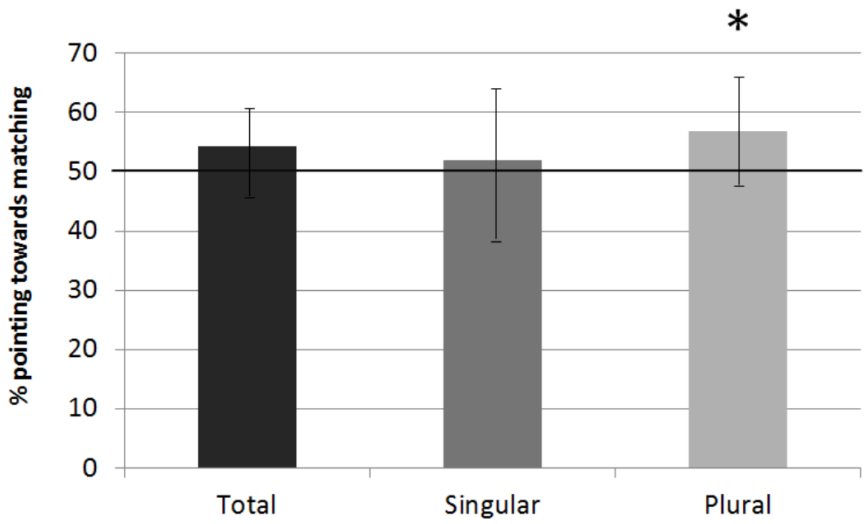


Figure 14: Results Experiment 1, Spanish (Gómez & Maye, 2005)

(40) Agarran el objeto.
grab-3PL D-M-PL object
'(They) grab the object.'

The results of Experiment 1 and Experiment 2 are summarized in Table 23. Experiment 1 revealed overall performance at chance level with no significant effect of age. In contrast, Experiment 2 showed above-chance performance for both singular and plural conditions, as well as for both age groups tested.

Table 23: Results of Experiment 1 and Experiment 2, Spanish based on (Gómez & Maye, 2005)

Condition	Experiment 1	Experiment 2
Total	54.37 (15.90)	61.56 (18.64)**
Singular	51.87 (27.96)	60.63 (23.94)**
Plural	56.88 (18.76)	62.50 (24.67)**

The results of Experiment 1 prompted observations that the pseudo-nouns used might have introduced significant cogitative challenges. The authors report evidence by children's expression of confusion, such as *No sé cuál es el miso* ' I do not know which the miso is', suggesting that the pseudo-nouns detracted from their ability to concentrate on subject-verb agreement. These results of experiment 1 align with with previously reported studies, since this study fails to detect early parsing of agreement in Spanish, as it is shown in Figure 14.

Overall performance was at chance level ($t(39) = 1.74$, $p = .09$) and for the singular condition ($t(39) = .43$, $p = .67$). However, performance was above

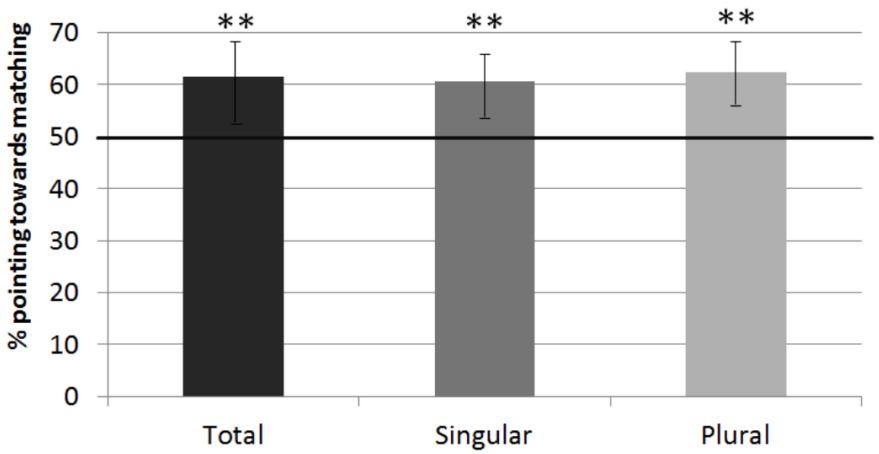


Figure 15: Results Experiment 2, Spanish (Gómez & Maye, 2005)

chance for plural trials (t(39) = 2.32, p = .03), though this significance did not hold after correction for multiple comparisons. Age-based analysis showed chance-level performance for both younger (MTotal = 55.26%, SD = 17.34%; t(18) = 1.32, p = .20) and older groups (MTotal = 53.57%, SD = 14.87%; t(20) = 1.10, p = .28), with no significant age effect (t(38) = .33, p = .74). It is important to note that in contrast to, for example, Pérez-Leroux (2005) and Johnson et al. (2005), this study used more interactive and engaging tasks using a touch-screen, live auditory stimuli and videos.

Experiment 2 directly addressed the methodological concerns raised in Experiment 1 by replacing pseudo-nouns with the noun *objeto* 'object', while maintaining identical experimental conditions otherwise. This strategic modification aimed to ascertain if task performance could be enhanced the use of a familiar object.

Figure 15, summarizes the findings of experiment 2. The group means were: MTotal = 61.56% (SD = 18.64%), MSingular = 60.63% (SD = 23.94%), and Plural = 62.50% (SD = 24.67). Overall performance was significantly above chance level (t(39) = 3.92, p < .001), for both singular (t(39) = 2.81, p = .007) and plural trials (t(39) = 3.20, p = .002). Age-based analysis showed performance above chance for both younger (MTotal = 62.50%, SD = 19.45%; t(19)= 2.87, p = .009) and older groups (MTotal = 60.62%, SD = 18.26%; t(19) = 2.60, p = .01), with no significant age effect (t(38) = .09, p = .93).

The authors discuss that the improvement observed in Experiment 2 strongly suggests that eliminating the pseudo-noun facilitated the parsing of subject-verb agreement among children aged 41–50 months, as shown in Figure 15. This change underscores the critical role of task demands in assessing language parsing abilities in children. The authors further discuss that the findings suggest a method to minimize collective/distributive interpretations of verbal stimuli in such tasks without introducing the complexity of pseudo-words. Experiment 2 demonstrated that Spanish-learning children

as young as 41 to 50 months can parse number subject-verb agreement, providing new information on early language acquisition. The authors note that while Experiment 2 revealed earlier comprehension of subject-verb agreement in Spanish than previously reported, but differences relative to French learners remain. Previous research has shown successful comprehension of subject-verb agreement in French as early as 30 months (Culbertson, 2010; Legendre et al., 2010), indicating that pseudo-nouns did not hinder French learners' performance. The authors propose several factors that may contribute to this discrepancy:

1. Practice Trials: Presenting two objects and asking children to match a noun label may have led children to expect that objects were relevant to the task, rather than the number of actors.

2. Similar Test Trials: The two videos for each test trial were very similar, always showing two boys and the same action, making the unfamiliar objects particularly salient.

3. Cognitive Load: Pseudo-words likely introduced a higher processing load, distracting children from focusing on subject-verb agreement markers.

The authors highlight that differences in the agreement systems of French and Spanish also play a role. French uses prefixal agreement markers that are overt and perceptually salient, while Spanish uses suffixal markers that are less transparent. The high cue reliability and perceptual salience of the French liaison /z/ marker may explain why French-learning children showed earlier comprehension despite similar experimental conditions (Barrière et al., 2011; Spinelli et al., 2003).

As discussed, previous studies have primarily focused on English and Spanish, revealing that children's comprehension of number morphology often lags behind their production abilities. Smolík and Bláhová (2016) extend the investigation of grammatical number comprehension to Czech, a language with a rich morphological inflectional system. Their comprehensive study examined how Czech children aged 3 to 4 years understand number agreement in verbs through two experiments. They hypothesized a proportional increase in vocabulary growth and comprehension and employed a pointing picture selection task, suggesting that pointing induces deliberate and controlled responses. Czech has a complex system of morphological inflection, where verbs inflect for both number and person to indicate subject agreement. For example, the verb *běžet* 'to run' conjugates as *běžím* (1st person singular), *běžíš* (2nd person singular), and *běží* (3rd person singular) in the singular form, and *běžíme* (1st person plural), *běžíte* (2nd person plural), and *běží* (3rd person plural) in the plural form. This intricate system makes Czech an ideal language to examine the acquisition and comprehension of grammatical number agreement in children.

The study used linguistic material in four conditions: two with a transitive verb or an intransitive verb where the subject was omitted, and two control conditions focusing on object marking in singular and plural. The expeirmental conditions are exemplified below:

(41) Tady běží/běhají
Here run.SG/run.PL
'Here he runs/they run.'

(42) Tady čte/čtou knihu
Here reads.SG/read.PL book.SG
'Here he reads/they read a book.'

In experiment 1, children (N = 72, ages 3;0–4;7) were shown 20 items on a laptop screen, each consisting of a sentence and a pair of pictures differing in the number of participants or objects involved. In half the items, the subject was omitted, making the verb's number inflection the sole cue. The other half included lexical subjects or objects marked for number. This design ensured a balanced distribution of singular and plural items across participants. The vocabulary test, similar to the Peabody Picture Vocabulary Test (Stein & Lukasik, 2009), was a 30-item receptive vocabulary task. Children were shown a page with four pictures and asked to point to the one corresponding to the word spoken by the experimenter.

Experiment 2 replicated Experiment 1 with only transitive and intransitive sentences with null subjects and number marking solely on verbs. The verbs belonged to a single class, with the ending -e (pronounced [ɛ]) in the third-person singular form, such as *nese* (he/she carries), and the diphthong -ou [ou] in the third-person plural form, such as *nesou* (they carry). A total of 45 participants aged 3;4–4;9 were tested with 16 items.

(43) Tady běží.
here run-3SG
'Here he/she runs.'

(44) Tady čte knihu.
here read-3SG book
'Here he/she reads a book.'

The statistical analysis revealed an interaction between age and comprehension levels. Specifically, there was no relationship between age and comprehension for plural items, but a clear increase in comprehension for singular items with age. When vocabulary scores were used as a measure of language development, there was an increase in accuracy with higher vocabulary scores. The authors further propose that the observed comprehension-production asymmetry may be due to pragmatic limitations rather than purely linguistic ones. They argue that singular agreement can be consistent with a plural representation; for example, a sentence like "The cat sleeps" can

describe a single cat or part of a scene with multiple cats. However, the suggestion of pragmatic limitations does not fully explain cross-linguistic differences. For instance, English-speaking children perform better wuth singular forms, while Spanish-speaking children show better performance with plural forms Johnson et al. (2005), Miller and Schmitt (2014), and Silva-Pereyra et al. (2005). This highlights the need for further research to explore the role of pragmatics in language comprehension across different languages.

The authors further suggest that the nature of the pointing task itself might have influenced the results. Pointing requires children to make a conscious, deliberate choice, which might be more demanding than responding in more naturalistic settings, as in preferential looking tasks, or truth value judgment tasks, where participants decide if a description fits a single picture Crain and Pietroski (2001).

A study by Sánchez (2020) also introduced a manipulation in the design, although quite different in nature to that of Gonzalez-Gómez et al. (2017). For this study, Sánchez (2020)translated and adapted the items of Pérez-Leroux (2005)'s experiment to Catalan. Unlike the stimulus sentences used in Johnson et al. (2005) and Pérez-Leroux (2005)'s studies, the experiment conducted consisted of three conditions: a full DP subject condition, a null subject condition and numerical subject condition, each comprising singular and plural forms. This experiment is the direct antecedent of Study 1 presented in chapter 3. The study by Sánchez is a picture selection task developed based on the earlier studies by Johnson et al. (2005) and Pérez-Leroux (2005) and follows the same experimental framework.

Table 24: Stimuli items for singular and plural scenes, Catalan by Sánchez (2020)

Condition	Singular	Plural
Full-DP Lexical subject	El gat dorm a terra.	Els gats dormen a terra.
	the cat sleep-3SG on floor	*the cats sleep-3PL on floor*
	'The cat sleeps on the floor.'	'The cats sleep on the floor.'
Full-DP Numeral	Un gat dorm a terra.	Tres gats dormen a terra.
	one cat sleep-3SG on floor	*three cats sleep-3PL on floor*
	'One cat sleeps on the floor.'	'Three cats sleep on the floor.'
Null subject	Dorm a terra.	Dormen a terra.
	sleep-3SG on floor	*sleep-3PL on floor*
	'(The cat) sleeps on the floor.'	'(The cats) sleep on the floor.'

The study included 30 sentences, with 10 sentences per condition, each with five singular and five plural sentences. Table 24 is an example of one experimental set. The age groups of the participants also followed Pérez-Leroux (2005)'s study. The sample included twenty-five typically developing children between the ages of three and six, in addition to adults who were

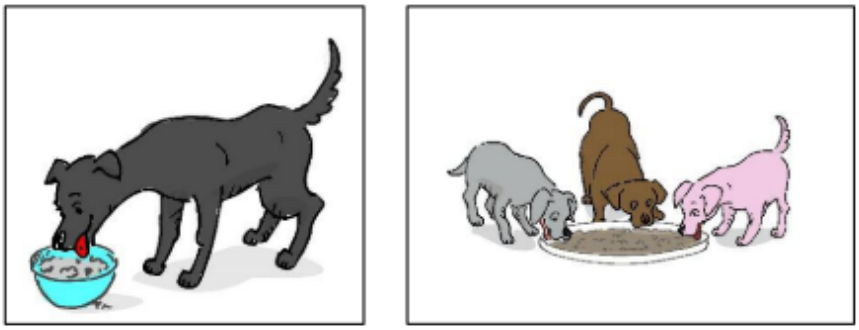


Figure 16: Visual stimuli of full-DP used by Sánchez (2020).

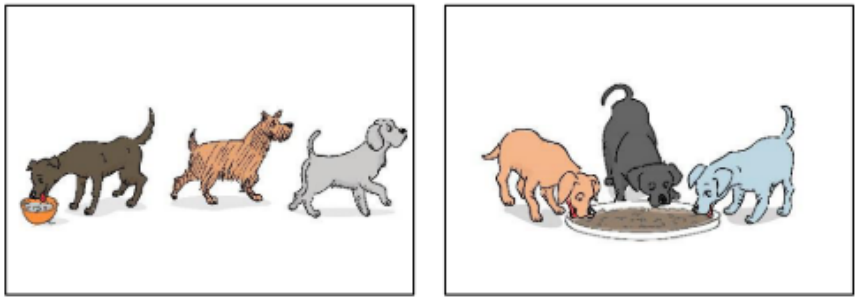


Figure 17: Visual stimuli of Numeral condition by Sánchez (2020).

native Catalan speakers. The stimuli used in the study were based on those utilized by Pérez-Leroux (2005), and consisted of one-agent versus three-agent pictures, as seen in Figure (16). For the numeral condition, the pictures were slightly different: the singular set depicted one individual performing the action while two others were not (e.g., eating), see Figure 17. In the plural set, children could observe an action carried out by three agents interacting with the same object (see Figure 17).

Participants were exposed to two simultaneous pictures as exemplified in Figure 24 for a few seconds during the test phase. The recording was played while the two pictures were presented side by side on the screen. Then, the participant was asked to point to the picture matching the sentence.

The results summarized in Table 25 show high performance, above 50% level, across conditions and age groups. In the lexical subject condition, the younger group (aged 3;1–4;11) performed with 90% accuracy in the singular condition and 69% in the plural condition. The older group (aged 5;2–6;2) showed better performance in the plural condition with 91% accuracy compared to 88% in the singular condition. Adults performed at 100% accuracy across all conditions. In the numeral subject condition, the younger group achieved 75% accuracy in the singular condition and 100% in the plural condition. The older group also performed at 100% accuracy in the plural condition and 83% in the singular condition. The null subject condition re-

vealed lower performance across age groups compared to the lexical and numeral subject conditions. The younger group showed 80% accuracy in the singular condition and 61% in the plural condition. The older group performed similarly with 80% accuracy in the singular condition and 81% in the plural condition.

Table 25: Summary of Correct Responses by Condition and Age Group

	Singular		Plural	
	Correct	**Correct %**	**Correct**	**Correct %**
Lexical Subject				
Younger group (3;1–4;11)	59 / 65	90%	45 / 65	69%
Older group (5;2–6;2)	53 / 60	88%	55 / 60	91%
Adults	150 / 150	100%	150 / 150	100%
Numeral Subject				
Younger group (3;1–4;11)	49 / 65	75%	65 / 65	100%
Older group (5;2–6;2)	50 / 60	83%	60 / 60	100%
Adults	148 / 150	98%	150 / 150	100%
Null Subject				
Younger group (3;1–4;11)	52 / 65	80%	40 / 65	61%
Older group (5;2–6;2)	48 / 60	80%	49 / 60	81%
Adults	148 / 150	100%	147 / 150	98%

Overall, the results indicate that while younger children performed better in the plural condition compared to the singular condition, the performance in the null subject condition was generally lower across all age groups. In the results of this study infants did not present a comprehension delay in verb-subject agreement like the one in Johnson et al. (2005) and Pérez-Leroux (2005). The analysis presented by Sánchez (2020) shows high accuracy percentages across conditions and age groups. This might be related to several aspects of the experimental design by Sánchez (2020), which were changed in contrast to Johnson et al. (2005) and Pérez-Leroux (2005). The material was simplified by removing the distracting background and simplifying each action. The inclusion of the numeral condition by Sánchez (2020)'s study might have boosted children's performance as well.

A recent investigation conducted by Forsythe and Schmitt (2021) utilized a picture-selection task to probe the understanding of Spanish verbal agreement and clitics (including number and person features) in children aged between 2;03 to 6;07 years. This study sought to examine the impact of phonological salience and semantic (under)specification—crucial linguistic variables—on language comprehension. Phonological salience is defined as the perceptual prominence of a morpheme, influencing its detectability and,

	Agreement		Clitics	Semantic hypothesis
	1st plural *–mos*		1st plural *nos*	
	1st singular *–o*		1st singular *me*	earlier
	2nd singular *–s*		2nd singular *te*	
	3rd plural *–n*		3rd plural *los, las*	--------
	3rd singular *–ø*		3rd singular *lo, la*	later
Phonological hypothesis	later	<<	earlier	

Figure 18: Prediction of comprehension asymmetries Forsythe and Schmitt (2021)

thereby, its acquisition and comprehension by young learners. For example, in Spanish, the 2nd person singular marker /-s/ (as in *tú comes* 'you eat') is phonologically more salient than the zero-marked 3rd person singular form (as in *él come* 'he eats'). The presence of the /-s/ makes the 2nd person singular form more noticeable to children, aiding in its acquisition. Conversely, semantic (under)specification concerns the extent of semantic detail a linguistic form provides. Forms that are less specified, such as the 3rd person plural marker /-n/ (as in *ellos comen* 'they eat'), present comprehension challenges due to their broad applicability and sparse contextual cues. In comparison, 1st and 2nd person forms explicitly include features like [+speaker] and [+hearer], providing clearer semantic detail. For instance, the 1st person plural form *comemos* ('we eat') specifies that the action includes the speaker, whereas the 3rd person plural form *comen* does not specify the participants beyond their plurality, making it more semantically underspecified and potentially harder for children to interpret without additional context.

The predictions are summarized in Figure 18; 3rd person forms, which are less semantically specified, will be understood later than 1st and 2nd person forms, and clitics, which are more phonologically salient than suffixes, witll also precede subject-verb agreement.

The methodology embraced a fishing task, an interactive approach inspired by the work of Girouard et al. (1997), aimed at assessing children's language comprehension in a manner that is both naturalistic and engaging. A sample of the visual stimuli used is exemplified in Figure 19. This task capitalizes on the motivation and curiosity of young learners by embedding language assessment within an activity that simulates fishing. In the application of Forsythe and Schmitt (2021), however, the task does not entail actual

fishing; rather, it serves as a metaphorical equivalent, wherein children were required to align verbal prompts with corresponding images or scenarios depicted in photographs. Therefore, the task was a picture-selection task. The study comprised 30 test items, evenly divided between subject-verb agreement in present tense verbs and object clitics. Subjects were presented with an array of five photos depicting: (i) the subject, (ii) the experimenter, (iii) the subject and experimenter together, (iv) an unrelated teacher, and (v) two unrelated teachers together. In each photo, participants performed the same action, requiring identification based solely on interpreting the agreement or clitic morpheme in the prompt. Only feminine clitics were tested, and all experimenters were female. For the agreement condition, a set of intransitive verbs (unaccusative or unergative) or detransitivized verbs were used: *saltar* 'jump,' *aplaudir* 'clap,' *dormir* 'sleep,' *dibujar* 'draw,' and *bailar* 'dance'. An example of an agreement condition prompt is shown in (45). In the clitic condition, the photos showed a puppet named Nemo performing actions on each of the five persons: *besar* 'kiss,' *peinar* 'comb,' *lavar* 'wash,' *tapar* 'cover,' and *tocar* 'touch'. An example of a clitic condition prompt is shown in (46).

(45) Muéstrame la foto en donde bailamos/o/s/n/ø.
Show-me the photo in where dance-1P/1S/2S/3P/3S
'Show me the photo where we/I/you/they/(s)he dance(s).'

(46) Muéstrame la foto en donde Nemo está
Show-me the photo in where Nemo is
tapándonos/me/te/las/la
covering-1P/1S/2S/3P/3S
'Show me the photo where Nemo is covering us/me/you/them/her.'

The participant group included 46 Mexican Spanish-speaking children aged 2;3 to 6;7, in addition to 25 adult subjects. Prior to the main testing phase, a familiarization phase was conducted to ensure children could correctly identify each actor. During this phase, the primary experimenter introduced the actors and corrected any identification errors. This step was crucial for ensuring that children were familiar with the participants depicted in the photos, and could therefore identify the person feature.

The task was introduced to the children with clear instructions to ensure they understood what was required of them. The experimenter used the following instruction:

> "Vamos a ver algunas fotos de personas haciendo varias cosas y tú me vas a señalar la foto que yo te diga, ¿te parece? Pero sólo me vas a señalar una foto nada más, ¿bien?"
>
> "We're going to see some photos of people doing different things and you're going to point out the one I tell you, sound good? But you can only pick one photo, okay?"

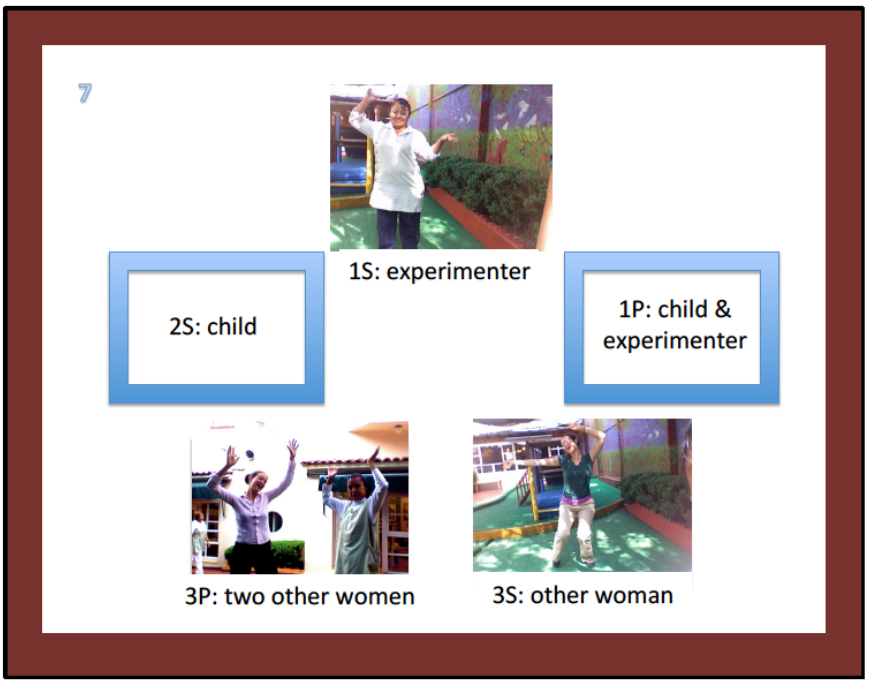


Figure 19: Stimuli example, Spanish by Forsythe and Schmitt (2021)

During the testing phase, children were shown an array of five photos and given a verbal prompt to point to the photo matching the description. Subjects were randomly assigned to one of two versions of the test items, each with a different random ordering to control for order effects. The experimental items were interspersed with fillers and distractors presented in a pseudorandom order. An example of the visual material employed by the study is shown in Figure 19.

Statistical analysis involved comparing responses to agreement and clitic forms, focusing on the differences in comprehension across first, second, and third-person conditions. The results indicated that both phonological salience and semantic underspecification significantly influenced comprehension. Both adults and children performed better with clitics and first- and second-person forms. Children, however, were more prone to errors in third-person conditions, often linking the third-person forms to the most recently mentioned referent.

A binary logistic regression was used to predict the probability of a target response based on the form (agreement vs. clitic) and person (first, second, or third). Table 26 shows the adult responses and Table 27 shows the responses of child participants (N = 42) to agreement and clitic conditions, organized by person and number (1Sg, 1Pl, 2Sg, 3Sg, 3Pl). In first- and second-person agreement conditions, children demonstrated high accuracy. The accuracy for first person singular (1Sg) was 0.88, for first person plural (1Pl) it was 0.69, and for second person singular (2Sg) it was 0.94. Third-person agreement conditions showed lower accuracy, with third person sin-

Table 26: Adult responses (N = 23; target responses in bold cells).

Picture choice	1Sg	1Pl	2Sg	3Sg	3Pl	Proportion target
investigator	**56**	0	1	14	1	0.91 (0.22)
adult & investigator	**7**	**66**	**3**	5	26	0.96 (0.15)
adult other	2	0	**64**	17	0	0.97 (0.13)
female-Sg	4	0	0	**30**	3	0.48 (0.37)
other female-Pl	0	3	1	**3**	**38**	0.55 (0.27)
other	0	0	0	0	1	0
no answer	0	0	0	0	0	0

gular (3Sg) at 0.30 and third person plural (3Pl) at 0.17. These results suggest that children find first- and second-person forms easier to understand than third-person forms, supporting the semantic hypothesis. Additionally, clitics, being more phonologically salient, generally led to higher accuracy than agreement forms, especially in third-person conditions, partially supporting the phonological hypothesis. The study reported a significant effect of form (agreement vs. clitic) for both adults and children, with participants producing more target answers in the clitic condition compared to the agreement condition. This effect was significant for both singular and plural forms. For adults, the effect of form was $\beta = 0.96, p < .05$ for singular and $\beta = 1.26, p < .05$ for plural forms. Similarly, for children, the effect was $\beta = 0.98, p < .05$ for singular and $\beta = 1.27, p < .01$ for plural forms. Additionally, there was a significant effect of person for both adults and children. First and second-person forms were better identified than third-person forms. In adults, the first-person effect was $\beta = 3.1, p < .01$ and the second-person effect was $\beta = 4.39, p < .01$. For children, the first-person effect was $\beta = 3.35, p < .01$ and the second-person effect was $\beta = 2.59, p < .01$. Moreover, a significant interaction was found between first-person forms and clitics for both adults and children, with $\beta = 1.50, p < .001$. These results confirm that phonological salience and semantic underspecification significantly influence the comprehension of agreement and clitic forms in both adults and children.

In summary, the study demonstrates that phonological salience and semantic underspecification play crucial roles in the comprehension of agreement and clitic forms. Both adults and children show better performance with clitics and first- and second-person forms, while more prone to errors in third-person conditions. They partially support the phonological hypothesis and offer more robust evidence for the semantic hypothesis. The phonological hypothesis posits that morphemes with greater phonological material are more salient and thus easier for children to process and comprehend. Consistent with this hypothesis, the study found that children were

Table 27: Child responses (N = 42, target responses in bold cells).

Picture choice	1Sg	1Pl	2Sg	3Sg	3Pl	Proportion target
investigator	**57**	9	2	15	12	0.88
child	**54**	**86**	**31**	33	44	0.69
child	6	14	**88**	39	34	0.94
other	3	1	2	**20**	13	0.30
female-Sg	5	15	3	**17**	**21**	0.17
other female-Pl	1	0	0	2	2	0.88
other	0	0	0	0	0	0.72
no answer	0	1	2	0	0	0.92

more accurate in their responses to third-person singular and plural clitics (e.g., *la, las*) compared to the less phonologically salient third-person agreement markers (e.g., *-o, -s, -n*). However, the authors note that this phonological advantage was not consistently observed across all forms, indicating that phonological salience alone does not fully explain the children's performance. In contrast, the semantic hypothesis, which argues that more semantically specified forms are easier to comprehend, received stronger support. Children showed higher accuracy in interpreting first- and second-person forms compared to third-person forms. This suggests that children can more easily grasp the semantic content of forms that encode specific person references (e.g., *me, te*) than those that do not (e.g., third-person forms). The authors reference theories of semantic underspecification, which propose that less specified forms present greater processing cost due to their broader applicability and lack of concrete contextual cues. The study also highlights the role of discourse prominence in shaping comprehension. The authors observed that both children and adults frequently allowed third-person agreement and clitics to refer to the speaker or addressee, a tendency not seen with first- and second-person forms (Gundel et al., 1993). Despite these findings, some questions remain unanswered. For instance, the study did not find reliably higher accuracy for the first- and second-person singular clitics (*me, te*) compared to their agreement counterparts (*-o, -s*), which challenges the phonological salience hypothesis. Additionally, since adults and children performed in similar ways, it is not clear that acquisition is being addressed, rather than processing.

Table 28 presents a comprehensive overview of research efforts examining subject-verb agreement acquisition among infants and children. This table highlights the diversity of methodologies employed, the range of languages investigated, and the different developmental stages considered. The participants range in age from 16 months to 6 years, covering a critical period

for linguistic development in languages such as English, French, German, and Spanish. The table delineates the specific linguistic constructs under investigation, including syntactic comprehension, verb learning, and mastery of functional language elements, by listing the specific test sentences utilized in each study. The studies are categorized by author, task, language, age, and sample test sentences, and encompass a variety of methodologies such as picture selection tasks Picture selection tasks (PS), the IPLP, and the Head-turn preference procedure (HPP). Off-line methodologies have been considered in this chapter; on-line methods will be presented in chapter 4.

Table 28: Overview of agreement studies across methods and languages

Study	Task	Language	Age		Stimuli
Johnson et al. (2005)	PS	ENG	3-6ys	(1)	a. The duck swims on the pond.
					b. The ducks swim on the pond.
Pérez-Leroux (2005)	PS	SPA	3-6ys	(2)	a. Nada en el charco.
					b. Nadan en el charco.
					c. El pato nada en el charco.
					d. Los patos nadan en el charco.
Melançon and Shi (2015)	PS	FREN	2.5ys	(3)	a. Le joli ravole.
					b. La joli ravole.
Smolík and Bláhová (2016)	PS	CZE	3-4ys	(4)	a. Tady běží/běhají
					b. Tady čte/čtou knihu.
					c. Maminka/maminky tlačí kočár.
					d. Pán nese tašku/tašky.
Gonzalez-Gómez et al. (2017)	PS	SPA	2.8ys	(5)	a. Agarra el miso.
					b. Agarran el objeto.

Continued on next page

Study	Task	Language	Age		Stimuli
Forsythe and Schmitt (2021)	PS	SPA	2-6ys	(6)	Muéstrame la foto en donde hay alguien saltando
Legendre et al. (2014)	IPLP	FRE	30-36mo	(7)	a. Il embrasse le /gef/: /ilɛ̃bʁasləgef/.
		ENG			b. The boys kiss the /dajt/.
		SPA			c. Besa el micho.
Brandt-Kobele and Höhle (2010)	IPLP	GER	3-4ys	(8)	a. Sie fütter-t/en einen Hund.
Lukyanenko and Fisher (2016)	IPLP	ENG	2.6ys		a. Where is/are the. . . ?
					b. There is/are the. . . !
Shi et al. (2020)	IPLP	FRE	1.4ys	(9)	a. La banane dans le chapeau elle.
					b. *La banane et le chapeau elles.
					c. La banane et le chapeau ils.
					d. *La banane dans le chapeau il.
Soderstrom et al. (2007)	HPP	ENG	1.3ys	(10)	a. They used to sing in the chairs on the porch
					b. *They used to chairs in the sing on the porch
Nazzi et al. (2011)	HPP	FRE	1.5ys	(11)	a. Les garçons boit.
					b. *Le garçon font/lisent.

3.2 STUDY 1: PARSING OF SUBJECT-VERB AGREEMENT IN CHILDREN

To investigate the development of linguistic competence in young children, particularly their acquisition of subject-verb agreement, Study 1 employed a picture selection task to assess Catalan-speaking children's understanding of agreement in both full-DP and null-subject sentences, covering singular and plural forms.

Rationale

Study 1 used a picture selection task to assess children's acquisition of subject-verb agreement. I investigated subject-verb agreement in full-DP and null-subject sentences, covering both singular and plural forms in Catalan (experiments 1 and 2). The testing conditions were consistent across all experiments. To minimize potential confounding variables associated with subject-verb agreement complexities, only intransitive verbs were used as linguistic material. Experiments 1 and 2 explored the extent of subject-verb agreement knowledge in Catalan-speaking children aged 3, 4, 5 and 6 years. The critical aspect under investigation was agreement in number, with verbs conjugated in either third-person singular (*-ø*) or third-person plural (*-n*) forms. Experiment 2 introduced a numeral distractor to evaluate its impact on the conditions under examination. Both experiments employed the picture selection methodology, a well-established approach as discussed earlier in section 3.1 in language comprehension research. This method involves presenting participants with an auditory sentence alongside an array of pictures, asking the participant to select the picture that best corresponds to the verbal stimulus. The experimental design closely aligns with the work of Pérez-Leroux (2005) and the pilot study conducted by Sánchez (2020), both of which drew inspiration from Johnson et al.'s experimental framework. However, adjustments were made to the visual stimuli, and the sample size was significantly expanded compared to the aforementioned studies. In both Experiments 1 and 2, children's comprehension of subject-verb agreement

was assessed using pairs of pictures, each pair consisting of a target picture and a number distractor picture.

Concurrently, the study aims to determine the chronological point at which this linguistic competence crystallizes in their development. The theoretical postulation aligns with the notion that young language learners, alongside their emerging expressive abilities, possess the cognitive aptitude to unravel the intricacies of subject-verb agreement in both null- and non-null subject languages. Should this hypothesis be confirmed, illustrating the early mastery of subject-verb agreement parsing, it would bring further evidence for the Very Early Parameter Setting (VEPS) framework (Wexler, 1998). As per this theory, prior to progressing into the two-word developmental stage, very young children (by 18 months), adjust the feature values within their target language's grammatical system, which includes inflectional markers and associated grammatical elements.

Predictions

In this experiment, measuring the correct response percentage to null subject and full-DP sentences in singular and plural forms, several predictions are made:

1. Successful parsing of subject-verb agreement: Children with the linguistic competence to parse subject-verb agreement are expected to show a significantly higher correct response rate.

2. Random performance without parsing: In the absence of subject-verb agreement parsing, children's responses are predicted to be random. Lacking knowledge of the grammatical structures, their selections would resemble chance-level performance.

3. Variation across sentence types: The ability to parse subject-verb agreement might differ across sentence types. For example, children might show higher accuracy with full DP subject indicating that number markers in the subject are necessary for the child to identify number.

4. Developmental patterns: Older children may demonstrate higher accuracy, suggesting that acquiring subject-verb agreement is a developmental process that improves with age and linguistic experience.

3.3 EXPERIMENT 1

Design and materials

Experiment 1 aimed to analyze subject-verb agreement in young Catalan-speaking children through a picture-sentence matching task. This task assessed the number contrast between singular and plural forms in the third person, encompassing both full-DP and null subjects. The experiment included 50 items: 20 with full-DP subjects, 20 with null subjects (evenly split between singular and plural), and 10 fillers. Table (29) illustrates each type of sentence. Six nouns (*nen* 'boy', *gos* 'dog', *gat* 'cat', *ànec* 'duck', *nena* 'girl', *ocell* 'bird') and ten verbs (*volar* 'fly', *llegir* 'read', *beure* 'drink', *patinar* 'skate', *dibuixar* 'draw', *jugar* 'play', *dormir* 'sleep', *córrer* 'run', *menjar* 'eat', *saltar* 'jump') were selected for their familiarity to the children. The verbs were used intransitively.

Table 29: Linguistic material experiment 1, Catalan

Item	Stimuli	Condition
1	La dona camina	
	the woman walk-3SG	Filler (Unrelated)
2	El nen dibuixa	
	the boy draw-3SG	Full-DP
3	Els nens dibuixen	
	the boys draw-3PL	Full-DP

4	Dibuixen	
	draw-3PL	Null-subject
5	Dibuixa	
	draw-3SG	Null-subject

Intransitive verbs were chosen for the experimental phase to minimize extraneous variables. To enhance children's performance, familiar verbs with simple syllabic structures could be used, as suggested by Theakston et al. (2003). Additionally, placing verbs at the end of sentences, as found effective by Sundara et al. (2011), might aid comprehension. Contrarily, less familiar nouns could adversely affect performance Leonard (2014).

The visual materials included simple coloured pictures of a person or animal performing an action, adapted from Sánchez (2020). Unlike in her pilot study, the experiments featured three actors in each image targeting a plural. The colors were adjusted for realism. Each sentence condition was depicted by two images, differing in actor number. The drawings, measuring 300mm x 200mm, were displayed on both sides of the screen and varied for each phase. A detailed list of visual materials is available in Appendix (52). Two picture sets were used: one for training and one for testing. Test items are shown in Figures (20) and (21).

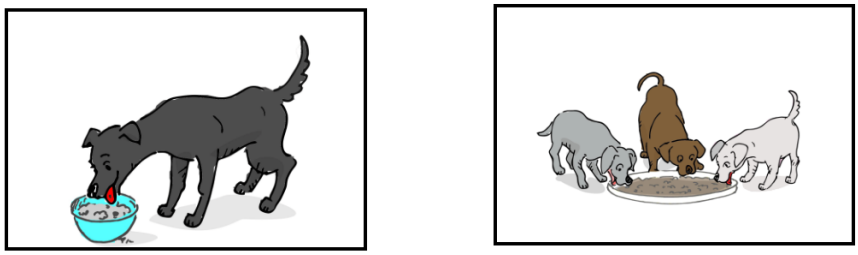


Figure 20: Ex. 1, Visual material of Full-DP, SG and PL

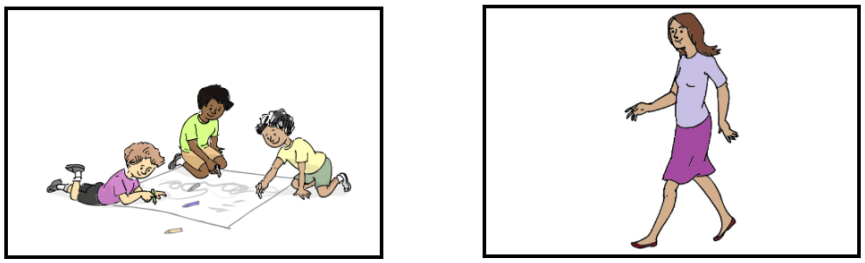


Figure 21: Ex 1, Visual material of distractor

Three training items with immediate feedback preceded the experimental phase. The experiment was conducted on a laptop with a touch-sensitive screen. The verbal stimuli, recorded by a native Catalan speaker, were edited using Praat (Boersma & Weenink, 2007). Sentence duration averaged 1861 ms, ranging from 1483 to 2760 ms.

Participants

In this study, a total of 53 participants were recruited, ranging in age from 3;6 to 6;5. These participants were native Catalan speakers from Barcelona and its surrounding metropolitan area, predominantly speaking the central Catalan dialect. Rigorous selection criteria ensured the inclusion of only those children who exhibited no discernible language deficits. Prior to participation, informed consent was obtained from the parents of the child participants. Additionally, the study included a cohort of 32 adult participants recruited from the Universitat Autònoma de Barcelona. A detailed overview of participants is presented in Table (30).

Table 30: Participants of Experiment 1

Group	Exp 1	Mean Age	Age Range
3-year-olds	11	3 years, 5 months	3;0–3;5
4-year-olds	22	4 years, 5 months	4;2–4;8
5-year-olds	13	5 years, 4 months	5;0–5;8
6-year-olds	7	6 years, 5 months	6;3–6;7
Adults	32	52 years	20–78

For the analysis, children were grouped into two age groups: a younger group (3 to 4 years old, Mean 3;8, N = 33) and an older group (5 to 6 years old, Mean 5;9, N = 20), following the methodology of Pérez-Leroux (2005).

Procedure

The study involved individual testing sessions conducted at the participants' respective school premises, providing a quiet environment for the assessments. Participants were seated in child-sized chairs, with a touch-screen laptop serving as the primary tool for experiment administration (see Figure 22). Notably, the laptop was equipped with a tactile screen to efficiently record participant responses. Additionally, due to the COVID-19 lockdown, I conducted the first round of testing remotely. I ensured that the participants wore headphones during the experiment, and I was present via Skype during the testing phase to monitor and address any possible interruptions. The analysis did not differentiate between this first testing group and the others tested in person, as no statistical differences were observed. The experiment was facilitated through the Labvanced platform, a versatile online tool renowned for its effectiveness in capturing participant responses. Standard ethical considerations, as were those driven by the constraints imposed by the COVID-19 pandemic, required written consent from all adult participants and legal guardians of child participants.

Figure 22: School set-up for testing

The experimental procedure adhered to a standardized structure for all participants. It began with the simultaneous display of two images on the laptop screen, accompanied by pre-recorded sentence stimuli. To familiarize children with the experimental setup, a practice trial was initiated. During this phase, participants encountered two concurrent images, reflecting the format of subsequent test trials. Auditory stimuli, consisting of pre-recorded sentences, were presented synchronously with the visual stimuli. It is important to note that sentences used in the practice phase were not repeated in the subsequent testing phase. An integral part of the practice trials was the immediate verbal feedback following each response. This feedback was delivered through pre-recorded audio cues accompanied by corresponding facial expressions (either happy or sad). The purpose of this feedback was to ensure participants' understanding of the experimental processes. Feedback expressions included phrases such as *No, torna-ho a provar!* 'Oh no, try again!' or *Molt bé!* 'Very good!'. Test trials began after the training session and were administered in a pseudo-randomized order. This sequence was designed to prevent the consecutive presentation of more than three items from any specific condition. Additionally, measures were taken to vary the positioning of items and images, thereby mitigating potential biases.

Data analysis

Participant responses were coded to measure accuracy [2]. A response was classified as correct when the selected picture matched the experimental item in number and, conversely, as incorrect when the chosen picture did not align in number with the experimental item. SAS v9.4 software was employed for data analysis. This statistical analysis aimed to model the number of correct responses while considering several key variables, including age group (3-4 years, 5-6 years), condition (full-DP subject, null-subject), and scene (singular and plural). A Generalized Linear Model (GLM) was chosen for the statistical analysis. This model accommodates the binomial distri-

2 The statistics have been run with the help of the *Servei d'Estadística Aplicada* by Ester Boixadera.

bution inherent in the response variable. Separate generalized linear mixed models (GLMM) were fitted for accuracy and sensitivity to assess the effects of age, grammatical number, and their interaction. This model also measured the children's sensitivity to the full-DP and null-subject condition, encompassing singular and plural grammatical constructs. The analysis uses these two sets of values (Bias and Sensitivity) to capture the contrast between how children of different age groups respond to singular and plural grammatical constructs within these conditions. The "Bias" values within this study provide crucial insights into participants' preferences for either singular or plural grammatical forms in their responses [3], p values were adjusted by the tukey's correction for multiple comparisons.

Results: Experiment 1

I collected 2,650 responses from children within the 3- to 6-year age range and 1,600 responses from adults (20 to 78 years). The adult group demonstrated an estimated 96.44% accuracy in their responses (SD = 10.30), and these data were excluded from the principal statistical analysis. Upon delving into the results of this study, summarized in Table 31, the overall mean accuracy during the exposure to the full-DP condition, which encompasses both singular and plural contexts, for children aged 3-4 years was an average accuracy rate of 77.1%. In comparison, the older group of 5-6-year-olds displayed a significantly higher mean accuracy rate of 90.6%. Similarly, in the null-subject condition, which incorporates singular and plural instances, the younger group of 3-4-year-olds exhibited an average mean accuracy of 56.0%. In contrast, the older group of 5-6-year-olds demonstrated a remarkable increase in mean accuracy, reaching 80.45%.

3 For example, if the "Bias Singular" value is higher, it suggests a stronger preference for singular forms, whereas a higher "Bias Plural" value suggests a stronger preference for plural forms. "Sensitivity" values gauge participants' capacity to recognize and accurately respond to the intricacies of grammatical number distinctions. Therefore, higher "Sensitivity Singular" values suggest a greater sensitivity to singular forms, while higher "Sensitivity Plural" values suggest a greater sensitivity to plural forms

Table 31: Ex.1, Estimated % of correct answers, Catalan

Age group	Distractor	Full DP, sg.	Full DP, pl.
3-4	96.7%	77.2%	76.9%
CI95%	93.8%-98.2%	69.1%-83.6%	68.8%-83.3%
5-6	97.3%	91.7%	89.5%
CI95%	94.1%-98.8%	85.4%-95.4%	82.2%-94.0%

Age group	Null, sg.	Null, pl.
3-4	45.5%	66.5%
CI95%	36.1%-55.2%	57.2%-74.7%
5-6	72.4%	88.5%
CI95%	60.6%-81.7%	80.9%-93.3%

When analyzing the children's data, a Generalized linear mixed model was constructed. This analysis highlighted significant age-related variations in the accuracy of responses ($F = 10.41$, $p = 0.0015$), with the 5-6 year-old group showing significantly higher performance. Additionally, distinct differences were noted with regard to the experimental condition ($F = 45.78$, $p < 0.0001$), though there was no significant interaction between age and condition variables.

For the age group 3-4 years:

In the 3-4 years age group, null-subject conditions showed significant differences when compared to both filler and full-DP conditions. Specifically, null-subject plural had higher odds ratios compared to null-subject singular, indicating a greater likelihood of correct responses. Conversely, null-subject singular showed significant differences with lower odds ratios when com-

pared to both filler and full-DP conditions. Similarly, full-DP conditions exhibited significant differences compared to filler conditions, with lower odds ratios.

Statistically significant differences were observed between the targets null-subject plural and null-subject singular, with an odds ratio of 2.39 (95% CI = $[1.40, 4.08]$) ($t = 5.19$, $p < 0.0001$). Significant differences were also found between the targets null-subject plural and filler, with an odds ratio of 0.07 (95%CI = $[0.03, 0.18]$) ($t = -8.66$, $p < 0.0001$). The targets null-subject singular and full-DP plural showed significant differences, with an odds ratio of 0.25 (95%CI = $[0.14, 0.44]$) ($t = -7.85$, $p < 0.0001$). Additionally, significant differences were observed between the targets null-subject singular and full-DP singular, with an odds ratio of 0.25 (95%CI = $[0.14, 0.43]$) ($t = -7.93$, $p < 0.0001$). Significant differences were also noted between the targets null-subject singular and filler, with an odds ratio of 0.03 (95%CI = $[0.01, 0.08]$) ($t = -11.48$, $p < 0.0001$). Lastly, significant differences were found between the targets full-DP plural and filler, with an odds ratio of 0.11 (95%CI = $[0.04, 0.31]$) ($t = -6.91$, $p < 0.0001$), and between the targets full-DP singular and filler, with an odds ratio of 0.12 (95%CI = $[0.04, 0.32]$) ($t = -6.85$, $p < 0.0001$).

For the age group 5-6 years:

In the 5-6 years age group, null-subject plural showed significant differences when compared to both null-subject singular and filler. Null-subject singular showed significant differences with lower odds ratios when compared to full-DP conditions and filler. full-DP plural conditions also showed significant differences compared to filler, with lower odds ratios.

Statistically significant differences were observed between the targets null-subject plural and null-subject singular, with an odds ratio of 2.95 (95% CI = $[1.21, 7.17]$) and a t-value of 3.89, $p = 0.0052$. This indicates that

the likelihood of a correct response was significantly higher for null-subject plural compared to null-subject singular in the 5-6 years age group.

Similarly, significant differences were found between the targets null-subject plural and filler, with an odds ratio of 0.21 ($95\%\text{CI} = [0.06, 0.81]$), and a t-value of -3.72, $p = 0.0095$. This suggests that null-subject plural responses were less likely to be correct compared to the filler condition.

The targets null-subject singular and filler also showed significant differences, with an odds ratio of 0.07 (95% CI $= [0.02, 0.26]$), and a t-value of -6.55, $p < 0.0001$. This indicates a substantially lower likelihood of correct responses for null-subject singular compared to the filler condition.

Further, significant differences were observed between the targets null-subject singular and full-DP plural, with an odds ratio of 0.31 (95% CI $= [0.13, 0.76]$), and a t-value of -4.16, $p = 0.0019$. This shows that null-subject singular responses had a lower probability of being correct compared to full-DP plural responses.

The targets null-subject singular and full-DP singular displayed significant differences, with an odds ratio of 0.24 (95% CI $= [0.09, 0.61]$), and a t-value of -4.84, $p = 0.0001$. This suggests that null-subject singular responses were less likely to be correct than full-DP singular responses.

Finally, significant differences were observed between the targets overt plural and filler for comparison purposes, with an odds ratio of 0.23 (95% CI $= [0.06, 0.89]$), and a t-value of -3.47, $p = 0.0218$. This suggests that overt singular responses were much less likely to be correct compared to the filler condition in the older age group.

These findings indicate a higher competence in full-DP language forms in the older group.

Generalized mixed model

A generalized linear mixed model (GLMM) was used to conduct the statistical analysis to model the number of correct responses. This analysis took

into consideration the variables of age group (3-4, 5-6), condition (Full-DP subject, Null-subject), and scene (singular and plural) while accounting for repeated measures. The choice of a GLMM was deliberate, as it accurately handles the binomial distribution inherent in the response variable and accounts for the correlation within subjects due to repeated measures.

The statistical analysis revealed significant differences attributed to age on the number of correct responses ($F = 10.41$; $p = 0.0015$), with a notably higher performance observed in the 5-6 age group. Moreover, statistically significant differences were also observed as an effect of the condition ($F = 45.78$; $p < 0.0001$), although no interaction between age and condition was found. Interestingly, the performance in the null-subject singular condition did not differ significantly from chance (50%) ($p = 0.38$).

These results, visually represented in Figure 23, show the estimated proportion of correct answers in groups 3-4 and 5-6 during exposure to the Full-DP and null-subject conditions in both singular and plural scenes, with overall higher performance in the older group and a by-chance performance in the younger group during the null-subject singular exposure.

Overall, as depicted in Figure 23, the rate of correct responses was notably high, with performance generally surpassing the chance level of 50%, except in the null subject singular condition for the 3-4-year-old group.

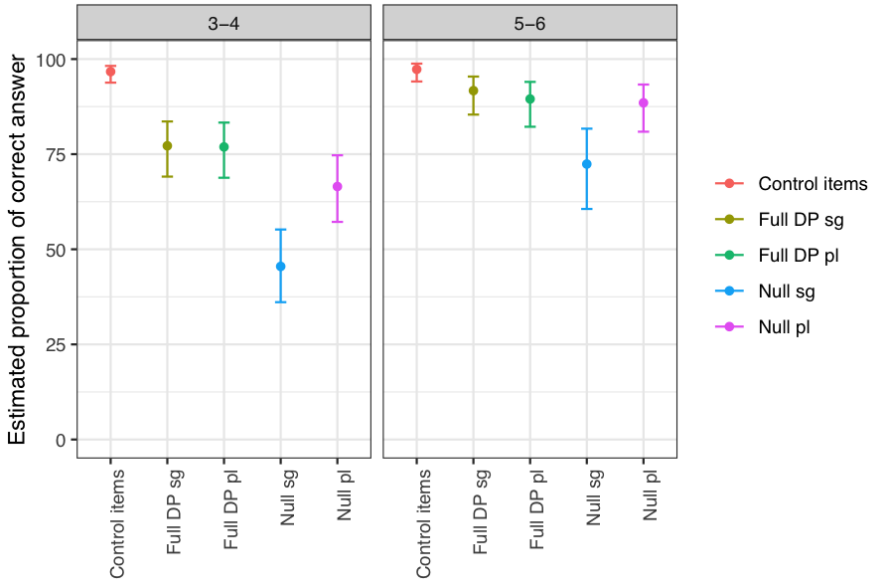


Figure 23: Estimated proportion of correct answers in Experiment 1 for groups 3-4 and 5-6

Sensitivity analysis - Experiment 1

The analysis for sensitivity involved evaluating the proportion of correct responses based on grammatical number (singular vs. plural) under two conditions: null-subject and full-DP. The results revealed significant effects for grammatical number on sensitivity in the null-subject condition, while no significant effects for grammatical number or the interaction between age and grammatical number were detected in the full-DP condition. A Generalized Linear Model was conducted, taking the number of correct responses out of the total sentences (binomial distribution) as the response variable according to *Grammatical Number Condition (Singular, Plural)*, *Age*, and the interaction between them, considering repeated measures for each participant.

For sensitivity analysis, the model detected statistically significant differences when considering *Age Group* in the number of correct responses model. No statistically significant differences were detected when considering the effect of *Grammatical Number* in the number of correct responses model. No statistically significant differences were detected when considering the interaction of *Age* with *Grammatical Number* in the number of correct responses model.

In the null-subject condition, younger children (3-4 years) show limited sensitivity to grammatical number, with balanced but low percentages of correct answers. In contrast, older children show a marked improvement, particularly for singular forms. In the full-DP condition, younger children display moderate sensitivity, with balanced percentages for singular and plural forms. Older children show high sensitivity to both forms, with significant improvement compared to younger children.

Full-DP Condition

In the 3-4 years age group, full-DP conditions showed relatively high sensitivity to grammatical number, though lower than the 5-6 years age group. The analysis indicates statistically significant differences when considering the effect of age group on the model of the number of correct answers (F Value = 7.15; $p = 0.0100$). No significant differences were detected for the effect of grammatical number or the interaction between age and grammatical number. For the age group of 3-4 years, the estimated percentage of correct answers was 78.4% [69.6%, 85.3%] and for the age group of 5-6 years, it was 91.5% [84.6%, 95.4%]. For grammatical number, the estimated percentage of correct answers for plural answers was 78.1% [68.3%, 85.5%] and for singular answers, it was 78.8% [69.1%, 86.0%]. Non statistically significant differences were observed between the targets plural answer and singular answer, with an odds ratio of 0.94 95%CI = [0.63, 1.40] ($t = -0.31$, $p = 0.7584$). Additionally, significant differences were found between the age groups 3-4 years and 5-6 years, with an odds ratio of 0.34 95%CI = [0.15, 0.76] ($t = -2.67$, $p = 0.0100$).

This table 32 presents the mean and standard deviation of bias and sensibility scores across different age groups (3–4, 5–6, Adults, and All) under the full-DP condition, categorized into singular and plural forms. The data indicates that sensibility increases with age, with even the youngest group (3–4 years old) showing a notable level of sensibility, and adults exhibiting nearly perfect sensibility scores in both singular and plural forms.

Null-Subject condition

In the 3-4 years age group, null-subject conditions showed limited sensitivity to grammatical number, with similar estimated percentages of correct answers for singular and plural answers. In the 5-6 years age group, null-subject conditions showed significantly higher sensitivity, particularly for

Table 32: Means (SD) for Bias and Sensibility, Overt Condition

Group	Bias				Sensibility			
	Singular		Plural		Singular		Plural	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
3–4	0.50	0.1	0.50	0.1	0.76	0.2	0.75	0.2
5–6	0.51	0.1	0.49	0.1	0.88	0.2	0.86	0.2
Adults	0.51	0.1	0.49	0.1	0.98	0.1	0.98	0.1
All	0.51	0.1	0.49	0.1	0.87	0.2	0.86	0.2

singular answers, indicating better sensitivity to grammatical number compared to the 3-4 years age group. The analysis indicates statistically significant differences when considering the effect of age group on the model of the number of correct answers (F Value = 19.79; $p < 0.0001$). No significant differences were detected for the effect of grammatical number or the interaction between age and grammatical number. For the age group of 3-4 years, the estimated percentage of correct answers for singular answers was 56.0% [46.9%, 64.7%] and for plural answers was 55.1% [46.9%, 63.0%]. For the age group of 5-6 years, the estimated percentage of correct answers for singular answers was 83.3% [74.6%, 89.5%] and for plural answers was 75.1% [65.8%, 82.6%]. Statistically significant differences were observed between the age groups 3-4 years and 5-6 years, with an odds ratio of 0.32 95%CI $= [0.19, 0.54]$ ($t = -4.45$, $p < 0.0001$). Additionally, the model detected following results between plural and singular answers for the age group 5-6 years, with an odds ratio of 0.61 95%CI $= [0.30, 1.22]$ ($t = -1.89$, $p = 0.2438$), indicating lower sensitivity to plural answers in older children. Further analysis showed differences between plural and singular answers within the 3-4 years age group, showed non statistically differences with an odds ratio of 0.96 95%CI $= [0.61, 1.53]$ ($t = -0.21$, $p = 0.9968$) . Comparisons

between the age groups showed significant differences for plural answers, with an odds ratio of 0.41 95%CI = [0.19, 0.85] ($t = -3.25$, $p = 0.0108$), and for singular answers, with an odds ratio of 0.26 95%CI = [0.11, 0.60] ($t = -4.26$, $p = 0.0005$).

Table 33 corresponds to the number of correct responses per answer, i.e., how sensitive the response is. In this case, not many differences are seen depending on whether it is singular or plural.

Table 33: Means (SD) for Bias and Sensibility, Null-subject condition

	Bias				Sensibility			
Group	Singular		Plural		Singular		Plural	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
3-4	0.40	0.2	0.60	0.2	0.57	0.2	0.56	0.2
5-6	0.43	0.1	0.58	0.1	0.83	0.2	0.75	0.2
Adults	0.49	0.1	0.51	0.1	0.95	0.1	0.93	0.1
All	0.44	0.1	0.56	0.1	0.77	0.2	0.74	0.2

3.4 EXPERIMENT 2

Experiment 2 builds upon the foundation established by Experiment 1, introducing a numerical distractor as in Sánchez (2020). The decision to incorporate numerical fillers in Experiment 2 was inspired by the insights from Gonzalez-Gómez et al. (2017), highlighting how experimental factors could shape research outcomes. Their study implied that variations in children's performance might stem from these factors, even under a unified language and methodology framework. In Experiment 2, the inclusion of numerals in fillers aimed to draw the children's attention to number. The intricacies of numeral comprehension, as discussed by Hackl et al. (2021), and the align-

ment of the approach with studies like Katsos et al. (2016) on quantifier acquisition, which demonstrated positive numeral comprehension outcomes, guided this decision. Primarily, the fillers featured the numeral 'three', often one of the first numbers children learn.

Design and materials

Experiment 2 mirrored the design and materials of Experiment 1, except for the introduction of numerals in the filler items. This experiment included 50 items: 20 with full-DP subjects, 20 with null subjects (balanced between singular and plural), and 10 fillers. An example of a condition and fillers is given in 34, with detailed visuals in Figure (24). The full list of experimental items is available in the Appendix.

Table 34: Linguistic material experiment 2, Catalan

Item	**Stimuli**	**Condition**
1	Tres nens dibuixen	
	three boys draw-3PL	Filler (Numerical)
2	Els nens dibuixen	
	the boys draw-3PL	Full-DP
3	El nen dibuixa	
	the boy draw-3SG	Full-DP
4	Dibuixen	
	draw-3PL	Null-subject
5	Dibuixa	
	draw-3SG	Null-subject

Methodologically, Experiment 2 retained the procedural methods, coding protocols, and statistical analyses of Experiment 1, ensuring consistency

and comparability. The primary change was in the numeral distractor, but following the design of test items in terms of picture size, colouring style, and experimental voice. A sample item, corresponding to the sentence *Tres gossos mengen* 'Three dogs are eating', is displayed in a Figure (24).

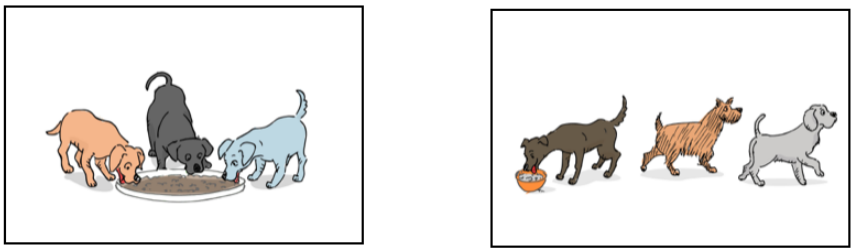


Figure 24: Ex.2, Filler (Numerical)

Participants

For this study, we recruited 58 participants (age range 2;4 – 6;9 years) who were Catalan speakers from Barcelona and its extended metropolitan area, where central Catalan is spoken. The participants belonged to different age groups: 3-year-olds (Mean = 3;1), 4-year-olds (Mean = 4;5), 5-year-olds (Mean = 5;5), and 6-year-olds (6;5), see Table 35. The child participants were grouped into age groups : 3 to 4-year-olds (Mean 3;8, N = 21) and 5 to 6-year-olds (Mean 5;0, N = 27). Only children without any known language deficits were chosen to participate. Additionally, the study included 30 adults. The age of the adult group ranged from 20 to 66 years (Mean = 37), with 20 females and 12 males. Before participating in the study, all adult participants and the children's parents provided informed consent.

Table 35: Participants of experiment 2

Group		Mean age	Range
3	11	3;1	2;4–3;8
4	20	4;5	4;1–4.9
5	21	5;5	5;1–5;9
6	6	6;5	6;1–6;9
Adults	30	37	20-60

Results

A total of 2,900 responses were gathered from child participants, with an additional 1,500 responses obtained from adults. The adult group demonstrated an approximate correct response rate of 96.5% (SD = 7.1). Subsequently, the data from adults were excluded from further statistical analyses. Upon delving into the results of this study, summarized in Table 36, the overall mean accuracy during the exposure to the full-DP condition, which encompasses both singular and plural contexts, for children aged 3-4 years was 73.5% (SD = 18.6%). In comparison, the older group of 5-6-year-olds displayed a higher mean accuracy rate of 83.9% (SD = 19.8%). Similarly, in the null-subject condition, which incorporates singular and plural instances, the younger group of 3-4-year-olds exhibited an average mean accuracy of 63.7% (SD = 22%). In contrast, the older group of 5-6-year-olds demonstrated an increase in mean accuracy, reaching 78.9% (SD = 20.8%). The same statistical analysis methodology employed in Experiment 1 was also applied to evaluate the results obtained from children.

For the age group 3-4 years:

In the 3-4 years age group, null-subject conditions showed significant differences when compared to numeric and full-DP conditions. Null-subject

Table 36: Ex.2 Estimated percentage of correct

Age group	Control items (Numerals)	Full DP, sg.	Full DP, pl.
3-4	88.2%	76.5%	73.1%
CI95%	82.9%-92.0%	69.1%-82.6%	65.3%-79.8%
5-6	96.1%	87.6%	85.1%
CI95%	92.8%-97.9%	81.7%-91.8%	78.6%-89.9%

Age group	Null, sg.	Null, pl.
3-4	59.8%	69.6%
CI95%	51.0%-68.0%	61.4%-76.7%
5-6	72.8%	89.3%
CI95%	64.2%-80.0%	83.9%-93.1%

plural had lower odds ratios compared to numeric, indicating a lower likelihood of correct responses. Null-subject singular showed significant differences with lower odds ratios when compared to numeric and full-DP conditions. Numeric conditions showed significant differences compared to full-DP conditions, with higher odds ratios.

Statistically significant differences were observed between the targets null-subject plural and numeric, with an odds ratio of 0.31 95%CI $= [0.15, 0.60]$ ($t = -5.56$, $p < 0.0001$). Similarly, significant differences were found between the targets null-subject singular and numeric, with an odds ratio of 0.20 95%CI $= [0.10, 0.39]$ ($t = -7.71$, $p < 0.0001$). The targets null-subject singular and full-DP plural also showed significant differences, with an odds ratio of 0.55 95%CI $= [0.31, 0.96]$ ($t = -3.43$, $p = 0.0243$). Further, the targets null-subject singular and full-DP singular displayed significant differences, with an odds ratio of 0.46 95%CI $= [0.26, 0.81]$ ($t = -4.36$, $p = 0.0008$). Significant differences were also observed between the targets numeric and

full-DP plural, with an odds ratio of 2.75 95%CI = [1.38, 5.47] ($t = 4.69$, $p = 0.0002$). Lastly, significant differences were found between the targets numeric and full-DP singular, with an odds ratio of 2.30 95%CI = [1.14, 4.61] ($t = 3.81$, $p = 0.0067$).

For the age group 5-6 years:

In the 5-6 years age group, null-subject conditions showed significant differences when compared to numeric and full-DP conditions. Null-subject plural had higher odds ratios compared to null-subject singular, indicating a greater likelihood of correct responses. Null-subject singular showed significant differences with lower odds ratios when compared to numeric and full-DP conditions. Numeric conditions showed significant differences compared to full-DP conditions, with higher odds ratios.

Statistically significant differences were observed between the targets null-subject plural and null-subject singular, with an odds ratio of 3.13 95%CI = [1.46, 6.69] ($t = 4.79$, $p = 0.0001$). Similarly, significant differences were found between the targets null-subject plural and numeric, with an odds ratio of 0.11 95%CI = [0.04, 0.30] ($t = -6.97$, $p < 0.0001$). Further, significant differences were observed between the targets null-subject singular and full-DP plural, with an odds ratio of 0.47 95%CI = [0.23, 0.95] ($t = -3.42$, $p = 0.0254$). The targets null-subject singular and full-DP singular displayed significant differences, with an odds ratio of 0.38 95%CI = [0.18, 0.79] ($t = -4.22$, $p = 0.0015$). Significant differences were also found between the targets numeric and full-DP plural, with an odds ratio of 4.26 95%CI = [1.49, 12.15] ($t = 4.42$, $p = 0.0006$). Lastly, significant differences were observed between the targets numeric and full-DP singular, with an odds ratio of 3.44 95%CI = [1.19, 10.00] ($t = 3.71$, $p = 0.0097$).

Figure 25 provides a visual representation of these results, showing the estimated proportion of correct answers in groups 3-4 and 5-6 during the exposure to the Full-DP and Null-subject conditions in the singular and plural scenes.

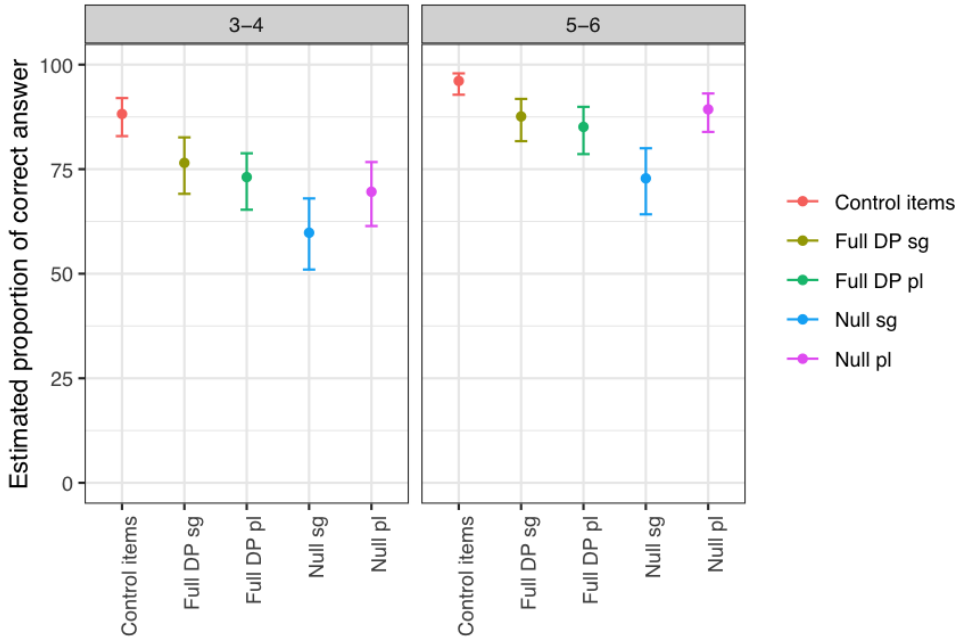


Figure 25: Estimated proportion of correct answers of experiment 2 of groups 3-4 and 5-6.

Generalized linear model

The generalized linear mixed model (GLMM) was used to conduct the statistical analysis to model the number of correct responses in Experiment 2 and summarized in Table 36. This analysis considered the variables of age group (3-4, 5-6), condition (Full-DP sg, Full-DP pl, Null-subject sg, Null-subject pl, and Numerical) while accounting for repeated measures. The choice of a GLMM was deliberate, as it accurately handles the binomial distribution inherent in the response variable and accounts for the correlation within subjects due to repeated measures. The statistical analysis revealed significant differences due to age on the number of correct responses ($F = 15.99$; $p < 0.0001$), with notably higher performance observed in the 5-6 age group. Moreover, statistically significant differences were also observed as an effect of condition ($F = 27.97$; $p < 0.0001$), although no interaction between age and condition was found.

Sensitivity analysis - Experiment 2

The sensitivity test was conducted to evaluate differences in sensitivity and bias among different age groups under various linguistic conditions in Experiment 2. This analysis aimed to determine these differences for children aged 3-4 years, 5-6 years, and adults. The conditions tested include null-subject and full-DP in singular and plural. The estimated sensitivity, bias, and odds ratios along with their 95% confidence intervals (CIs) are reported for each age group.

Full-DP condition

In the 3-4 years age group, grammatical number show moderate sensitivity to grammatical number, with similar estimated percentages of correct answers for singular and plural answers. In the 5-6 years age group, full-DP

conditions show higher sensitivity to grammatical number, particularly for plural answers, indicating improved sensitivity compared to the 3-4 years age group. The analysis indicates statistically significant differences when considering the effect of age group on the model of the number of correct answers (F Value = 7.00; $p = 0.0106$). No significant differences were detected for the effect of grammatical number or the interaction between age and grammatical number. For the age group of 3-4 years, the estimated percentage of correct answers for singular answers was 74.3% [65.5%, 81.5%] and for plural answers was 76.4% [67.8%, 83.3%]. For the age group of 5-6 years, the estimated percentage of correct answers for singular answers was 85.1% [77.6%, 90.3%] and for plural answers was 88.4% [81.9%, 92.8%]. Statistically significant differences were observed between the age groups 3-4 years and 5-6 years, with an odds ratio of 0.46 95%CI $= [0.26, 0.83]$ ($t = -2.65$, $p = 0.0106$). Within the age groups, the differences between plural and singular answers were not statistically significant, with an odds ratio of 1.22 95%CI $= [0.89, 1.69]$ ($t = 1.27$, $p = 0.2110$). Further analysis showed no significant differences between plural and singular answers within the 3-4 years age group, with an odds ratio of 1.12 95%CI $= [0.67, 1.86]$ ($t = 0.59$, $p = 0.9352$). For the age group 5-6 years, the differences were also not statistically significant, with an odds ratio of 1.34 95%CI $= [0.68, 2.63]$ ($t = 1.14$, $p = 0.6659$). Comparisons between the age groups showed no significant differences for plural answers, with an odds ratio of 0.42 95%CI $= [0.17, 1.04]$ ($t = -2.54$, $p = 0.0653$), and for singular answers, with an odds ratio of 0.51 95%CI $= [0.21, 1.20]$ ($t = -2.09$, $p = 0.1681$).

The sensitivity test results are summarized in Table 37. The results indicate that even the youngest age group (3–4 years old) demonstrates a notable level of sensibility in both singular and plural forms under the Full-DP condition, with sensibility scores of 0.73 and 0.75, respectively. This indicates that children as young as 3 to 4 years old have a measurable ability to correctly respond to the Full-DP condition, highlighting early developmental capabilities in understanding and processing these forms.

Table 37: Means (SD) for Bias and Sensibility, Full-DP Condition

	Bias				Sensibility			
Group	Singular		Plural		Singular		Plural	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
3–4	0.52	0.1	0.48	0.1	0.73	0.1	0.75	0.2
5–6	0.51	0.1	0.49	0.1	0.82	0.2	0.86	0.2
Adults	0.51	0.0	0.49	0.0	0.99	0.1	1.00	0.0
All	0.51	0.1	0.49	0.1	0.85	0.2	0.87	0.2

Null-subject condition

In the 3-4 years age group, null-subject conditions show limited sensitivity to grammatical number, with similar estimated percentages of correct answers for singular and plural answers. In the 5-6 years age group, null-subject conditions show significantly higher sensitivity, particularly for singular answers, indicating better sensitivity to grammatical number compared to the 3-4 years age group. The analysis indicates statistically significant differences when considering the effect of age group on the model of the number of correct answers (F Value = 19.93; $p < 0.0001$). Additionally, significant differences were found for the effect of grammatical number (F Value = 5.89; $p = 0.0184$). No significant differences were detected for the interaction between age and grammatical number. For the age group of 3-4 years, the estimated percentage of correct answers for plural answers was 62.5% [56.6%, 69.0%] and for singular answers was 65.7% [58.4%, 72.3%]. For the age group of 5-6 years, the estimated percentage of correct answers for singular answers was 84.7% [78.5%, 89.4%] and for plural answers was 75.8% [69.4%, 81.3%]. Statistically significant differences were observed between the age groups 3-4 years and 5-6 years, with an odds ratio of 0.43

95%CI = [0.29, 0.63] (t = −4.46, p < 0.0001). Additionally, significant differences were found between plural and singular answers, with an odds ratio of 0.70 95%CI = [0.53, 0.94] (t = −2.43, p = 0.0184). For the age group 3-4 years, the differences between plural and singular answers were not statistically significant, with an odds ratio of 0.87 95%CI = [0.55, 1.39] (t = −0.78, p = 0.8621). Comparisons between the age groups showed significant differences for plural answers, with an odds ratio of 0.53 95%CI = [0.30, 0.94] (t = −2.92, p = 0.0249), and for singular answers, with an odds ratio of 0.35 95%CI = [0.17, 0.69] (t = −4.09, p = 0.0008). The results indicate a significant improvement in sensitivity with increasing age across all conditions. Children aged 5-6 years consistently outperformed the younger group of 3-4 years, demonstrating reduced bias. Adults, as expected, exhibited the highest sensitivity, minimal bias. The younger age group (3-4 years) in Experiment 2 showed higher sensitivity compared to Experiment 1, indicating a potential difference in experimental conditions or sample characteristics.

The results are summarized in Table 38, that reveals that while bias scores are relatively stable across age groups, sensibility improves notably with age, especially in singular and plural conditions. Even the youngest participants demonstrate a measurable ability to discern the null-subject condition, with sensibility scores indicating an emerging understanding in early childhood.

CONTRASTING RESULTS OF EXPERIMENTS 1 AND 2

The comparison between Experiment 1 and Experiment 2 highlights differences in accuracy rates among children aged 3-4 years and 5-6 years under the full-DP and null-subject conditions in singular and plural scenes. In Experiment 1, significant differences were observed in the null-subject singular condition, indicating a strong effect of age and condition on the accuracy rates. Specifically, the estimated proportion of correct answers in the null-subject singular condition for Experiment 1 was 57.0% (95%CI = [52.5%, 61.3%]), while in Experiment 2, it was higher at 65.5%

Table 38: Means (SD) for Bias and Sensibility, Null-subject condition

Group	Bias				Sensibility			
	Singular		Plural		Singular		Plural	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
3–4	0.45	0.2	0.55	0.2	0.68	0.2	0.64	0.1
5–6	0.42	0.1	0.58	0.1	0.84	0.2	0.76	0.1
Adults	0.50	0.0	0.51	0.0	0.97	0.1	0.96	0.1
All	0.46	0.1	0.54	0.1	0.83	0.2	0.79	0.2

(95%CI = [61.5%, 69.4%]). This suggests an improvement in performance in the null-subject singular condition from Experiment 1 to Experiment 2. The null-subject plural condition showed an estimated proportion of correct answers of 79.1% (95%CI = [75.5%, 82.4%]) in Experiment 2, is similar to 76.1 [72.1%, 79.8%] in Experiment 1. indicating a consistent but improved performance in Experiment 2. For the Full-DP plural condition, the estimated proportion of correct answers was 80.6% (95%CI = [76.9%, 83.8%]) in Experiment 1, compared to 77.7% (95%CI = [74.1%, 81.0%]) in Experiment 2, showing no significant difference. The Full-DP singular condition revealed an estimated proportion of correct answers of 82.0% (95%CI = [78.4%, 85.1%]) in Experiment 1, and 80.9% (95%CI = [77.4%, 84.0%]) in Experiment 2, indicating stable performance across both experiments. The statistical analysis demonstrated significant differences due to age group in all conditions, confirming the impact of age on performance. The results of the estimated proportion of correct answers are shown in Table 39.

The comparison between Experiment 1 and Experiment 2 indicates that while the accuracy rates remain relatively stable across most conditions, there is a notable improvement in the null-subject singular condition in Experiment 2.

Table 39: Estimated Proportion Correct Answer with 95% Confidence Intervals

Cond.	Ex	Est. Prop. Correct Answer	95% CI
Null-subj. pl.	Ex1	76.1%	72.1% – 79.8%
	Ex2	79.1%	75.5% – 82.4%
Null-subj. sing.	Ex1	57.0%	52.5% – 61.3%
	Ex2	65.5%	61.5% – 69.4%
Full-DP pl.	Ex1	80.6%	76.9% – 83.8%
	Ex2	77.7%	74.1% – 81.0%
Full-DP sing.	Exp1	82.0%	78.4% – 85.1%
	Ex2	80.9%	77.4% – 84.0%

DISCUSSION

In Experiments 1 and 2, a comprehensive study was conducted to assess children's comprehension of subject-verb agreement sentences in Catalan, focusing on sentences with third person full-DP and null subjects. Utilizing a picture selection task, the primary objective was to determine the accuracy of participants in selecting pictures congruent with the number information conveyed by verb inflection. A higher accuracy rate, where participants chose between a plural and a singular scene following a singular or plural inflected verb, indicated successful parsing.

The sensitivity data indicates that parsing abilities improve significantly with age. In the null-subject singular condition, children aged 3-4 years exhibited lower sensitivity and higher bias compared to older children and adults. This suggests that younger children have more difficulty parsing sentences with null subjects. The higher sensitivity observed in the 5-6 years age group in Experiment 2 compared to Experiment 1 suggests that the nu-

merical condition might have had a boosting effect enhancing their ability to parse these constructions in the given experimental setting.

The findings reveal that Catalan children aged 3 to 6 have acquired morphosyntactic knowledge pertaining to number agreement in both full-DP and null-subject sentences. This contrasts with some research involving English- and Spanish-speaking children, who did not effectively utilize number information from verbal inflection until later ages in the experiments administered to them (Johnson et al., 2005; Pérez-Leroux, 2005). The Catalan rich system of verb inflection differs from English, which primarily marks verbs in the third person singular and past tense. The results from studies on Spanish-speaking children challenge the significance of morphological richness, as Spanish-speaking children do not exhibit earlier comprehension of verb inflections compared to English-speaking counterparts (Pérez-Leroux, 2005).

The research of (Cutler et al., 1985) and (Polišenská, 2010) argued that prefixes marking number might be more salient to infants than suffixal marking, potentially facilitating their early linguistic grasp of morphology . This theory is based on the premise that prefixes, being morphemes affixed at the start of a word, are processed earlier, thus possibly standing out more in a child's perception.Later research, including that of (Gonzalez-Gómez et al., 2017), broadened this perspective. They discovered that children around the age of four could successfully navigate subject-verb agreement in languages with suffixal plural markers, despite these being considered less salient than prefixal markers. This finding suggests that, while certain morphological attributes might appear more conducive to language learning initially, children are capable of adapting to and processing various linguistic structures effectively, irrespective of the salience of grammatical markers.

The findings from this study align with the generative framework's notion of the null-subject parameter, which posits that languages allowing null subjects (e.g., Catalan, Spanish) enable the omission of subject pronouns when they can be inferred from verb inflection (Chomsky, 1981). Children learn-

ing null-subject languages must rely heavily on verb inflections to parse many of the sentences they encounter. The results showing that Catalan children aged three to six successfully utilize number information from verbal inflection support the idea that the null-subject parameter is set early in these language learners. This early competence in subject-verb agreement suggests that Catalan-speaking children are attuned to the morphosyntactic cues provided by verb inflections.

4

EARLY PARSING OF SUBJECT-VERB AGREEMENT IN INFANTS'

This chapter delves into the early parsing of subject-verb agreement in infants, focusing on how infants acquire and parse this critical aspect of grammar. The chapter is structured around two primary studies that apply online methodologies to investigate subject-verb agreement parsing in Catalan and German infants. The chapter begins with a review of previous research on the comprehension of subject-verb agreement using online methods.

The second study of this thesis is divided into two experiments focusing on the early acquisition of subject-verb agreement in Catalan and German. The rationale behind this study is to assess the cognitive capabilities of infants in acquiring and internalizing subject-verb agreement, particularly in languages with complex verbal morphology. The study aims to determine whether the differences observed in language production between null subject languages (like Catalan) and non-null subject languages (like German), the <oi stage, are also evident in the parsing of subejct-verb agreement.

4.1 SUBJECT-VERB AGREEMENT THROUGH ONLINE METHODS

Investigating the pre-verbal parsing abilities of infants is of profound importance in the field of language acquisition research. Within the UG framework, understanding subject-verb agreement in pre-verbal stages is essential. Distinguishing null and non-null-subject languages, as examined in chapter 2, is a crucial area in UG studies. Prominent studies in this field include the work of Biberauer (2008) and Huang (1995) which highlight the importance of parametric linguistics.

Pioneering methodologies, as demonstrated in studies like that of Oviatt (1980), have been pivotal in evaluating and enhancing grammatical abilities in infants, indicating notable advancements in receptive language capacity when infants interact with unfamiliar names through dynamic online methods. Considering these developments, this chapter initially reviews prior research employing online methods to study agreement, then proceeds to an eye-tracking study focused on how 17-month-old infants parse subject-verb agreement. This research, conducted in two linguistically distinct environments—Catalan, a null-subject language, and German, a non-null subject language—investigates the processing of both overt and null subjects. The introduction of online methods has significantly advanced the study of language comprehension, particularly in examining subject-verb agreement and inflection in infants. These methods have demonstrated substantial progress in assessing receptive language capacity (Gonzalez-Gómez et al., 2017). Online techniques enable researchers to capture real-time data on how infants process subject-verb agreement (Kaltsa et al., 2016).

Legendre et al. (2014) is an attempt to explore and compare different languages to understand when agreement takes place. They applied the preferential-looking paradigm to compare French, English, and Spanish. A total of 90 children were tested across the three studies. All were exposed to the same visual and equivalent auditory stimulus design with the assigned language adaptation and were asked to perform the same picture selection task. The average age of the tested children across experiments was 30 months. The auditory stimuli were recorded by a female speaker and included short sentences with the same subject in either singular (referring to one boy) or plural (referring to two boys). Each child was presented with six to eight trials, depending on the number of test verbs known to the child as reported by their parents. During the test phase, an auditory stimulus targeting one of the two scenes was presented, followed by a six-second-long presentation of the same two videos shown during the baseline phase. Infants were then asked to point to the target videos. The study in-

cluded dynamic scenes with one or two actors and sentence examples of singular or plural combinations of a subject pronoun, a familiar transitive verb, and a nonce object noun. Infants were exposed to: *hang, tie, catch, kiss, take, wipe, dress, pull, throw,* and *wrap*. An example of the stimuli used in the tested languages is depicted in Table 40.

Language	**Stimulus**
French	Il embrasse le /gef/: /ilɛb̃ɜasləgef/ kiss.3sg the 'gef'
French	Ils embrassent le /tak/: /ilzã ɜas lətak/ kiss.3pl the 'tak'
English	The boys kiss the /dajt/ kiss.3pl the 'dajt'
English	The boy kisses the /naj/ kiss.3sg the 'naj'
Spanish	Besa el micho. kiss.3sg the 'micho'
Spanish	Agarran el duco. catch.3pl the 'duco'

Table 40: Stimuli used in the experiments in French, English, and Spanish.

The video stimuli of the experiment consisted of two 8-year-old boys in which, for each action, either one boy performed the action alone while the other boy stood next to him (singular video), or the two boys performed the action simultaneously (plural video). As depicted in Figure 26, *He is kissing the pseudonoun*, referring to the stuffed animal could apply to a scene with one boy kissing the stuffed animal or two boys kissing the stuffed animal.

G. Legendre et al. / Lingua 144 (2014) 21–39

Figure 26: Visual Stimuli (Legendre et al., 2014)

However, distinct pseudo-nouns were used as objects (e.g., *embrasser le voube* meaning 'to kiss the voub' versus *embrasser le taque* meaning 'to kiss the tak'), and the events were differentiated based on the unfamiliar objects involved. In each trial of the experiment, a different unfamiliar object was used for the same action in the singular and plural conditions. This was done to prevent a collective interpretation of the display where the plural auditory stimulus could be understood to refer to all the actions on the screen.

The group of French-speaking infants was divided into two groups. Group 1 performed task 1, measuring only the looking percentage towards the stimuli, and Group 2 performed task 2, which involved a pointing task. Group 1 consisted of 20 monolingual 30-month-old French-learning children (M = 30 months, range = 28-35 months). The results, illustrated in Figure 27, showed that when auditory stimuli were presented, children looked significantly longer at the target videos for singular forms. Additionally, no significant difference was found between singular and plural trials. These results demonstrate that 30-month-old children acquiring French are able to distinguish the singular and plural marking expressed as the liaison plural

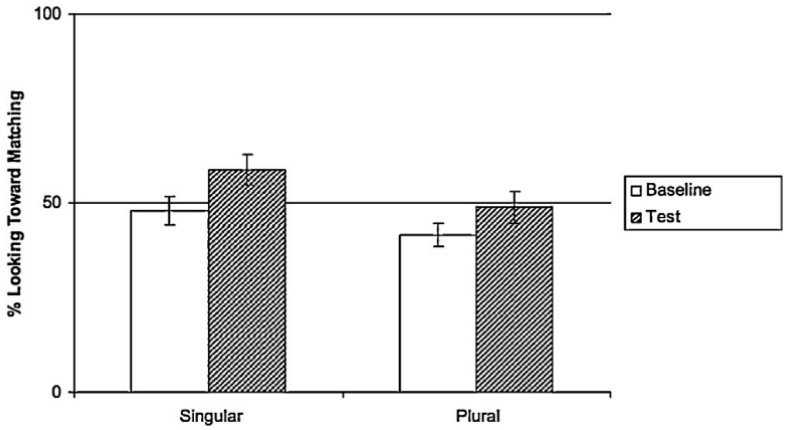


Figure 27: Mean % looking times at 30 Months by Target Number, with SE, (French)

consonant /z/ in the onset position of otherwise phonologically identical verbs. Specifically, they were able to match these forms to the target visual stimuli, in the absence of any additional morpho-syntactic or lexical cues.

Group 2 (requested to point towards the target image) consisted of 16 monolingual 30-month-old French children (M = 30 months; range = 28–32 months). This was a potentially more demanding task, which required young children to make decisions, control their motor functions, and cooperate, even though the same auditory and visual stimuli were used. Children were instructed to point to the target videos. The results from this pointing task revealed that the children were significantly more likely than chance to point to the target video for both singular and plural utterances. Figure 28 indicates that children gazed significantly longer at the corresponding videos when auditory cues were given, despite the added decision-making and motor requirements. These findings confirm that even under increased decisional and motor demands, French-learning 30-month-olds can distinguish between 3rd person singular and plural forms and match both plural and singular expressions of liaison to the target visual stimuli.

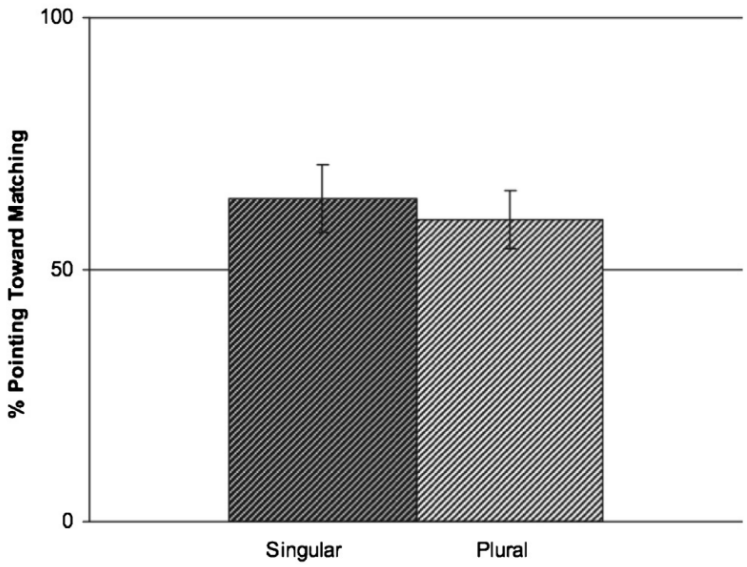


Figure 28: Mean % pointing to the target video, at 30 months of age (French).

The study showed that comprehension of subject-verb agreement is not universally late, supporting the hypothesis that verb-subject comprehension can vary depending on particular language features.

The group of English-speaking children in the study comprised 21 participants, 11 male and 10 female, with a mean age of 35 months and a range of 28 to 46 months. The results indicated that, even with non-masked number marking on the subject, these children did not demonstrate an understanding of 3rd person singular subject-verb agreement, consistent with the findings reported by Johnson et al. (2005). Notably, this study used a more interactive and engaging task (preferential looking with dynamic videos as opposed to static drawings). As illustrated in Figure 29, children did not consistently look longer at target videos when auditory stimuli were played, compared to the baseline, for both singular and plural trials. Given the relatively broad age range of our participants, they examined whether perfor-

mance improved with age by testing for a correlation between age and task performance. No significant correlation was found.

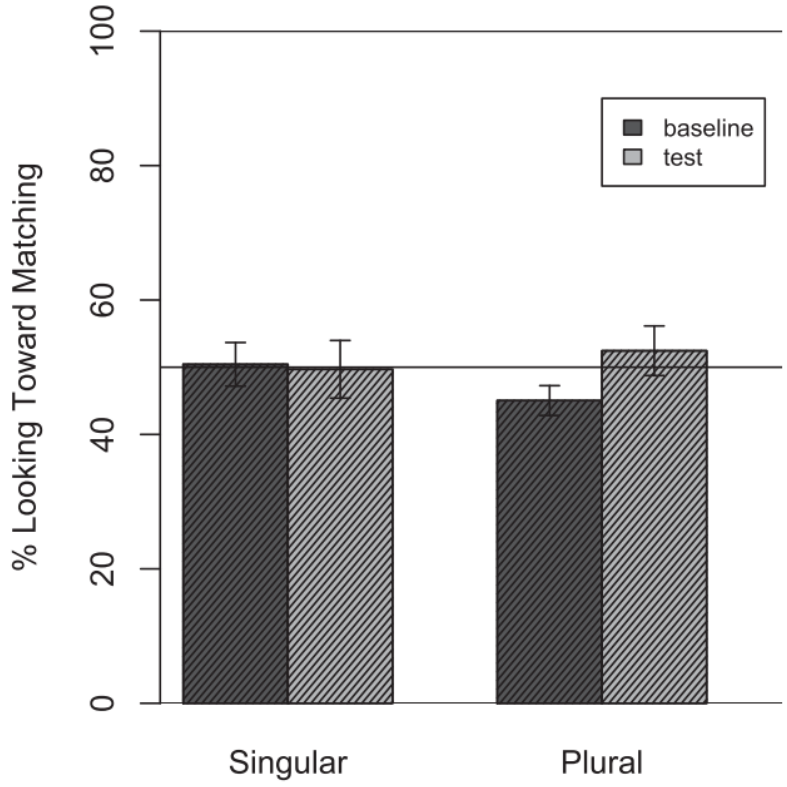


Figure 29: Mean % looking times (and SEs) in SG and PL at 28-46 months (English).

The procedure for testing the Spanish infant group was the same as in the French pointing experiment. Participants included 31 monolingual, Spanish-speaking children (15 male, 16 female; M = 36.6 months, range = 30–47 months). The results of the experiment are illustrated in Figure (30). Overall, children pointed at the target video 53.94% of the time, which is not significantly different from chance level.

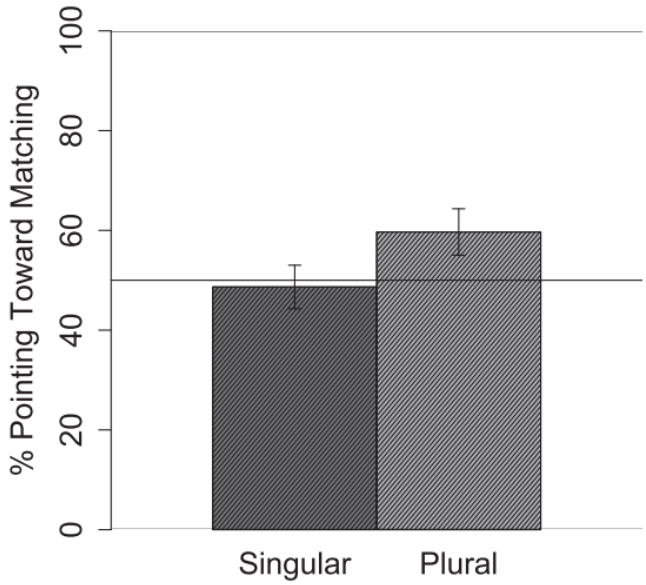


Figure 30: Mean % pointing to target video in SG and PL at 28-46 months (Spanish).

According to the results of this study by Legendre et al. (2014), Spanish and English comprehension data show a high difference between comprehension and production. French-speaking children appear to have achieved subject-verb agreement by the age of 30 months and mastered the ability to discriminate singular from plural agreement and this is shown in preferential looking and pointing tasks. By contrast, even at an older age, approximately 35 months, no clear evidence of parsing in English children and Spanish has been detected. The observed asymmetry in the comprehension and production of subject-verb agreement cannot be fully explained by existing theories, even though the presence or absence of overt morphophonological features may play a role, as suggested by Pérez-Leroux (2005). The authors suggest that the high perceptual salience and reliability of the /z/ liaison consonant in French, which unambiguously marks plural morphology, may contribute to the observed differences, whereas English lacks

such a strong agreement cue. The Spanish *-n*, while not as ambiguous as English *-s*, does not possess the same level of reliability as a marker of plurality (or person) of French.

It is also remarcable that the test age in Legendre et al. (2014) for Spanish-speaking children was a mean age of 36 months, whereas the French-speaking children were a mean age of 30 months, slightly younger. Bearing in mind Gonzalez-Gómez et al. (2017) results on Spanish (see Chapter 3)[1], the children tested performed well when the pseudo-noun was replaced in the object position by *objeto*, 'object,' a real noun. The comprehension of a pseudo-word might be more difficult to process for an older child than a younger one and might affect the results. This observation is supported by Bialystok et al. (2016), who found that younger children often find novel words easier to understand in context compared to older children. Additionally, Smith and Yu (2015) observed that younger children's flexibility in processing new linguistic information might contribute to this trend.

In line with possible methodological artefacts, Brandt-Kobele and Höhle (2010) examined the early comprehension of verb inflection of children. Their study involved considering two aspects: first, whether German-learning children aged 3 to 4 years are sensitive to verb inflection, and second, comparing different methodological approaches by examining the outcomes of their experiments. A total of 56 children participated in two experiments. These experiments exposed infants to sentences where verb inflection was the only cue to the subject's number. The study resorted to test sentences in German, containing the homophonic 3rd-person singular feminine pronoun and the 3rd-person plural pronoun *Sie*, as shown in examples (47) and (48). This setup challenged the children to depend solely on verb inflection to discern the number of subjects in a sentence.

(47) Sie fütter-t einen Hund.
she feeds.3sg a dog

1 The study by (Gonzalez-Gómez et al., 2017) applies offline methods and for coherence was introduced earlier; however, it replicates the study by Legendre et al. (2014)

'She feeds a dog.'

(48) Sie fütter-n einen Hund.
they feed.3pl a dog
'They feed a dog.'

The two experiments performed involved presenting each sentence along with two pictures depicting the action described, performed by one or two actors. The material followed methodologies similar to those of Johnson et al. (2005) and Pérez-Leroux (2005). Each child was exposed to 4 practice trials and eight experimental trials, involving 2 sentences each, using different verbs (*streicheln* 'to pet', *angeln* 'to fish', *basteln* 'to do handicrafts', *füttern* 'to feed', and *öffnen* 'to open'), known to young German children. The materials are illustrated in Figure 31.

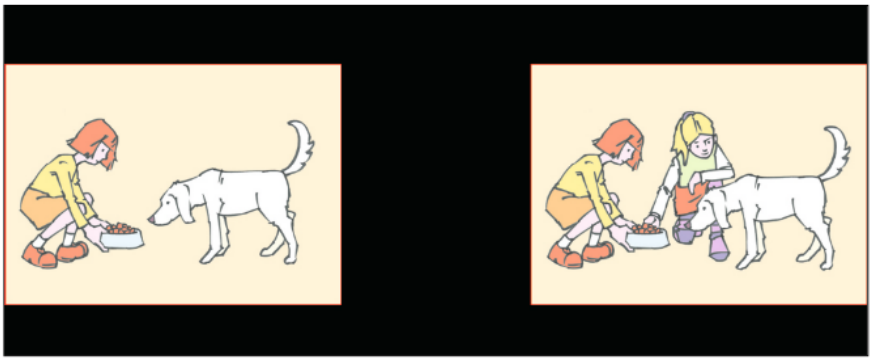


Figure 31: Visual material: Single Actor (left) and Two Actors (right) by Brandt-Kobele and Höhle (2010)

Eye-tracking was used to measure gaze fixation and fixation duration. The experiments assessed whether infants demonstrated sensitivity to a picture that targeted the number information provided by the verb inflection. The accuracy of comprehension was evaluated based on the duration and frequency of gazes at the picture depicting one actor following a singular inflected verb, and at the picture depicting two actors following a plural

inflected verb. In the first experiment, children were simply instructed to observe the images and listen to the sentences, without a pointing task. The second experiment, however, involved a picture selection task, where infants were asked to point to the picture targeted by the sentence heard.

Experiments 1 and 2 revealed that during the baseline phase, the 2-actor picture consistently attracted longer looking times, which the authors attribute to the increased visual information it presented. In Experiment 1 the infants' looking time at the 2-actor picture decreased significantly from the baseline phase to the testing phase when a singular sentence was presented ($F(1,27) = 11.46$, $p < 0.01$), but not when a plural sentence was presented ($F(1,27) = 1.75$, $p = 0.197$). This suggests that a German child aged 3-4 years can infer the number of a sentence's subject from the verbal inflection number information. In contrast, Experiment 2 did not yield significant results in correct action performance in either number condition. Specifically, 10 out of 28 children pointed only to the 2-actor picture, and 1 child pointed only to the 1-actor picture, irrespective of the number condition. The remaining 25 children's responses were distributed randomly, supporting the assumption that guessing was a prevalent strategy.

Figure 32, from Experiments 1 and 2 shows the mean-looking times in the singular and plural number conditions. The results for the singular condition revealed higher looking times for the 1-actor picture (the target) in Experiment 1, while the 2-actor picture (the distractor) showed lower looking times in both experiments. In the plural condition, the 2-actor picture (now the target) had significantly longer looking times in Experiment 1 than in Experiment 2, and the 1-actor picture (the distractor) had shorter looking times in Experiment 1 than in Experiment 2. Overall, the results indicate that the target picture elicited longer looking times in Experiment 1 than in Experiment 2. In their study, Brandt-Kobele and Höhle (2010) show the modality asymmetry. The study underscores the importance of critically evaluating the methods used in language development research, as different approaches can lead to contrasting results.

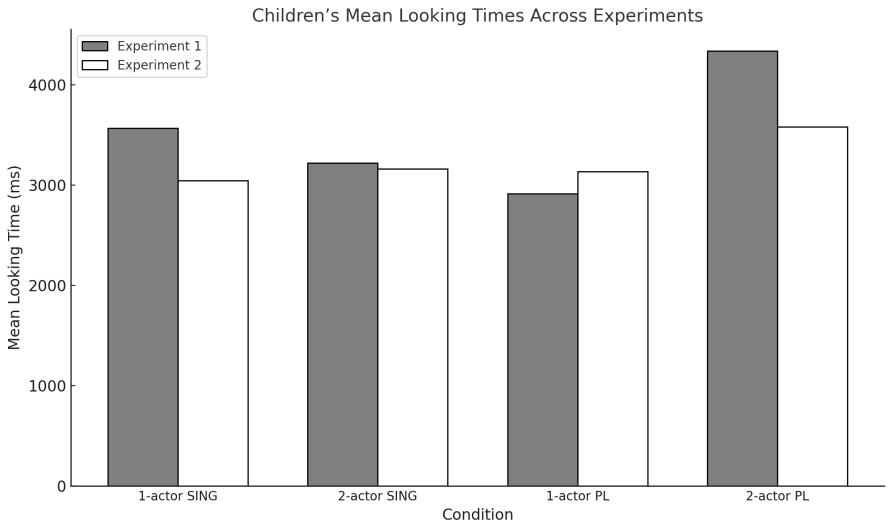


Figure 32: Children's average looking times (ms) for SG and PL in (Brandt-Kobele & Höhle, 2010)

Lukyanenko and Fisher (2016) conducted a study using the visual preference technique to investigate the predictive processing of agreement in infants and adults. The study aimed to determine whether 2.5-year-old children, like adults, can use informative agreeing verbs to facilitate the identification of a following subject noun phrase and pre-activate the number properties of the subject. The study included two experimental groups: 64 3-year-olds (34.2–42.4 months; M = 37.8; 32 girls) and 48 adults (18–27 years; M = 20.1; 30 women), who were tested with the same stimuli. In Experiment 1, participants were exposed to sentences in informative trials where the target noun phrase was the subject of a preceding number-marked verb, exemplified in (49) to (52).

(49) *Informative trial, wh- question*

where	are	the	good	cookies
WH	AUX.3PL	DET	ADJ	N.PL

(50) *Informative trial, locative*

there is/are the...
LOC AUX.3SG/3PL DET

(51) *Uninformative trial*

can you find the good cookies
AUX PRON.2SG V DET ADJ N.PL

(52) *Uninformative trial*

oh, look at the...
INTERJ V PREP DET

There were 16 trials of each type (informative and uninformative), with eight singular and eight plural targets, also counterbalanced for nouns vs. pseudo-nouns. In each trial, two images were presented side by side, and participants' eye movements were recorded (see Figure 33). Adult participants were asked to point to the named target picture in each trial to encourage attentiveness, while child participants were not given a specific task.

The expectation was that participants in informative trials would be more likely to shift their gaze towards the target in the pre-noun window compared to those in uninformative trials. The results are shown in Figure 34 for children and adults.

The results of Experiment 1 showed that both infants and adults looked earlier at the target picture in informative trials compared to uninformative trials, indicating that they could predict the number of subjects based on the preceding verb.

In Experiment 2, Lukyanenko and Fisher (2016) aimed to investigate whether 2.5-year-old children can use processing of subject-verb agreement in the same as 3-year-olds. The study included 64 2.5-year-old children (32 girls) with a mean age of 31.9 months (range: 28.1–35.4 months). The same visual preference technique and stimuli used in Experiment 1 were employed in Experiment 2. The results showed that the 2.5-year-olds also used informative agreeing verbs to facilitate the identification of a following subject noun phrase and pre-activated the number properties of the subject.

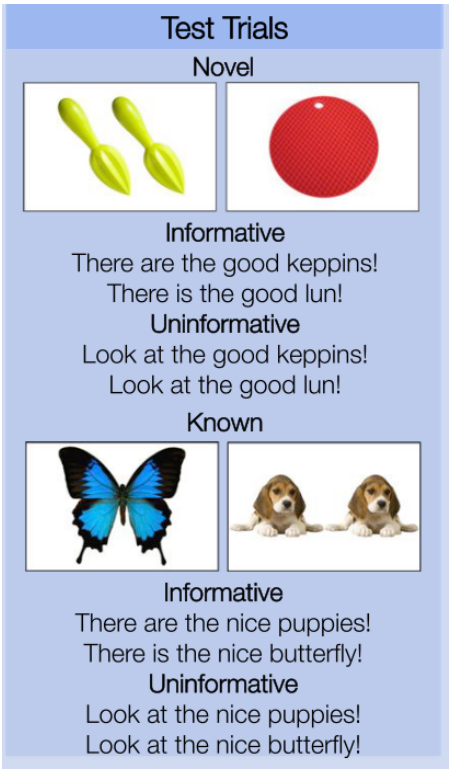


Figure 33: Trial phase stimuli, Lukyanenko and Fisher (2014).

This suggests that even very young children can incrementally use the predictive information of subject-verb agreement to aid processing. Children in this age group were observed to be faster in looking at named pictures when an agreeing verb provided information about the properties of the forthcoming noun. This behaviour was particularly noticeable in plural trials, where toddlers were more likely to shift their gaze from the distractor to the target picture even before the noun was mentioned, indicating an ability for anticipatory processing in early language comprehension. However, timing differences were observed between 2.5 and 3-year-olds. These differ-

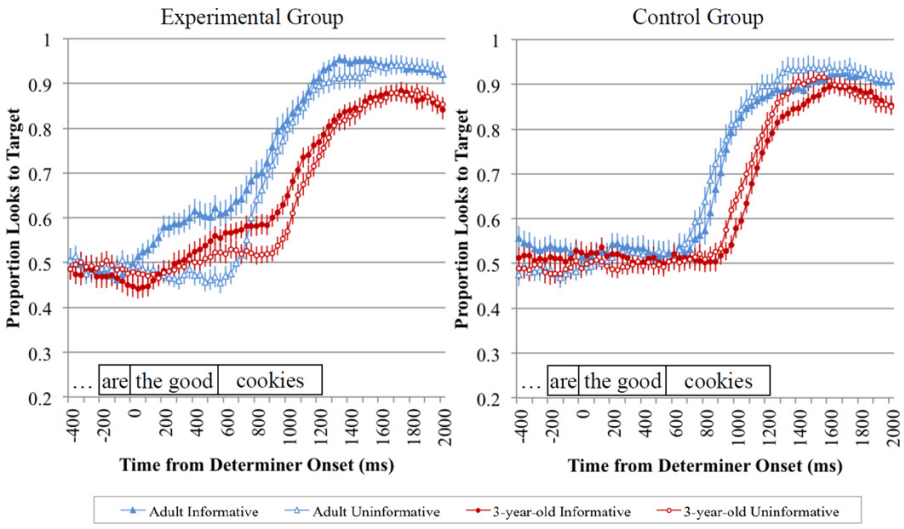


Figure 34: Results from Lukyanenko and Fisher (2016): proportion of looks to the target

ences reflect the well-known increases in the speed of language processing and command of verbal morphology as children grow older.

Importantly, even in cases of language impairment, children can understand verbal number agreement in simple Spanish sentence structures, highlighting the fundamental nature of this aspect of language processing (Christou et al., 2022). Despite some minor differences between the children diagnosed with Developmental Language Disorder and control groups, the results of this study suggest that tense morphology comprehension in children with DLD may be more typical than previously thought.

Although not dealing with subject-verb agreement, the study by Melançon and Shi (2015) examined how 30-month-old children processed determiner and adjective noun agreement. The study tested French-learning children on first taught novel word–object pairs in the context of a gender-marked determiner (e.g., *un* (MASC) *ravole* 'a ravole'). The trials manipulated the gender agreement between the new determiner and the non-

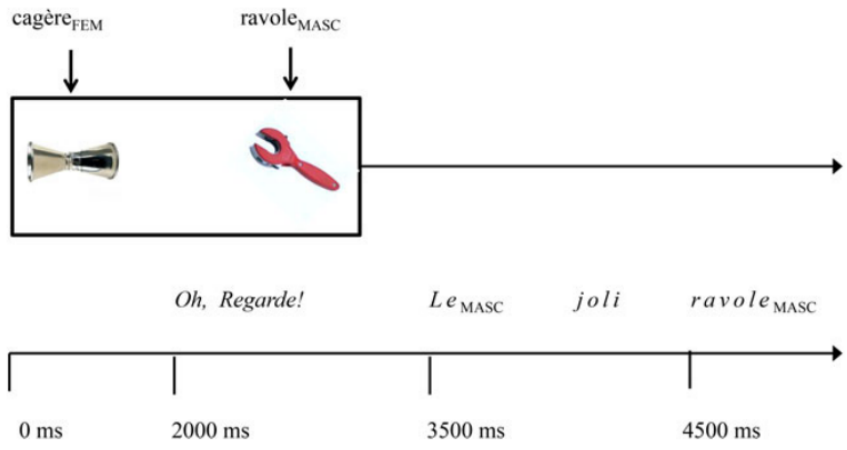


Figure 35: Stimuli presentation timeline during a test trial, one by Melançon and Shi (2015)

adjacent noun, with some trials featuring correct gender agreement (e.g., *le* (MASC) *ravole* (MASC)) and others featuring incorrect gender agreement (e.g., *la* (FEM) *ravole* (MASC)The test trials were categorized into Gender-Match, Gender-Mismatch. The stimuli appear in the figure.

The analysis examined the proportion of looking time directed towards the target. The findings indicate that children exhibited better performance in trials where there was agreement between the gender of the determiner and noun. Conversely, recognition was most hindered when there was a gender mismatch between the two categories. The results seem to suggest a possible facilitation effect on the named target triggered by gender-match trials and hindrance in gender-mismatch trials. The authors have interpreted the results to suggest that young children exhibit evidence of abstract featural representation as adults. Specifically, children were able to assign determiner gender to novel nouns, and during the subsequent phase, they processed non-adjacent gender agreement between determiners and nouns when separated by adjectives. This happened without relying on gender-

specific phonological indicators, as these were absent in the novel nouns. These results were consistent for both new and known nouns, demonstrating that children's understanding of grammatical gender is not limited to individual vocabulary but is abstracted and applied abstractly within their mental lexicon, allowing for productive use with both familiar and new words and aiding language processing.

In a subsequent nominal agreement study, Shi et al. (2020) aimed to determine if a similar ability is present in much younger infants, specifically those between 17 and 18 months of age. The methodology involved a combination of audio recordings and visual animations to present stimuli to the infant participants. The study included 24 monolingual French-learning infants aged between 17 to 18 months. The stimuli in the study involved sentences with correct gender agreement and sentences with agreement violations. There were two sentence types are exemplified in Table 41.

Table 41: Test sentences and design, French by Shi et al. (2020)

Group 1	
Structure 1 (Correct AGR)	**Structure 2 (Incorrect AGR)**
(1) [La banane$_{F}$ dans le chapeau$_{M}$]F elle$_{F}$	(2) *[La banane$_{F}$ et le chapeau$_{M}$]M elles...$_{F}$
(The banana in the hat, it...)	(The banana and the hat, they...)
Group 2	
Structure 2 (Correct AGR)	**Structure 1 (Incorrect AGR)**
(3) [La banane$_{F}$ et le chapeau$_{M}$]M ils...$_{M}$ . . .	(4) *[La banane$_{F}$ dans le chapeau$_{M}$]F il...$_{M}$
(The banana and the hat, they...)	(The banana in the hat, it...)

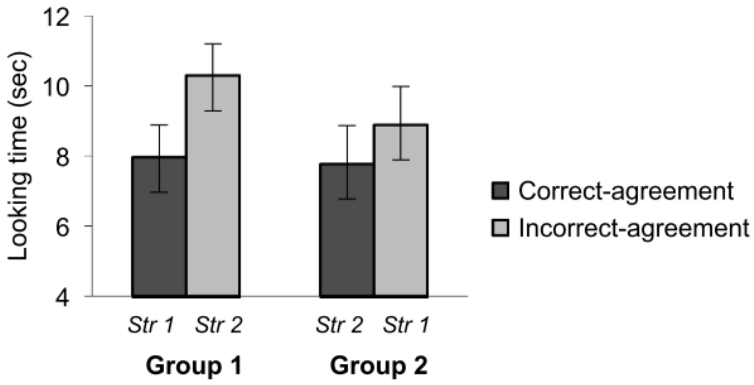


Figure 36: Mean Looking times to target in 17-month-olds' in Shi et al. (2020)

In Structure 1, six grammatical sentences and corresponding ungrammatical sentences were created. The difference between grammatical and ungrammatical sentences was the subject pronoun clitic of the follow-up, which depended on whether the subject was a coordinated structure or not, as exemplified in Table 41. In Structure 2, six grammatical sentences and corresponding ungrammatical sentences were also created. The difference between correct and incorrect sentences within this structure was the subject pronoun clitic, again determined by the presence vs. absence of coordination. The study's results were revealing. The infants demonstrated longer looking times for the incorrect-agreement trials, suggesting an ability to discriminate between correct and incorrect gender agreement in the sentences.

The results include the report of groups 1 and 2, younger and older respectively as shown in the Figures 36 and 37.

The study by Shi et al. (2020) shows that infants as young as 17-18 months, when infants are just beginning to learn noun genders, can already track gender agreement in a structure-dependent manner. This skill aligns with the principle of structure dependence in universal grammar, as postulated in Chomskyan theory (Chomsky, 1965, 1995). The sentence structures em-

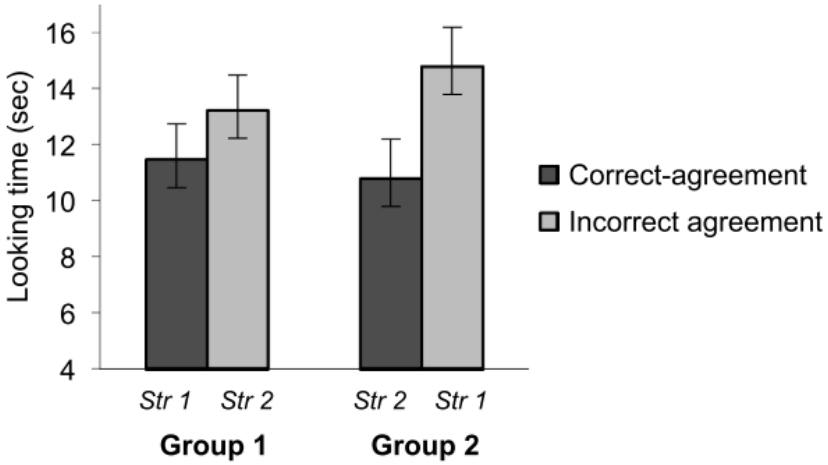


Figure 37: Mean looking times to target in 30-month-olds' trials in Shi et al. (2020)

ployed were rare in the natural language exposure of French children, suggesting that the infants' performance cannot be solely attributed to inductive learning from frequent input.

Finally, the research conducted by Ferry et al. (2020) delves also into the acquisition of morphological rules in the nominal domain, investigating the developmental trajectory of morphological processing in Italian infants aged 12, 18, and 24 months. The results of the study indicated that already twelve-month-old infants demonstrated an initial recognition of morphological rules. This pattern was stronger by eighteen-month-old infants and even more so by twenty-four-months. Ferry et al. conclude that infants as young as 12 months provides new insights into the onset of morphological processing capabilities, which previous research often overlooked.

It is crucial to experimentally verify and compare the obtained results using a unified experimental design applicable to different languages and methodologies. The studies presented, among many others, demonstrate

that children may exhibit early linguistic knowledge when tested using a methodological paradigm with minimal task demands.

4.2 STUDY 2: EARLY ACQUISITION OF AGREEMENT IN CATALAN AND GERMAN

Rationale

Building upon the encouraging findings from the picture-selection task in Chapter 1, where Catalan-speaking children successfully decoded subject-verb agreement with null/-n marking, my research focused on assessing younger participants. I employed the preferential-looking paradigm with eye-tracking technology. This approach had been used successfully in studies on the agreement as reported by Legendre et al. (2014) and Höhle et al. (2009), albeit with older participants.

The objective is to compare the parsing aspects of two distinct language types, null subject languages and non-null subject languages, to determine whether the previously observed differences in language production are also evident in language comprehension. If subject-verb agreement comprehension emerges at an early age, it could also suggest that infants and young children have already internalized the language-specific features of agreement. This would align with the hypothesis of Very Early Parameter Setting (Wexler, 1998), which states that children establish the feature values that define their target grammars, including inflectional markers, prior to entering the two-word stage of language development.

I present Study 2, which includes Experiments 1 and 2, a study on subject-verb agreement on Catalan and German-speaking infants aged 1;2 to 3;4. The age group of 1;2-2;4 falls within the pre-productive stage of language acquisition. The aim is to examine infants' early sensitivity to grammatical features, such as subject-verb agreement, regardless of whether the language employs null subjects, suggesting that certain grammatical principles may

be universal and innate. At its core, Study 2 aims to assess the capabilities of children in acquiring and internalizing subject-verb agreement, particularly in languages with complex verbal morphology.

The study examined null-subject conditions for Catalan and, for German, a pronominal subject condition with ambiguous cues, following the early work by Höhle et al. (2009).

Predictions of study 2

The hypothesis would predict that young children will exhibit noticeably prolonged fixation durations on the congruent scene if they have mature, abstract syntactic knowledge.

1. If children do not have adult-like abstract syntactic knowledge yet, they will show no difference in looking times between the target and distractor scenes in response to the presented sentences.

2. If children have some abstract syntactic knowledge but are not fully developed, they may show some but not significant differences in looking times between the target and distractor scenes in response to the presented sentences.

3. If the task demands or verbal stimuli are too taxing for infants, they will show no significant differences in looking times between the target and distractor scenes.

4. If children do not have adult-like abstract syntactic knowledge yet, they will show no difference in looking times between the target and distractor scenes in response to the sentences for both null-DP/ambiguous DP and Full-DP conditions.

5. If there are no statistical differences between null-subject language (Catalan) and non-null subject language (German) this would suggest that children's sensitivity to subject-verb agreement is not significantly

affected by language type indicating a universal or language-general aspect of this comprehension process.

4.3 EXPERIMENT 1

I conducted an experiment involving both null-subject sentences in Catalan and full-determiner phrase (full-DP) sentences to determine if infants were sensitive to the verbal suffixes. In these sentences, the verbs were either inflected for the third person singular or third person plural, with the distinction marked by the presence or absence of the suffix *-n*. It's important to note that in the Catalan variety I examined, the vowel difference between the singular and plural forms was purely orthographic. In this context, both *a* and *e* in the singular and plural forms represented the schwa sound.

Design and materials

In Experiment 1, I maintained the intransitive usage of verbs, consistent with the approach employed in study 2. However, there was a modification in Experiment 1, as we focused on testing only two specific disyllabic verbs when inflected for either singular or plural verbs: *ballar* 'dance' and *jugar* 'play'. These verbs were known to be familiar to young Catalan-speaking infants. To construct the full-determiner phrase (full-DP) sentences, I employed a definite masculine article in either singular or plural form, coupled with the noun *animal* 'animal' or *animals* 'animals' in accordance with the subject's grammatical number. Consequently, the visual stimuli correspondingly featured singular or plural representations of animals. In total, this experiment consisted of 8 distinct test items, as exemplified in examples (53) to (56). These puppets encountered represented animals frequent in Catalan storytelling, namely, *vaca* 'cow', *gos* 'dog', *porc* 'pig', *ovella* 'sheep', and *llop* 'wolf', the full list of experimental items appears in the Appendix for reference (54).

(53) L'animal balla.
the animal.sg dance.3sg

(54) Balla.
dance.3sg

(55) Els animals ballen.
the animals dance.3pl

(56) Ballen.
dance.3pl

The experimental stimuli utilized in the study were recorded by the same female Catalan native speaker featured in experiments 1 and 2, and the recording process followed the same protocol. The recordings were conducted in a sound-attenuated studio, where the speaker employed a child-directed speech style. Subsequently, the recorded sentences were digitized at a sampling rate of 44.1 kHz, utilizing a mono-channel setup to ensure audio quality. The recorded sentences were edited using Praat software (Boersma & Weenink, 2007). On average, the length of the sentences was approximately 1601 milliseconds, with a range spanning from 1201 to 2001 milliseconds.

For each sentence, a straightforward coloured video illustrating the described scenario was produced using puppets, as depicted in Figure 38. All videos had dimensions of 115 mm x 65 mm, with a 35 mm gap between them, set against a black background. In the case of each experimental sentence, two videos were created, and the only difference between them was the number of characters involved in carrying out the action specified by the verb. In both simultaneously presented videos, the characters executed the same action side by side. For instance, in one video, only a single animal, the pig, was engaged in the action mentioned in the sentence (e.g., *balla* -

dance-3sg), while in the other video, two animals, a pig and a wolf, were jointly performing the same action, as depicted in Figure 38.

Figure 38: Sample of visual material from Study 2

Visual content was captured using a Canon EOS 2000d camera. Synchronized videos featured target sentences, including both full-DP and null-subject forms in singular and plural, as well as the number distractors. The video content was edited using Adobe Premiere Pro CC 2017 (v. 11.0.2). A total of 8 test items were presented in a random order, ensuring that target and reverse actions were evenly distributed between the left and right sides of the screen.

Participants

Twenty-nine typically developing Catalan infants, comprising sixteen girls and thirteen boys, with a mean age of 21.86 months (*SD=4.69*, ranging from 14 to 32 months), participated in the study. Nine infants were not included in the final results; for five of them significant errors in calibration occured, and four infants did not complete the task. The infants were recruited in the metropolitan area of Barcelona and had no reported history of speech, hearing, or language disorders. Given the relatively wide age range, the results were analyzed with respect to two age groups: a younger group of infants aged 1;2 to 1;9 (mean=19;06, *SD=2.28* N=15) and an older group of children aged 2;0 to 2;8 (mean=24;85, *SD=2.35* N=14)

Procedure

The eye-tracking data collection utilized the Tobii Pro X3-120 eye-tracking system, which operated at a sampling rate of 120 Hz. The Tobii StudioTM platform (Version 3.4.8) was employed for the recording and subsequent analysis of eye gaze data. To present the video stimuli, a laptop with a screen resolution of 1920 x 1080 was used. Each participating child was seated on their caregiver's lap, maintaining an approximate distance of 60 cm from the screen, ensuring that the gaze angle remained under 40 degrees. The experimental session started with an essential eye calibration procedure, followed by both a training phase and the subsequent experimental phase. The calibration process was initiated at the outset of the experimental session. A controlled calibration was performed, involving the display of a yellow chick at each of the four corners and the center of the screen, accompanied by an auditory cue. The resulting calibration data obtained from the Tobii Pro system were assessed and determined whether to accept the calibration or proceed with a re-calibration if necessary.

Following the calibration procedure, the training session was conducted. During this phase, the young participants were introduced to the characters, with all puppets being presented one by one, once while half of the screen remained blank, with this presentation lasting for approximately 6 seconds, as shown in example Figure 39.

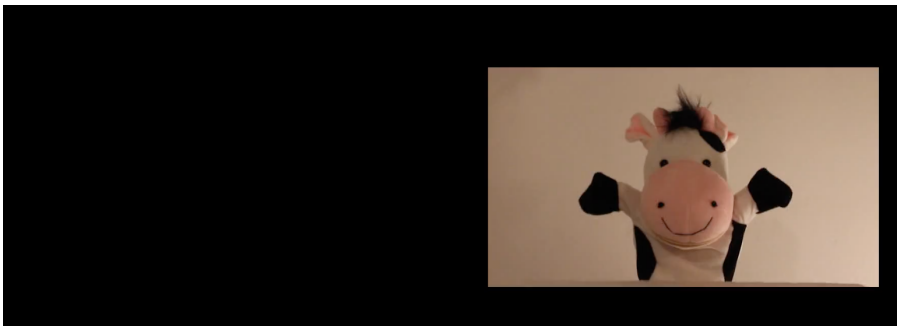


Figure 39: The character-introduction video clip, Study 2

Subsequently, the participants were exposed to simultaneous presentations featuring two different animals, while a recorded voice prompted them to locate one of them. For example, *Mira, veus el gos? On és el gos?* which translates to 'Look, do you see the dog? Where is the dog?', as shown in Example Figure 40. A full list of the experimental materials used is available in Appendix 54.

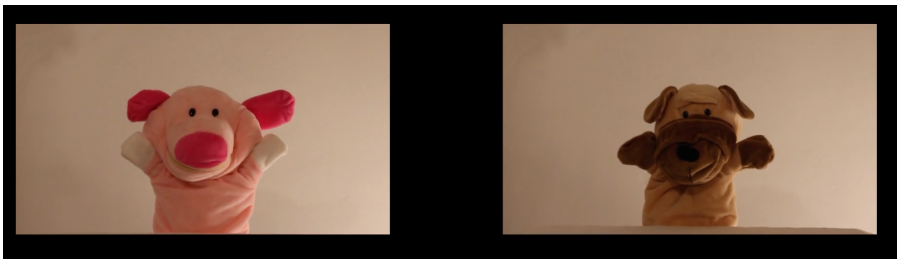


Figure 40: Simultaneous character-introduction video clip, Study 2

After the completion of the training session and a brief interlude featuring a Teletubby cartoon (see Figure 41), the experimental session was initiated, as depicted in Figure 42.

Each experimental item was separated by a two-second blank screen interval, supplemented with additional clips showing Teletubbies landscapes after items 3, 4, and 5. This strategic inclusion of interludes was designed

Figure 41: Transition to experimental phase

to help sustain the infant's attention throughout the session. Each video sequence began with a sentence designed to capture the child's attention, such as *Mira, què passa?* which translates to 'Look, what's happening?'. This served as the baseline, followed by the experimental sentences, which were played three times consecutively. Consequently, the recording of gaze duration took place across four windows: the baseline and three successive exposures to the target sentence starting at 6, 12, and 21 seconds, as illustrated in 43. This experimental design follows closely the design in Franck et al. (2013).

The entire experimental session had a duration of 10 minutes, and the sequence of the experimental trial is visually presented in Figure (43), depicting the Baseline (BS) and the subsequent time windows (S1, S2, and S3) for reference.

Figure 42: Experimental trial for the verb: play

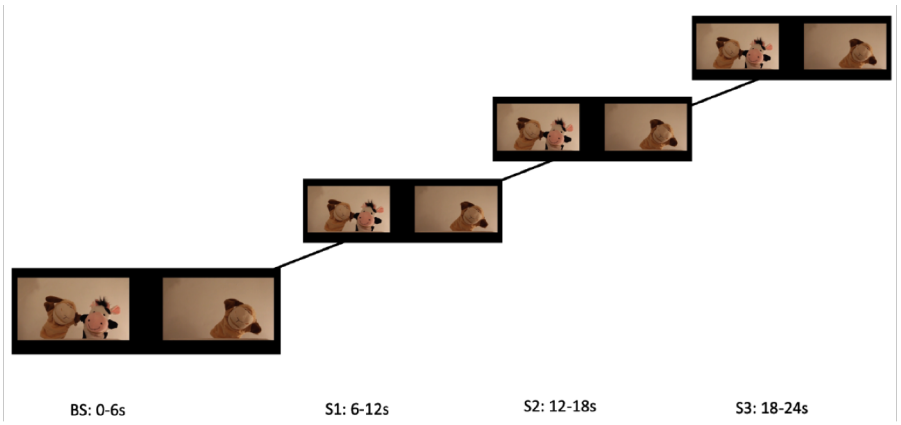


Figure 43: Experimental sequence of trial dancing

Data analysis

In the investigation of subject-verb agreement in very young Catalan-speaking children, I employed advanced statistical techniques to analyze eye-tracking data collected. This approach again follows methodologies similar to those used by Franck et al. (2013) and Gavarró et al. (2015).

The paradigm involved measuring the participants' eye gaze towards the videos depicting one or two actors performing similar actions, while they heard sentences with verbs inflected for either 3rd person singular or 3rd person plural. The primary objective was to discern patterns in children's

gaze behaviour that would reveal their ability to match verb inflections with corresponding video stimuli. Before delving into the analysis, I subjected the data to a Shapiro-Wilk test. This statistical test assesses the normality of a dataset distribution. In this context, I applied the Shapiro-Wilk test to scrutinize whether the proportions of gaze duration on different regions of interest (ROIs). This step was crucial as many subsequent statistical analyses hinge on the assumption of normality. The Shapiro-Wilk test determined whether the proportions of gaze duration deviated significantly from a normal distribution. Non-normality could impact the validity of certain statistical tests. Deviations from normality could necessitate alternative analytical approaches or data transformations. For the contrast of MATCH vs. MISMATCH in each window, we used the Signed Rank test for non-normally distributed data and the t-test for normally distributed data. If the p-value from the Shapiro-Wilk test fell below the chosen significance level (typically set at 0.05), it indicated that the data significantly departed from a normal distribution, and thus, the Signed Rank test was used. Otherwise, the t-test was employed for normally distributed data. For the core analysis, I employed Linear Mixed Models (LMMs), a sophisticated statistical technique. The aim was to investigate how specific variables, such as the Windows being observed (Baseline, Sentence 1, Sentence 2 and Sentence 3) and the condition (full-DP or null-subject), influenced participants' gaze duration proportions. LMMs enable the comprehensive analysis of complex datasets that encompass both fixed effects (systematic differences) and random effects (variance within and between participants and items). In the study, LMMs allowed us to delve into the relationship between variables of interest (Windows and condition) and the response variable (gaze duration proportions). These models are particularly valuable when dealing with hierarchical or repeated measures data, such as eye-tracking data. LMMs provide insights into the significance and direction of the effects of various factors on the response variable. This analysis helped us understand whether differences in gaze duration were statistically significant. Importantly, LMMs allow re-

searchers to draw inferences while accounting for the inherent variability in the data due to differences between participants and items. Therefore, I employed the Shapiro-Wilk test to evaluate data distribution normality, ensuring the validity of subsequent analyses. I then harnessed Linear Mixed Models to explore intricate relationships between variables and participants' gaze behaviors, providing a robust framework to uncover patterns and influences while addressing the variability inherent in the data.

Results

Overall results

The results encompassing all tested participants of experiment 1, 29 infants, are presented in Tables 42 and 43. These tables provide a comprehensive overview of the mean looking time (measured in milliseconds), with standard deviations enclosed in parentheses, across the four Windows. Table 42 pertains to the conditions involving full DP subjects, while Table 43 is dedicated to null subject condition. To assess the statistical significance of the findings, non-parametric localization tests, specifically the Signed Rank tests, were conducted for each Condition, Scene, and Window. The objective was to evaluate whether fixation duration on the target video significantly deviated from the expected chance performance, represented by the value 0.5.

In this scenario, the fixation in the full-DP singular condition duration exhibited a noteworthy departure from chance performance. Specifically, significant differences were observed in all three windows: S1 ($S = 218$, $p < .0.0001$), S2 ($S = 218$, $p < .0.0001$), and S3 ($S = 213$,$p < .0001$). These findings underscore the children's capacity to discriminate and fixate on the target video when confronted with full DP-subject singular sentences. Similarly, the results for the full-DP plural condition displayed a conspicuous deviation from chance. Significant differences were observed in scenes S1 ($S = 194$, $p < .0.0001$), S2 ($S = 205$, $p < .0.0001$), and S3 ($S = 218$, $p < .0.0001$). In

full DP-subject plural sentences, infants exhibited a robust ability to differentiate and maintain fixation on the target video. This indicates that children's gaze patterns during full-DP subject plural sentences significantly differed from random performance.

During the presentation of the null-subject condition in the singular scene, significant differences were detected in the following windows: S1 ($S = 109$, $p = 0.0161$), S2 ($S = 139$, $p = 0.0014$), and S3 ($S = 187$, $p < 0.0001$). The baseline window did not show a significant difference ($S = 18$, $p = 0.7121$). Further analysis with the t-test revealed significant differences in S2 ($t = 3.36$, $p = 0.0023$), and S3 ($t = 5.07$, $p < 0.0001$), but no significant difference in the baseline window ($t = 0.72$, $p = 0.4746$).

During the presentation of the null-subject condition in the plural scene, significant differences were detected in the following windows: S1 ($S = 156$, $p = 0.0002$), S2 ($S = 158$, $p = 0.0002$), and S3 ($S = 133$, $p = 0.0025$). The baseline window did not show a significant difference ($S = 17$, $p = 0.7279$). Further analysis with the t-test revealed significant differences in S1 ($t = 3.54$, $p = 0.0014$).

These findings suggest that even though fixation durations were generally longer in the full-DP condition, the null-subject condition still exhibited evidence of prolonged fixation durations among infants in the study. Figure (46) graphically illustrates these differences.

Notably, no significant differences from chance were detected during the baseline window in the full-DP and null-subject conditions, aligning with expectations. These findings collectively provide compelling evidence of infants' capacity to discern and react to number distinctions, even when very young. The results suggest that children as young as 1;4 can exhibit comprehension abilities previously thought to emerge at later developmental stages, challenging certain earlier claims regarding the asymmetry between production and comprehension of verb inflection in early language acquisition.

Table 42: Duration of looking time, Full-DP, Catalan

	Singular		Plural	
	Target	Distractor	Target	Distractor
BS (0-6s)	2000 (382)	2043 (438)	2041 (323)	1946 (312)
S1 (6-12s)	2080 (203)***	1612 (293)***	2333 (192)***	1911 (332)***
S2 (12-24s)	2349 (218)***	1781 (183)***	2305 (185)***	1848 (294)***
S3 (24-30s)	2201 (123)***	1856 (217)***	2084 (250)***	1730 (238)***

Table 43: Duration of looking time, Null subject, Catalan

	Singular		Plural	
Window	Target	Distractor	Target	Distractor
BS (0-6s)	1992 (330)	1958 (363)	2040 (358)	1992 (401)
S1 (6-12s)	2113 (257)*	2001 (294)*	2288 (412)***	2031 (385)***
S2 (12-24s)	2182 (239)**	1982 (232)**	2310 (208)***	2081 (322)***
S3 (24-30s)	2148 (212)***	1758 (336)***	2192 (246)**	1961 (377)**

The generalized mixed model analysis, encompassing all participants as a unified group, unearthed statistically significant fixation duration on the target video. Confidence intervals for fixation duration during the baseline window in both conditions exhibited a containment of the 50% mark. This suggests that, on average, participants allocated an equal amount of time viewing the target and distractor videos in these instances. However, for the subsequent time intervals, referring to time windows S1, S2 and S3, the confidence intervals exceeded the 50% threshold and participants directed a greater proportion of their gaze towards the target video rather than the distractor video.

Notably, significant differences emerged in the proportion of fixation duration on the target between the null-subject and full-DP conditions ($t = -4.95$; $p < 0.0001$), with a difference of -1.89. This indicates that participants exhibited lengthier fixations on the target in the full-DP condition. Furthermore, a more in-depth examination of the null-subject condition unveiled statistically significant differences in the proportion of fixation duration on the target between the baseline and S3 $t = -4.63, p = 0.0001$), with an estimated difference of -3.54. In the null-subject singular condition, there were also statistically significant differences ($t = -4.32$; $p = 0.0021$) in the proportion of fixation duration time on the target between baseline and S3, with S3 registering a higher estimated fixation duration on the target (-4.65 difference).

No statistically significant differences were observed between the singular and plural conditions. For visual clarity, the results have been graphically depicted in Figure 44. To delve deeper into our second research question, which revolves around the timing of subject-verb agreement parsing, a more focused analysis was conducted, segregating the two age subgroups.

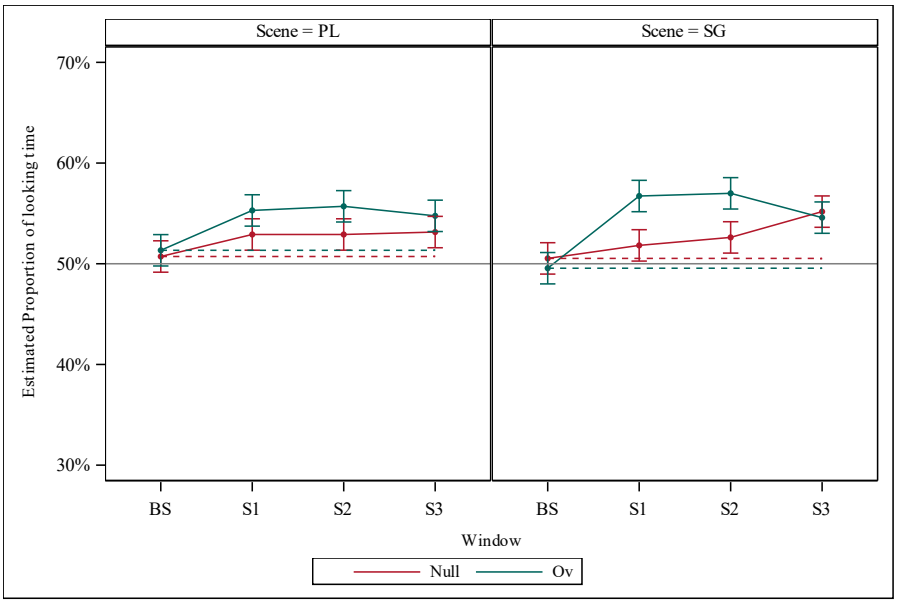


Figure 44: Estimated proportion of looking time full-DP and Null-subject overall results, Catalan

Older group

This group included 14 infants, with an age range of 2;3 – 3;1 (mean= 28;8, N=14). In the final analysis of the older participant group, the Signed Rank test exhibited statistically significant results across all examined windows, scenes, and conditions except that, there was no significant departure from chance during the baseline window in both the full-DP and null subject conditions (Table 44 and Table 45) as expected.

During the presentation of the full-DP within the singular scene, notable significance was observed in the following windows: S1, S2, and S3 all showed a highly significant $p < 0.0001$. During the presentation of the full-DP in the plural scene, notable significance was evident within the fol-

Table 44: Duration of looking time, Full-DP, older group, Catalan

	Singular		Plural	
Window	Target	Distractor	Target	Distractor
BS (0-6s)	2126 (153)	2118 (133)	2110 (108)	2108 (98)
S1 (6-12s)	2223 (101)***	1820 (191)***	2257 (97)***	1972 (149)***
S2 (12-24s)	2222 (124)***	1908 (81)***	2159 (88)**	2037 (76)**
S3 (24-30s)	2183 (78)***	1897 (123)***	2263 (98)***	1861 (222)***

lowing conditions: Time window S1 and S3 exhibited a highly significant $p < 0.0001$. S2 displayed a statistically significant outcome with $p = 0.0037$.

The analysis of the null-subject condition within the singular scene showed that looks towards the target and the distractor during the BS window did not show a significant difference, with a Signed Rank test result of $S = 21$, $p = 0.2102$. However, significant differences were observed in subsequent windows in the singular scene: S1 ($S = 41$, $p = 0.0082$), S2 ($S = 32$, $p = 0.0494$), and S3 ($S = 33$, $p = 0.0419$).

For the plural scene, the BS window showed a Signed Rank test result of $S = -16$, $p = 0.3490$, indicating no significant differences in looks towards the target and the distractor. In contrast, significant differences were detected in windows S1 ($S = 39$, $p = 0.0126$), S2 ($S = 50$, $p = 0.0006$), and S3 ($S = 37$, $p = 0.0203$). These findings suggest notable deviations from the null hypothesis during these windows.

The Linear Mixed Model, was conducted using the proportion of time spent looking at the target as the dependent variable, considering Condition, Scene, and Time and their two-way interactions and the three-way interaction, incorporating the information about repeated measures for each participant. To reduce the not relevant information, the backward selection method was used dropping the non-significative interactions. The selected model in the old group only contain the main effects: Condition, Scene

Table 45: Duration of looking time in Null Subject, older group, Catalan

Window	**Singular**		**Plural**	
Time	Target	Distractor	Target	Distractor
BS (0-6s)	2191 (96)	2095 (193)	2200 (125)	2236 (94)
S1 (6-12s)	2315 (58)**	2026 (295)**	2296 (78)*	2134 (214)*
S2 (12-24s)	2247 (132)*	2079 (246)*	2236 (87)***	2018 (150)***
S3 (24-30s)	2227 (174)*	2031 (162)*	2375 (92)*	2178 (303)*

and Time or Window. The model did not detect statistically significant differences between singular and plural across all windows and conditions ($F = 3.68$; $p = 0.0564$). Significant differences ($F = 4.96$; $p = 0.0270$) were detected when considering Condition (Full-DP and null-subject). Furthermore, statistically significant differences ($F = 18.23$; $p < 0.0001$) were observed in target looking time between windows, suggesting that infants spent significantly more time looking at the target than the distractor. Significant statistical differences ($t = -2.23$; $p = 0.027$) were identified in the proportion of fixation duration towards the target video and the distractor in between the Full-DP and Null-subject conditions.

The models unveiled substantial differences in fixation duration towards the target and the distractor across all Windows, in contrast to the baseline scenario. Noteworthy statistical differences ($t = -6.66$; $p < 0.0001$) were also observed in the proportion of target time between BS and S1. Additionally, significant statistical differences ($t = -4.51$; $p < 0.0001$) were found in the proportion of target looking time between BS and S2, and substantial statistical differences ($t = -6.1$; $p < 0.0001$) were observed in the proportion of target time between BS and S3.

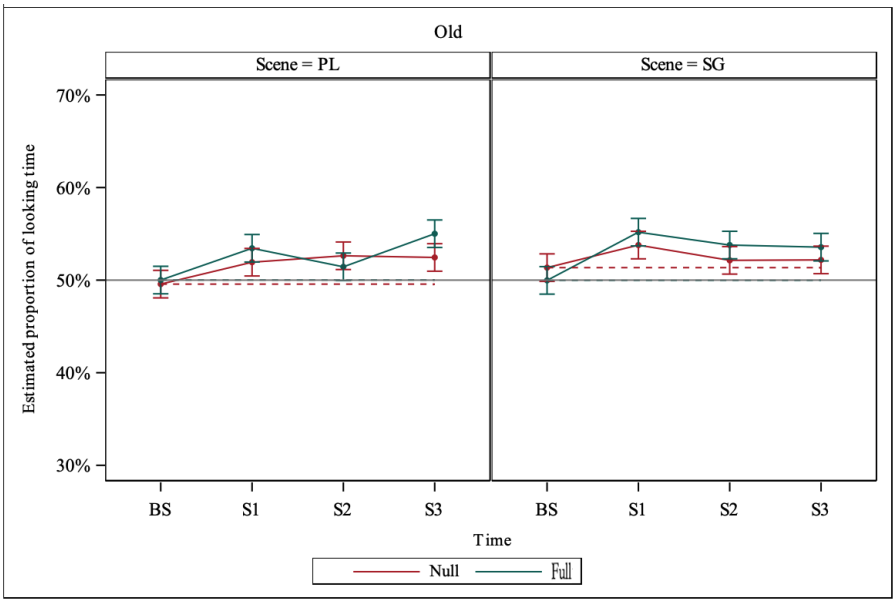


Figure 45: Estimated proportion of looking time full-DP and Null-subject, older group, Catalan

Younger group

I explored the fixation duration patterns in infants aged 1;2 to 2;1 (mean age 19.06 months) comprising a total of 15 recordings (see Table 4.3). The results are summarized in Tables (46) and (47).

The analysis of the full-DP data within the singular scene showed the following results: For the BS window, no significant differences were observed, with a Signed Rank test result of $S = -13$, $p = 0.4792$. Significant differences were detected in windows S1 ($S = 60$, $p < 0.0001$), S2 ($S = 60$, $p < 0.0001$), and S3 ($S = 58$, $p = 0.0002$).

Within the full-DP the plural scene, significant differences were observed in the BS window with $S = 40$, $p = 0.0215$, and $t = 2.64$, $p = 0.0193$. Additionally, significant differences were found in windows S1 ($S = 46$,

Table 46: Duration of looking time, Full-DP, younger group, Catalan

	Singular		Plural	
Window	Target	Distractor	Target	Distractor
BS (0-6s)	1883 (489)	1972 (597)	1976 (434)*	1794 (368)*
S1 (6-12s)	1947 (183)***	1417 (232)***	2405 (232)**	1855 (439)**
S2 (12-24s)	2466 (223) ***	1661 (171)***	2441 (143)***	1672 (315)***
S3 (24-30s)	2218 (154)***	1818 (278)***	1917 (232)***	1608 (187)***

Table 47: Duration of looking time, Null-subject, younger group, Catalan

Window	Singular		Plural	
Time	Target	Distractor	Target	Distractor
BS (0-6s)	1807(365)	1829(438)	1892 (438)	1765 (445)
S1 (6-12s)	1925(224)	1978(302)	2281 (577)*	1935 (482)*
S2 (12-24s)	2122(299)*	1891(181)*	2380 (263)*	2140 (423)*
S3 (24-30s)	2075(224)***	1502 (237)***	2021 (219)	1759 (330)

$p = 0.0062$), S2 ($S = 59$, $p = 0.0001$), and S3 ($S = 60$, $p < 0.0001$). These findings suggest notable deviations from the null hypothesis during these windows. The analysis unveiled significant differences in fixation duration at the linguistic target and distractor between both conditions.

Table 47 shows the mean looking duration spent on the null-subject condition in the younger group.

For singular items significant differences in the null-subject condition were observed in Window S2 ($S = 36$, $p = 0.0396$) and Window S3 ($S = 60$, $p < 0.0001$), with infants exhibiting significantly longer gaze durations at the target video during these periods. For plural items in the null-subject condition, statistically significant differences were observed in Window S1

($S = 42$, $p = 0.0143$), Window S2 ($S = 35$, $p = 0.0464$). To further explore the fixation duration differences, a generalized linear mixed model was constructed.

This model revealed statistically significant differences ($F = 22.38$, $p < 0.0001$) in the time spent on the proportion of looking time at the target video, considering the effect of Condition. Significant differences ($F = 16.11$, $p < 0.0001$) were also found considering the effect of time window. Additionally, significant differences ($F = 9.78$, $p < 0.0001$) were observed when considering the interaction between Condition and time window. There were significant differences ($F = 3.4$, $p = 0.0187$) in the time spent on the proportion of looking time at the target video condition when considering the interaction between singular and plural and time window.

No significant differences were detected between the singular and plural at any time point. Significant differences ($t = -4.73$, $p < 0.0001$) were found in the proportion of looking time between null-subject and full-DP, with an estimated difference in time spent on the proportion of looking time between null-subject and full-DP of -2.91, 95%CI = [-4.13, -1.7]. Significant differences ($t = -4.51$, $p < 0.0001$) were found in the proportion of looking time between BS and S1, (t = -6.49, $p < 0.001$) between BS and S2, and (t = -5.32, $p < 0.0001$) between BS and S3.

These findings indicate that even though fixation durations were generally longer in the full-DP condition, the null-subject condition still exhibited evidence of prolonged fixation durations among infants in the study. Figure (46) graphically illustrates these differences.

No statistically significant differences were detected between Scene singular and plural at any time or condition.

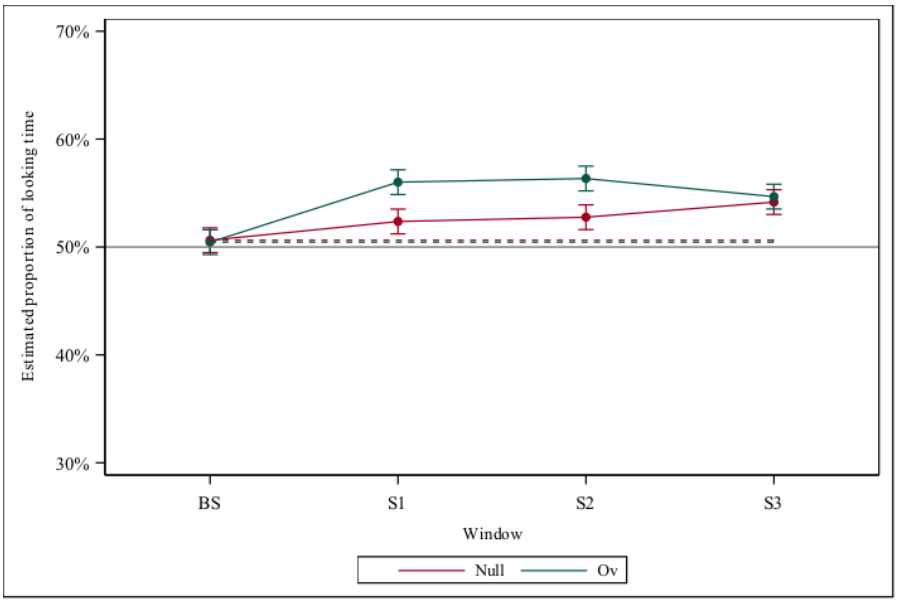


Figure 46: Estimated proportion of looking time in full-DP and null subj., younger group, Catalan

4.4 EXPERIMENT 2

Experiment 2 replicates the design and setup of experiment 1 in German. The only difference lies in the verbal stimuli. Hence, for experiment 2, I designed new German experimental sentences resembling the ones used in experiment 1. Thus, the structure included a familiarisation phase, the introduction and the experimental phase.

Method

German being a non-null subject language, in this experiment I present to the pronominal *Sie* as subject, as done in previous work (Brandt-Kobele & Höhle, 2010).

Design and material

I tested sentences like those in examples (57) to (59) with both full-DP subjects and pronominal subjects using the pronoun *Sie*, homophonous between 'she' and 'they'. The verbs were either inflected for 3rd person singular (*-t*) or 3rd person plural (*-n*), providing the number variation in the experimental design. The noun phrases, as in experiment 2, referred to highly frequent animals in German storytelling (a cow, a dog, a pig, a sheep, and a wolf), all refered to as 'puppet' in the experimental phase. A total of 8 target items (four for each condition) were constructed as listed in Appendix (i). Each sentence was associated with a synchronized pair of videos depicting the puppet characters carrying out an action.

(57) Die Puppe tanzt.
ART.NOM.SG puppet.NOM.SG tanzen.PRS.3SG
'The puppet dances.'

(58) Sie tanzt.
PRON.NOM.SG tanzen.PRS.3SG
'It dances.'

(59) Die Puppen tanzen.
ART.NOM.PL puppet.NOM.PL tanzen.PRS.3PL
'The puppets dance.'

(60) Sie tanzen.
PRON.NOM.PL tanzen.PRS.3PL
'They dance.'

The structure of the experiment contained three parts. First, in the familiarisation phase, in which only one puppet was presented at a time, five puppets later used in the experimental trial were introduced in the same

way, *Schau, das ist ein Hund, eine Kuh, ein Schwein, ein Schaf, ein Wolf*, 'Look this is a dog/a cow/a pig/a wolf'. Second, the introduction phase, in which two puppets were shown at the same time, aimed to trigger higher involvement of the participant; the participant was exposed to sentences asking for one of the actors represented in the two simultaneously showing videos, like e.g. *Wo ist der Hund?* 'Where is the dog?'. In the experimental phase, all subject-verb combinations were presented in both number conditions, yielding eight test trials. All practice and test sentences are provided in the Appendix (see i).

Two disyllabic verbs were used *tanzen* 'to dance' and *spielen* 'to play'. The criteria for verb selection were that the actions would be depictable, the verbs and actions be known to German infants, and the verbs contained two syllables when inflected in the plural. The latter criterion was included to avoid verbs with more than two syllables. Each verb was combined with a subject in singular or plural, *die Puppe* 'the puppet', *die Puppen* 'the puppets'. All verbal stimuli were recorded by myself, a female native speaker of German, in a child-directed manner. The mean length of sentences was 1920 ms, ranging from 1480 ms to 2360 ms. The recording was conducted in a sound-attenuated recording studio, recorded and digitized at 44.1 kHz, mono-channel. I edited the recordings using Praat (Boersma & Weenink, 2007).

For each sentence and each number condition, a simple coloured video of the described situation was created. The two videos used for a pair of sentences only differed with respect to the number of actors accomplishing the action denoted by the verb. In the 1-actor video, only one puppet performed the action mentioned in the sentence (e.g., one puppet was dancing). In the 2-actor video, two puppets performed the same action together (e. g., two puppets were dancing). The resulting materials were the same as those used for experiment 1 and illustrated above.

Participants

A total of 22 infants were tested (10 male and 12 female). Due to low (under 50%) gaze fixation, I discarded three recordings [2]. The age range of the participants included in the analysis is 17.5 to 22 months, with a mean age of 19 months (10 female and 9 male) . Infants were recruited in the area of Potsdam and had no reported history of speech, hearing or language disorders. All children were natively only exposed to German, and were not born prematurely. Parents were asked to complete a control questionnaire to verify the main language spoken at home, and also signed a consent form for their infants to participate in the study.

Procedure

The same procedure as in Study 2, experiment 1 (Catalan) was used.

Data analysis

In the analysis, participants were considered as a single group since their ages were closely matched. Nineteen participants were analyzed. The analysis against chance level was conducted using the Wilcoxon signed-rank test to compare the performance of tested conditions against baseline performance. To examine eye gaze patterns, statistical analyses involving Linear Mixed-Effects Models (LMMs) for total fixation duration were used. In the full model, fixed effects included Scene (Singular vs. Plural) and Condition (Full DP vs. Pronominal Subject) and their interactions; random effects included random intercepts for participants (Baayen et al., 1997).

2 The initial extraction of eye-tracking data was performed to determine the completeness of the signal. According to our protocol, any recording where the total signal was lower than 50% was excluded right from the initial phase of data processing. This threshold was set based on standards from previous studies, which have demonstrated that less than 50% signal reliability can significantly compromise the validity of eye-tracking data (Holmqvist, 2011; Tobii Technology, 2015; Wass et al., 2013)

Results

The analysis of fixation durations revealed the following significant findings. Initially, at the outset of the experiment, at the baseline, no statistically significant differences in fixation durations singular and plural full-DP scenes were observed (S = 43, p = 0.0874), (S = -42, p = 0.0955), respectively.

During the presentation of the full-DP within the singular scene, significant differences in fixation durations were observed. In Window S1, significant differences were noted ($S = 51$, $p = 0.0401$; $t = 2.42$, $p = 0.0263$). Window S2 also showed significant differences ($S = 56$, $p = 0.0230$; $t = 2.71$, $p = 0.0143$). In Window S3, significant differences were detected ($S = 89$, $p < 0.0001$; $t = 5.35$, $p < 0.0001$). During the presentation of the full-DP within the plural scene, significant differences in fixation durations were observed. In Window S1, significant differences were noted ($S = 54$, $p = 0.0289$; $t = 2.35$, $p = 0.0302$). Window S2 exhibited significant differences ($S = 94$, $p < 0.0001$; $t = 6.40$, $p < 0.0001$). In Window S3, significant differences were observed ($S = 83$, $p = 0.0003$; $t = 4.93$, $p = 0.0001$).

These findings suggest notable deviations in fixation durations within both singular and plural scenes across different windows for full-DP structures. The results are given in Table 48.

Table 48: Duration of looking time (ms), full-DP, German

	Singular		Plural	
Time	Target	Distractor	Target	Distractor
BS(0-6s)	2262 (402)	2123 (331)	2310 (351)	2545 (377)
S1(6-12s)	2569 (238)*	2316 (383)*	2534 (300)*	2223 (479)*
S2(12-24s)	2495 (282)*	2182 (479)*	2738 (181)***	2206 (289)***
S3(24-30s)	2525 (189)***	1999 (405)***	2690 (204)***	2117 (409)***

In the singular pronoun condition, at the baseline, no statistically significant differences in fixation durations were observed ($S = 21$, $p = 0.4122$; $t = 1.07$, $p = 0.3006$). During singular scene in S1, significant differences in fixation durations were noted ($S = 67$, $p = 0.0053$; $t = 3.31$, $p = 0.0039$). As the experiment progressed into Window S2, significant differences in fixation durations were observed ($S = 88$, $p < 0.0001$). However, during Window S3, no significant differences in fixation durations were identified ($S = -10$, $p = 0.7086$; $t = -0.72$, $p = 0.4780$).

Within the plural pronoun condition, the BS window did not show a significant difference, with a Signed Rank test result of $S = 5$, $p = 0.8596$; $t = 0.20$, $p = 0.8404$. Similarly, the S1 ($S = -15$, $p = 0.5678$; $t = -0.54$, $p = 0.5948$) and S2 ($S = 27$, $p = 0.2935$) windows did not exhibit significant differences. However, the S3 window showed a significant difference, with a Signed Rank test result of $S = 68$, $p = 0.0046$. This indicates a notable departure from chance during the S3 window.

These findings suggest that gaze behavior in the pronoun condition varied significantly at different points during the experiment, particularly in the plural scene during the S3 window. The results of the pronominal condition are reported in Table 49.

Table 49: Duration of looking time, Pronominal subject, German

	Singular		Plural	
Time	Target	Distractor	Target	Distractor
BS(0-6s)	2385 (243)	2331 (251)	2334 (405)	2311 (438)
S1(6-12s)	2632 (175)**	2380 (252)**	2413 (410)	2445 (301)
S2(12-24s)	2632 (235)***	2228 (167)***	2511 (415)	2327 (236)
S3(24-30s)	2277 (516)	2384 (285)	2409 (355)**	2064 (459)**

Figure 47 shows the evolution of the proportion of looking time across the different time windows in the Full-DP and Pronominal subject condition for singular and plural.

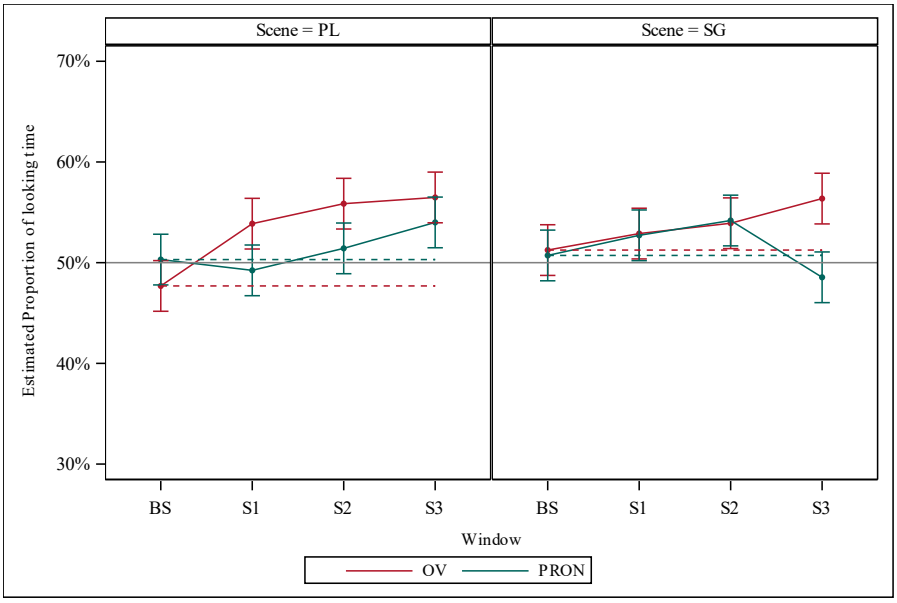


Figure 47: Estimated proportion of looking time in full-DP and pronominal subject conditions for singular and plural, German

In this study, I employed a Linear Mixed-Effects Model (LMM). This statistical approach allowed for examining fixation durations across different experimental conditions and windows. The analysis focused on the mean fixation duration toward the target and distractor during the full-DP and pronoun conditions within both singular and plural scenes across different experimental during baseline, Window S1, Window S2, and Window S3.

During the presentation of the full-DP sentences in the plural scene the model detected statistically significant differences between baseline and Window S1 ($t = -3.54$; $p = 0.0388$), Window S2 ($t = -4.68$; $p = 0.0005$), and Window S3 ($t = -5.03$; $p = 0.0001$). These differences indicated that par-

ticipants spent significantly more time looking at the target scene than the distractor scene in Windows S1, S2, and S3 compared to the baseline. Additionally, statistically significant differences were observed in the proportion of target time between baseline and Window S1 ($t = -3.17$; $p = 0.0360$), Window S2 ($t = -4.39$; $p = 0.0004$), and Window S3 ($t = -5.63$; $p < 0.0001$) for full-DP structures. These differences indicated that participants spent significantly more time looking at the target scene than the distractor scene in Windows S1, S2, and S3 compared to the baseline.

When comparing the full-DP and pronoun conditions, the following was detected: in the singular scene during Window S3, statistically significant differences were found in the proportion of looking time at the target between the full-DP and pronoun conditions ($t = 4.48$; $p = 0.0012$). In the full-DP condition there was a higher proportion of time looking at the target than in the pronoun condition. These findings suggest that participants fixated more on the target scene in the full-DP condition than on the pronoun condition during Window S3 in the singular condition. Finally, in Window S3, statistically significant differences were found in the proportion of looking at the target between the full-DP and pronoun conditions ($t = 4.17$; $p = 0.0011$). In the full-DP condition there was a higer proportion of looking time at the target.

As shown in Figure 47, the analysis reveals that in the baseline for the pronominal plural condition, the 95% confidence interval for the target time contained the value 50%, indicating that participants spent roughly equal time looking at the target and distractor scenes. No statistically significant differences were detected between full-DP and pronominal conditions on the same windows.

Figure 48 merges singular and plural estimated looking times and shows the behaviour across the different time windows and conditions.

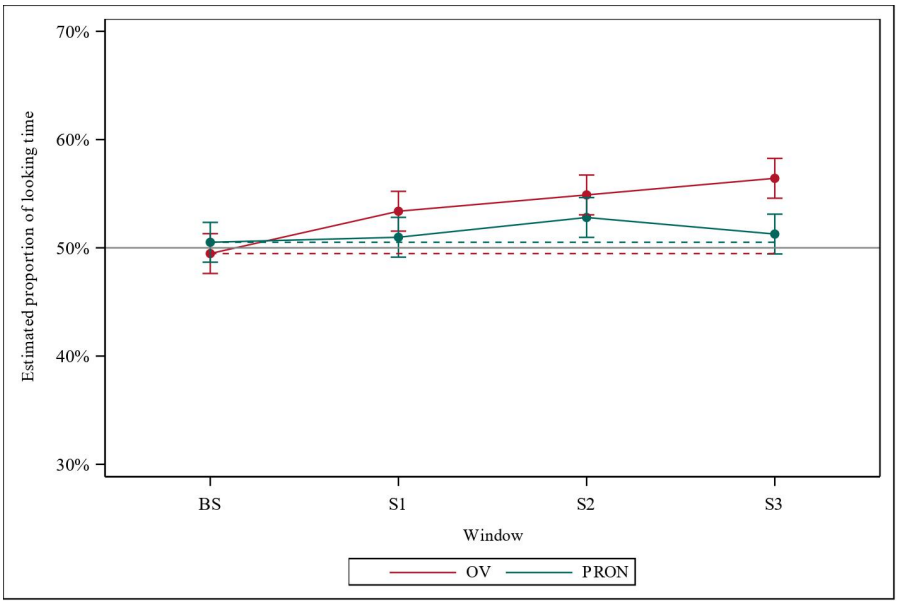


Figure 48: Estimated proportion of looking time in full-DP and pronominal subject conditions merging singular and plural, German

4.5 ANALYSIS ON THE PROPORTION OF LOOKING TIME TO TARGET IN CATALAN AND GERMAN

The statistical analysis was conducted using SAS v9.4, provided by SAS Institute Inc., Cary, NC, USA, with a significance level set at 0.05 for all statistical decisions. This analysis builds upon the previous analyses of Experiments 1 and 2 from Study 2, critically examining looking time to the target across languages, conditions, scenes, and time windows. For each language, condition (full-DP, null-subject, pronominal-subject), scene (singular, plural), and time window (BS, S1, S2, and S3), descriptive statistics, including mean and Standard deviation (SD), were computed.

The statistical analysis is organized into two primary comparative analyses: Full-DP in Catalan versus German and Null-subject in Catalan com-

pared to Pronominal-subject in German. Mann-Whitney-Wilcoxon tests were employed to assess the percentage of looks at the target video across the two languages for each condition, supplemented by t-tests in instances of confirmed data normality. In cases where no statistically significant differences are detected between the percentage distribution and the normal distribution, the parametric t-test (Student's t-test) for the Target Time percentage according to Language is also presented. The windows S1, S2, and S3 were consolidated to evaluate the mean fixation time as a unified measure across these intervals, thus bypassing the exploration of variance between individual time windows and considering it one joint Time window (TW). An examination of the time spent viewing each video confirmed that all participants maintained focus on the Region of Interest (ROI) (Target or Distractor) for at least 55% of the total time (24 s * 8 * 0.55 = 105.6 s). The analysis revealed that the minimum viewing time for a child was 115.5 s, surpassing the 105.6 s benchmark, which represents 55% of the total allocated viewing time for each child.

Results

Full-DP in Catalan versus in German

First, for each child, condition, language, window (BS, S1, S2, and S3), scene, and response, the following calculations were made: the average time spent looking at the two videos; in BS, as well as the average viewing time in Windows S1, S2, and S3 for the two videos; the average percentage of target (or distractor) in relation to the total looking time. Table 50 presents the basic descriptive statistics. This report examines the statistical significance in the duration of looking time (Target) between Catalan and German for each Scene and Window using the non-parametric Mann-Whitney-Wilcoxon test and the parametric Student's t-test.

Statistically significant differences were detected during the baseline but not during the TW. In the BS window during the plural scene, statistically

Table 50: Duration of looking mean time-based (ms) on Full-DP, Catalan vs. German

		Singular		Plural	
Language	Time	Target	Distractor	Target	Distractor
Catalan	BS	2000 (382)	2043 (438)	2041 (323)	1946 (312)
Catalan	TW	2210 (82)	1750 (152)	2241 (91)	1830 (215)
German	BS	2262 (402)	2123 (331)	2310 (351)	2545 (377)
German	TW	2530 (132)	2166 (324)	2654 (133)	2182 (264)

significant differences were detected ($S = 338$; $p = 0.0102$) in the proportion of looking time to target time between Catalan and German. It was observed that in Full-DP, BS, PL videos, the mean proportion spent on the target time in Catalan is 51.3% and in German is 47.7%. In the BS window during the singular scene, statistically significant differences were detected ($S = 562$; $p = 0.0487$) in the proportion of looking time to target time between Catalan and German. It was observed that in Full-DP, BS, SG videos the mean proportion of looking time to target in Catalan is 49.6% and in German is 51.3%. No significant differences were detected during the test windows for either the plural or singular scenes. Catalan and German show both higher proportion on the time spent looking at the target video than the distractor.

Figure 49 displays the distribution of the percentage of looking time towards target and distractor videos across Catalan and German under the Full-DP condition.

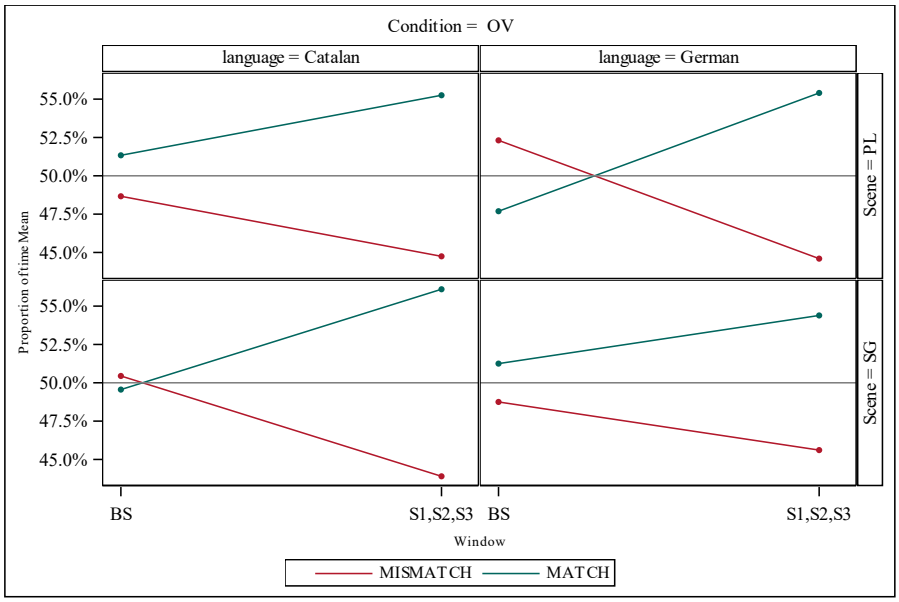


Figure 49: Average % of Target and Distractor, Catalan vs. during Full-DP, German and Catalan

For Catalan, the mean looking time at the target video is higher during the stimuli exposure period (S1, S2, and S3) than in to the BS window. In contrast, for German, a more pronounced mean looking time at the distractor condition is observed in the BS window. No statistical differences for looking time at the target have been detected during the experimental sentence presentation, showing similar processing in the full-DP condition for both singular and plural scenes for infants exposed to Catalan and German.

Null-subject in Catalan compared to pronominal-subject in German

The results[3] indicated a departure from normality in the Catalan plural data during the baseline (BS) window ($W = 0.87$; $p = 0.0021$) and the subsequent windows (S1, S2, S3) ($W = 0.86$; $p = 0.0012$). Conversely, the Catalan singular, German plural, and German singular data did not significantly deviate from a normal distribution in any of the observational windows, with p-values well above the conventional alpha level of 0.05. This suggests that the distribution percentages of looking time for these groups were consistent with normality.

Following the normality assessment, both non-parametric and parametric tests were employed to determine any statistically significant differences in the looking time to target videos between Catalan and German subjects. The direct comparison of null-subject and pronominal conditions is shown in Table 51.

Table 51: Duration of Looking Time (ms), Null subject /Pronominal subject, Singular and Plural, Catalan and German

		Singular		Plural	
Language	Time	Target	Distractor	Target	Distractor
Catalan (NULL)	BS	1992 (330)	1958 (363)	2040 (358)	1992 (401)
Catalan (NULL)	TW	2148 (166)	1914 (193)	2264 (196)	2024 (237)
German (PRON)	BS	2385 (243)	2331 (251)	2334 (405)	2311 (438)
German (PRON)	TW	2514 (170)	2331 (159)	2445 (198)	2278 (192)

3 The statistical analyses, encompassing both non-parametric and parametric tests, did not detect any statistically significant differences in the target time percentages between Catalan and German participants across all observed scenes and windows. This suggests that, within the scope of this study, language processing as measured by percentage looking time was not influenced by the linguistic differences inherent to the Catalan (null subject) and German (pronominal subject) plural conditions.

The non-parametric Mann-Whitney-Wilcoxon test was utilized to analyze the distributions of looking time between the two languages, focusing on their application in different scenes (plural and singular) and across various windows (BS and S1, S2, S3). The findings from this test indicated that there were no statistically significant differences in the distributions across the examined scenarios. Specifically, for the plural scene within the BS window, the test statistic was $S = 473.00$ with a p-value of 0.8833. When examining the plural scene across the S1, S2, and S3 windows, the test statistic stood at $S = 421.00$, accompanied by a p-value of 0.3583. For the singular scene within the BS window, the statistic was $S = 486.00$ with a p-value of 0.6752, and for the singular scene across the S1, S2, and S3 windows, the statistic was $S = 403.00$, with a p-value of 0.1975. These findings indicate that the distributions of looking time were similar for both Catalan and German participants, with no evidence to suggest a language effect in any scene or observational window.

In cases where the Shapiro-Wilk test confirmed the assumption of normality, the parametric Student's t-test was conducted to compare the means of looking between languages. The application of the Student's t-test did not reveal any statistically significant differences at the conventional alpha level of 0.05. Specifically, within the singular scene for the BS window, $t = -0.18$ with equal variances resulting in $p = 0.8613$. Similarly, for the singular scene across the S1, S2, and S3 windows, the analysis yielded $t = 1.49$ with equal variances, producing $p = 0.1427$. These findings indicate that the differences in the means of looking time between languages were not statistically significant in the evaluated scenarios. Figure 50 illustrates looking time proportions towards target and distractor stimuli across the two distinct linguistic conditions examined here, the Null-subject for Catalan and the pronominal condition for German, over BS and S1, S2, S3.

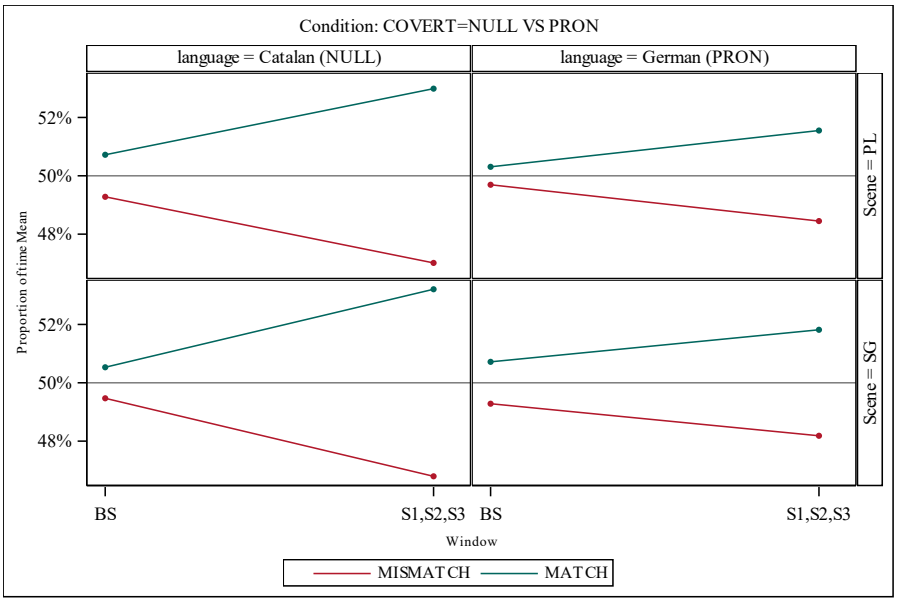


Figure 50: Average Response Times, Catalan vs. German

4.6 DISCUSSION

For infants with a mean age of 20.4 months exposed to Catalan, eye-tracking techniques revealed their ability to parse subject-verb agreement in null-subject sentences, identifying them as the youngest group documented to exhibit such syntactic abilities. In non-null subject languages like German, equivalent outcomes require masked subjects, though specific data for infants within our considered age were not available prior to my results.

The comparison between Catalan and German highlights the consistency of syntactic agreement processing across linguistic backgrounds despite language-specific properties. This consistency supports broader research suggesting that parsing under-performance often results from task demands rather than deficits in syntactic processing. The literature review disputes the idea that child grammar is incapable of computing syntactic agreement,

backed by evidence of infants' preverbal awareness of abstract syntax, including word order and inflection (Andreu et al., 2013; Nazzi et al., 2011; Perkins & Lidz, 2021). Further supporting the importance of task demands, Durrleman et al. (2016) explored the effects of syntactic complexity on the comprehension of wh-questions and other structures in children; they found that difficulties in parsing are often attributable to task demands rather than intrinsic deficiencies in syntactic understanding. This finding aligns with the findings of Gonzalez-Gómez et al. (2017) on subject-verb agreement in Spanish. Additionally, Brandt-Kobele and Höhle (2014) found similar syntactic processing capabilities in German-speaking children aged three to five years. Furthermore, there is evidence from processing studies also converging on the idea that subject-verb agreement is early (Phillips, 2010). This evidence reinforces the idea that the ability to process syntactic agreement is a robust feature of child grammar, unaffected by specific language properties.

Reflecting on the outcomes of Experiments 1 and 2 from Study 2, it is evident that infants can parse subject-verb agreement early in their linguistic development. This capability transcends individual languages, suggesting a universal cognitive mechanism underpinning syntactic development. These findings contribute significantly to the ongoing debate regarding the timing and nature of parameter setting in early language acquisition. Specifically, the ability of 20.4-month-old infants to parse subject-verb agreement in Catalan, a null-subject language, and the comparable performance of children in German, a non-null-subject language, indicate that parameter setting for agreement features occurs very early in development (Wexler, 1998). Moreover, in relation to the minimalist framework, the infants' ability to process subject-verb agreement suggests that the Agree operation, which checks and matches features between subjects and verbs, is operational at a very young age. The consistency of syntactic agreement processing across different languages, as observed in our comparison between Catalan and German, supports the idea of a universal grammar underlying all human languages (Crain & Lillo-Martin, 1992). This universality implies that infants, regard-

less of their linguistic environment, are equipped with the tools necessary to acquire complex syntactic structures.

The observed early parsing of subject-verb agreement also has implications for our understanding of the optional infinitive (OI) stage. This stage, characterized by children's occasional use of non-finite verbs in contexts where finite verbs are required. Top account for it, Wexler (1998) proposed the Unique Checking Constraint (UCC), a constraint subject to maturation that limit's the children's feature checking (or feature elimination) abilities. My findings indicate that, while the derivation of Tense and Agreement in the non-null subject languages may be subject to the UCC, children and infants are in full command of the inflectional system (as in fact argued by Wexler 1998). Furthermore, their computational limitations do not appear to interfere with the parsing of the subject-verb agreement of finite verbs.

5

CONCLUSIONS

The primary objective of this thesis was to investigate the early acquisition of subject-verb agreement in null and non-null subject languages, exemplified in Catalan and German. This study focused on infants aged between 17 and 19 months and children aged 3 to 6 years, aiming to understand the early parsing of subject-verb agreement through both offline and online methodologies.

The first study involved two experiments using sentence-picture matching tasks with children aged 3 to 6 years. Experiment 1 replicated the study by Pérez-Leroux (2005), focusing on parsing of number (singular, plural) and sentences with full-DP and null subjects among Catalan-speaking children. A total of 111 children (age range: 2;4–6;9) and 62 adults participated in a sentence-picture matching task. Results showed that performance was above chance for all conditions except the singular, null subject where children were at chance. Experiment 2 introduced a numeral distractor to the same experimental design. Performance was above chance for all conditions and age groups. These results corroborate the impact of methodological differences on the parsing of subject-verb agreement, as noted by Brandt-Kobele and Höhle (2010) and Gonzalez-Gómez et al. (2017). The findings suggest that the observed delays in the parsing of agreement in different studies on different languages (Johnson et al., 2005; Legendre et al., 2014; Pérez-Leroux, 2005) among others, are not due to a lack of grammatical knowledge, echoing findings by Gonzalez-Gómez et al. (2017) in Spanish-speaking children and similar patterns observed in German (Brandt-Kobele & Höhle, 2010), but rather due to experimental factors.

The second study included two experiments employing the Preferential Looking Paradigm to analyze the early acquisition of subject-verb agreement in infants. Experiment 1 measured gaze duration while infants listened to sentences with full-DP and null subjects in Catalan. The results showed a significant looking preference for the target, indicating that infants as young as 19.3 months can effectively parse subject-verb agreement in Catalan. Experiment 2 extended this paradigm to German, analyzing sentences with full-DP and pronominal subjects. Pronominal subjects introduced ambiguity through the pronoun *Sie* 'she/they', forcing infants to rely on the verb to identify the subject. Gaze duration analysis revealed significantly longer looks at the target in the full-DP and the pronominal conditions. These findings demonstrate that infants exhibit early syntactic competence in parsing subject-verb agreement. The results indicate that the overall trajectory of agreement acquisition is similar across languages, whether infants are acquiring a null-subject or a non-null-subject grammar. The statistical comparison of experiment 1 and 2 showed no significant differences between the results of the Catalan and German infants. In addition no significant differences have been detected in the proportion of gaze duration to target in singular and plural conditions.

The Minimalist Program, as proposed by Chomsky (1995, 2000b), seeks to explain language acquisition and syntactic structure through the simplest and most economical means. Central to this program is the operation Agree, which is responsible for establishing feature agreement between elements within a syntactic structure. Agree involves a probe (an element with unvalued and uninterpretable features) searching its c-command domain for a goal (an element with matching interpretable and valued features) to value its features (Chomsky, 2000b, 2001; D'Alessandro, 2019; den Dikken, 2011; Smith et al., 2020). The experiments described in the thesis involved scenarios where infants had to compute agreement based solely on verb cues, either in the absence of explicit subjects (as in Catalan) or with hidden subjects using pronouns (as in German). These conditions provided a robust

test of the infants' ability to use the Agree operation effectively. The successful parsing of subject-verb agreement suggests that the Agree operation is functional at a very young age.

While Agree is a universal operation, the feature values that make it operate are language specific. Not all languages dsiplay subject-verb agreement in number and person features, like Catalan and German do. Therefore, these feature values must be learned. Likewise, the null subject vs. non-null subject character of a language must be acquired by the child based on exposure to the language of the environment. In null-subject languages like Catalan, the parameter that allows for subject omission is set through the interaction of features via Agree. The verb morphology alone provides sufficient cues for the child to establish subject-verb agreement. In the experiments conducted as part of this thesis, Catalan-speaking infants were exposed to sentences where the subject was omitted. Despite the absence of an explicit subject, infants as young as 17 months were able to correctly parse the subject-verb agreement based solely on the verb's morphology. In non-null-subject languages like German, the presence of an explicit subject is required. The experiments involved presenting German-speaking infants with sentences where the subject was hidden using the pronoun *sie* (she/they). The infants had to rely on the verb to compute agreement features. The results demonstrated that German-speaking infants as young as 16 months could parse subject-verb agreement effectively.

Very Early Parameter Setting

The early parsing abilities observed in this study align closely with Wexler's (1998) VEPS model. Wexler's model posits that children set grammatical parameters very early in development, often before they can fully produce the relevant structures. According to Wexler, these parameters are innately specified and their feature values can be set rapidly upon exposure to sufficient linguistic input. The findings of the thesis provide direct support

for this model, demonstrating that infants possess the competence to parse subject-verb agreement well before the age typically associated with extensive syntactic production. Baker's (2001, 2008a) Hierarchical Acquisition model is consistent with my findings. Baker's model suggests that children set parameters in a specific hierarchical order, with some parameters being set very early in the acquisition process. The early ability to parse subject-verb agreement fits Baker's concept of a hierarchical structure where certain grammatical properties are foundational and established early. This model accounts for the early establishment of subject-verb agreement, which serves as a basis for further syntactic development.

Additionally, the discussion of null and non-null subjects within the Optional Infinitive Stage Hypothesis is particularly relevant. According to the Optional Infinitive Stage Hypothesis, children go through a stage where they optionally omit tense and agreement markers, leading to the use of non-finite verbs in contexts where finite verbs would be expected Wexler (1994a). This stage is characterized by the production of sentences that lack tense marking or subject-verb agreement. The findings in this thesis show that even within this stage, children can parse subject-verb agreement, suggesting that the underlying grammatical knowledge is already present and operational. In non-null subject languages like German, where subjects must be explicitly stated, children's early parsing abilities further demonstrate that they have already internalized the necessary grammatical rules for subject-verb agreement, even if they omit tense and agreement marking when producing OIs.

The rapidity with which infants demonstrate parsing abilities challenges the core assumption of Yang's Variational model, which emphasizes a gradual, input-driven process of parameter setting based on statistical properties of the input. Yang's (2002, 2004) Variational model posits that parameters are set through competition among different grammars, with the correct parameter value emerging gradually as the child is exposed to more input. According to Yang, this model relies heavily on the frequency and distribution

of linguistic structures in the input data. The idea is that children entertain multiple hypotheses about grammatical structures, and the correct hypothesis gains strength over time as it is reinforced by the input. However, the findings of the thesis indicate a different scenario. The ability of infants as young as 19 months to parse subject-verb agreement suggests that children are not merely relying on statistical frequency to gradually converge on the correct parameter setting. Instead, the rapid acquisition observed implies that children are equipped to set parameters very early in development.

KEY FINDINGS

The following research questions were formulated at the beginning of the study.

1. Research question: Can young children parse subject-verb agreement?
2. Research question: In the absence of subject-verb agreement parsing, do children's responses resemble chance-level performance?
3. Research question: Does the ability to parse subject-verb agreement differ across sentence types? For example, do children show higher accuracy with full DP subjects, indicating that number markers in the subject are necessary for the child to identify number?
4. Research question: Do older children demonstrate higher accuracy, suggesting that acquiring subject-verb agreement is a developmental process that improves with age and linguistic experience?

Research question 1: Can young children parse subject-verb agreement?

In my first research question I aimed to answer whether young children can parse subject-verb agreement. The hypothesis posited that children who have acquired subject-verb agreement would demonstrate a significantly

higher correct response rate and longer fixation duration on target compared to those who have not.

In Study 1, experiment 2 showed above chance performance across all conditions including null-subject singular where children of experiment 1 seemed to have failed. These results indicate a clear difference of the performance of Experiment 1 and 2, indicating that children in Experiment 2 can parse agreement accurately and that the experimental design might affect the performance in the Experiment 1. In Study 2, the results were more revealing, as infants also showed significant deviations from chance performance in fixation durations to the target for both singular and plural forms ($p < .0001$), both in Catalan and German.

Therefore, these results support the idea that the ability to parse subject-verb agreement is present from a very young age.

Research question 2: In the absence of subject-verb agreement parsing, do children's responses resemble chance-level performance?

With respect to research question 2, it was hypothesized that, if children had no knowledge of subject-verb agreement, we would predict chnace performance. While the hypothesis may hold, for none of the age groups tested have I found systematic chance performance.

In Study 1, Experiment 1, children's performance in the null-subject singular condition did not significantly deviate from chance, suggesting some level of difficulty. However, Experiment 2 showed statistically higher performance across all conditions, including the null-subject singular condition, indicating that children's responses were not random and were likely influenced by the experimental design. In Study 2, both experiments (Catalan and German) demonstrated that even the youngest participants performed above chance level, including in conditions where explicit subject-verb agreement cues were less evident. This suggests that children's responses were consistently better than chance, reflecting a sensitivity to gram-

matical cues. These findings challenge the hypothesis that infants might perform at chance level without explicit parsing of subject-verb agreement. Overall, the results highlight that children's syntactic competence is more nuanced and developed than previously thought.

Research question 3: Does the ability to parse subject-verb agreement differ across sentence types?

The third research question aimed to determine if children's ability to parse subject-verb agreement differs across sentence types and if explicit number markers are necessary for accurate number identification.

In study 1 both experiments demonstrated that children exhibited higher accuracy with full DP subjects compared to null-subjects. In Experiment 1, children aged 3-4 showed better performance in the full-DP condition relative to the null-subject condition. Significant differences were observed between null-subject singular and full-DP plural ($t = -6.92$, $p < 0.0001$), and between null-subject singular and full-DP singular ($t = -6.32$, $p < 0.0001$). The 5-6-year-old group exhibit a more stable response across conditions. Experiment 2 reinforced these findings with high accuracy for both full-DP singular ($p < .0001$) and plural conditions ($p < .0001$), but above chance performance on all conditions.

In study 2, overall the findings consistently indicate that the ability to parse subject-verb agreement is higher with full DP subjects but above chance also in the null-subject condition and different linguistic contexts, with both Catalan and German infants showing high performance across conditions and no statistical difference among these languages. The results from Study 2 showed higher performance when subjects were full DP subjects, but on the other hand infants were able to parse subject-verb agreement without full DP subjects.

In some previous studies it was also argued that differences emerged between first/second/third person or singular/plural, with performance in-

fluenced by factors such as speaker intent and situational context (Forsythe & Schmitt, 2021; Smolík & Bláhová, 2016). Focusing on number, (Smolík & Bláhová, 2016) found that comprehension of verb number morphemes in Czech children shows different relations to age and vocabulary for singular and plural forms. Their research indicates that singular forms are typically acquired earlier than plural forms and that these differences are influenced by vocabulary size and age. They also discuss the pragmatic implications of these findings, noting that apparent errors in parsing may often result from pragmatic limitations rather than deficits in syntactic knowledge. This supports the broader view that task demands and contextual factors play a substantial role in shaping syntactic performance, reinforcing the notion that syntactic comprehension is robust even in the presence of these variations. The discrepancy between my findings and those of (Smolík & Bláhová, 2016) may be attributed to differences in experimental design. The eye-tracking methodology used in my research provides a more direct and continuous measure of infants' processing abilities compared to the picture selection tasks employed by Smolik and Bláhová. Eye-tracking allows for the capture of real-time processing and can reveal infants' immediate responses to syntactic cues, thereby offering a more sensitive measure of their syntactic comprehension. Additionally, my findings align with other research demonstrating early syntactic awareness. They underscore the importance of considering methodological approaches when interpreting differences in syntactic acquisition. The findings of study 2, highlight that even at 20.4 months, infants are capable of parsing both singular and plural forms in subject-verb agreement, challenging the notion that significant differences exist between these forms due to age and vocabulary size. In conclusion, while (Smolík & Bláhová, 2016) provide valuable insights into the pragmatic factors influencing syntactic performance, my study offers compelling evidence that infants' parsing of subject-verb agreement, including both singular and plural forms, is more uniform and developed than previously thought. This emphasizes the robustness of syntactic parsing mechanisms in early language develop-

ment. The pragmatic effects seem not to be found with techniques such as eye-tracking, although they are found in experimental work with more traditional methods (and older children).

Research question 4: Do older children demonstrate higher accuracy, suggesting that acquiring subject-verb agreement is a developmental process that improves with age and linguistic experience?

In the studies reported, age affects were found. However, even for the youngest group of infants, there was evidence of subject-verb agreement parsing.

In study 1, Experiment 1, older children (5-6 years) showed significantly higher accuracy compared to younger children (3-4 years) across both full-DP and null-subject conditions. The GLMM analysis confirmed that age significantly affected the number of correct responses ($F = 10.41$; $p = 0.0015$). Experiment 2 supported these findings, with older children outperforming the younger group. Significant differences were observed in both singular and plural forms in the full-DP condition. In the null-subject condition, significant differences were detected between singular and plural forms for both age groups, with older children showing higher accuracy ($p < 0.05$). In study 2, Experiment 1 (Catalan), the GLMM analysis confirmed that age significantly affected fixation durations, with older infants spending more time looking at the target scene. Experiment 2 (German) only included one age group, so it could not contribute to answering research question 4.

In conclusion, the findings from both studies, with the exception of Study 2, Experiment 2, support the notion that the ability to parse subject-verb agreement improves with age. However, it is noteworthy that this ability is also detected in the youngest test group, as early as 17 months.

FUTURE DIRECTIONS

To further substantiate these findings, future research should expand the linguistic diversity of study samples. Incorporating languages with markedly different agreement systems from Catalan and German would provide a more comprehensive understanding of early language acquisition processes. Specifically, investigating gender agreement in languages of the Semitic family, and object agreement in languages of the Bantu family, could provide valuable data on the generalizability of these findings.

Employing eye-tracking technology to study young children learning these languages could reveal how early cognitive mechanisms support the acquisition of complex agreement systems. This approach is expected to show that children, even at a young age, are adept at parsing and understanding agreement features, supporting the hypothesis that these cognitive mechanisms are universally applicable. Cross-linguistic studies, augmented with EEG techniques or eye-tracking could offer deeper insights into the interplay between cognitive mechanisms and the acquisition of language-specific syntactic parameters (Friederici et al., 2011). Understanding the brain regions and neural pathways involved in language acquisition will refine our understanding. This comprehensive approach will bridge the gap between theoretical models and empirical data, advancing our knowledge of how children acquire language.

Future research should focus on expanding linguistic diversity, employing advanced technologies, and integrating cross-disciplinary approaches to further elucidate the universal mechanisms underpinning language acquisition.

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Part I

APPENDIX

APPENDIX

ETHICAL LETTER APPROVAL

UAB
Universitat Autònoma de Barcelona
Vicerectorat d'Investigació

Comisión de Ética en la Experimentación Animal y Humana (CEEAH)
Universitat Autònoma de Barcelona
08193 Bellaterra (Cerdanyola del Vallès)

La Comisión de Ética en la Experimentación Animal y Humana (CEEAH) de la Universitat Autònoma de Barcelona, reunida el día **16-06-2023**, acuerda informar favorablemente el proyecto con número de referéncia **CEEAH 6467** y que tiene por título **"An experiment of comprehension of agreement using eye-tracking thechniques in infants at 17 months to 2 years"** presentado por **Alejandra Keidel Fernandez**

Elaborado:	**Aprovado:**
Nombre: Nuria Perez Pastor Cargo: Secretària de la CEEA de la UAB Fecha: UAB Universitat Autònoma de Barcelona 2023.06.20 11:03:44 +02'00'	Nombre: José Luis Molina González Cargo: President de la CEEAH de la UAB Fecha: UAB Universitat Autònoma de Barcelona Data: 2023.06.20 15:13:55 +02'00'

LETTER OF INFORMAL CONSENT - STUDY 1, EXPERIMENTS 1

Benvolgudes famílies,
Em dic Alejandra Keidel Fernández. Sóc una estudiant de doctorat al Departament de Filologia Catalana de la Universitat Autònoma de Barcelona. Treballo en el meu doctorat en adquisició del llenguatge i en aquest moment estic duent a terme un estudi a l'Escola Maria Borés de la Pobla de Claramunt. Aquest estudi està concebut com un joc en què el nen ha de triar entre dues imatges la que es correspon amb la frase que sent.

La prova té una durada d'aproximadament 5 minuts i els nens la fan individualment, a l'aire lliure i prenent totes les precaucions que la situació sanitària requereix.

Les dades dels participants seran confidencials i els resultats seran utilitzats anònimament i només per a propòsits científics. La participació és voluntària i el nen pot abandonar l'estudi en qualsevol moment. Si us sembla bé que el vostre fill o filla participi a l'estudi, necessitem el vostre consentiment escrit, que trobareu aquí sota.

Podeu veure els materials de l'estudi a:
https://www.labvanced.com/player.html?id=18530
Si teniu cap dubte sobre l'estudi, us podeu posar en contacte amb mi a través del correu Alejandra.Keidel@uab.cat

Gràcies per endavant.

Alejandra Keidel Fernández
CLT Centre de Lingüística Teòrica
Departament de Filologia Catalana

Universitat Autònoma de Barcelona
(+34) 93 586 80 68

.....

Jo, ..., amb
DNI .....
autoritzo que el meu fill/la meva filla ..... amb
data de naixement .....
participi a l'estudi d'Alejandra Keidel.
A Barcelona, el dia _____ del 2021.

LETTER OF INFORMAL CONSENT - STUDY 2, EXPERIMENT 1

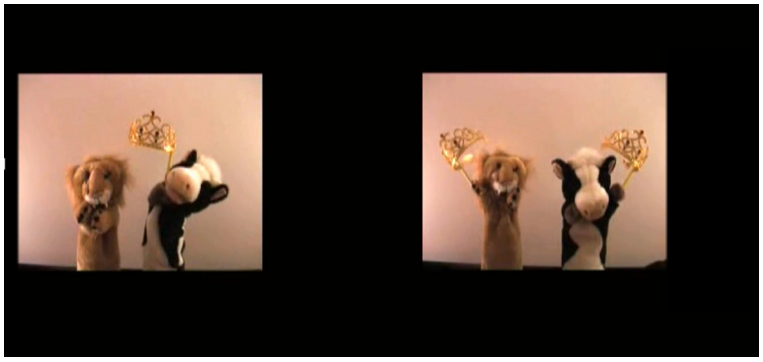
- Catalan
- German

Universitat Autònoma de Barcelona

Bellaterra, maig del 2023

Benvolguda directora Laia,

En aquest moment, el grup de recerca que dirigeixo a la UAB investiga l'adquisició de l'ordre de paraules en infants que tenen el català com a primera llengua. L'estudi es duu a terme amb l'ajuda d'uns materials de vídeo que els infants veuen en una pantalla de portàtil, i amb una càmera que monitoritza la mirada. Els materials són del tipus que il·lustrem aquí (i la gravació dels resultats requereix l'accés a internet):



La Núria Mañosa, en aquest moment assistent tècnica del Centre de Lingüística teórica, és la persona que durà a terme l'estudi i és qui m'ha proporcionat el vostre contacte. És per això que us demano la vostra col.laboració, si ens podeu facilitar accés a nens catalanoparlants d'entre 17 i 19 mesos. La tasca que hem elaborat té una duració de més o menys 15 minuts per nen – i d'acord amb la Convenció de Hèlsinki, els nens poden deixar de fer la prova en qualsevol moment si així ho volen, i les dades resultants seran confidencials. Necessitem, com és usual, el consentiment exprés de les famílies perquè els infants hi participin, tot i que la tasca no és gens invasiva.

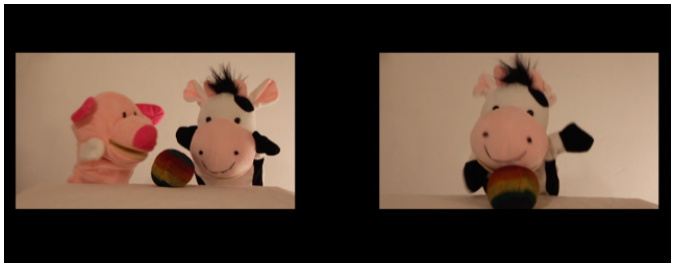
No cal dir que ajuda com la que us demanem és imprescindible per poder dur a terme aquest tipus d'estudis, raó per la qual us agrairíem molt la vostra col·laboració. Per qualsevol qüestió, no dubteu a contactar-me a anna.gavarro@uab.cat. Moltes gràcies.

Cordialment,

Anna Gavarró
Catedràtica en Lingüística
Departament de Filologia Catalana

Liebe Eltern,

vielen Dank, dass sie bei dieser Studie teilnehmen möchten! Sie wird im BabyLAB der Universität Potsdam durchgeführt und ist eine Kooperation mit der Universität Autònoma in Barcelona. Die eigentliche Messung für die Studie dauert nur ca. fünf Minuten, für Ihren Besuch sollten Sie eine halbe Stunde einplanen.
Im BabyLAB erforschen wir den frühen Spracherwerb von Kindern. Hierfür wird Ihr Kind kurze Videos sehen und dazu Sätze hören wie z.B. „Die Puppe tanzt“. Außerdem interessieren wir uns dafür, inwiefern Babys eine Präferenz für die Übereinstimmung der Videos mit dem Satz zeigen. Dafür sieht Ihr Kind auf dem Bildschirm entweder eine oder zwei Puppen, währen ein Satz abgespielt wird, der nur zu einem der Videos passt. Das sieht z.B. so aus:



Um zu messen, welches Bild die Kinder häufiger bzw. länger anschauen, erfassen wir ihr Blickverhalten mit einem automatischen Blickbewegungsmessgerät (Eyetracker). Beim Eyetracking werden die Augenbewegungen in hoher räumlicher und zeitlicher Auflösung registriert, während die Versuchsperson Bilder oder Videos auf einem Bildschirm betrachtet. Der Eyetracker ist unauffällig unter dem Monitor angebracht. Er erfasst über Infrarotlicht, das an der Hornhaut reflektiert wird, alle 10-20 Millisekunden die Position der Pupille und errechnet darüber die Blickposition. Das Infrarotlicht ist nahezu unsichtbar und völlig unbedenklich und die Kinder können Kopf und Oberkörper während der Messung frei bewegen. Wir benutzen Geräte der Firma Tobii.

Mit dieser Methode können wir die kognitive Entwicklung von Kindern erforschen. Die erhobenen Daten werden anonymisiert und streng vertraulich behandelt. Der Name Ihres Kindes wird somit nicht dokumentiert. Sie können die Studie jederzeit ohne Begründung abbrechen. Daraus entsteht Ihnen kein Nachteil und Sie erhalten trotzdem die Aufwandsentschädigung.

Als Dankeschön für die Teilnahme erhält Ihr Kind eine Fotourkunde und 7,50€.

Herzlichen Dank, dass Sie unser Forschungsvorhaben unterstützen!

Beste Grüße,
Alejandra Keidel Fernández

Falls Sie weitere Fragen zu den geplanten Untersuchungen haben, nehmen Sie bitte Kontakt mit der aufgeführten Ansprechpartnerin auf.

Alejandra Keidel Fernández
Center For Theoretical Linguistics of the Universitat Autònoma de Barcelona

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Homepage der Arbeitsgruppe: https://clt.uab.cat/apl/

Verantwortlicher Professor: Prof. Dr. Anna Gavarró Algeuró
EINVERSTÄNDNISERKLÄRUNG

Hiermit erkläre ich mich damit einverstanden, dass mein Kind,

_____, an der Eyetracking Studie teilnimmt.

Ich wurde über das Ziel der Studie und die geplanten Untersuchungen aufgeklärt. Weitere Fragen ergeben sich zum jetzigen Zeitpunkt nicht. Ich weiß, dass die Teilnahme an der Untersuchung freiwillig ist.

Ich wurde darüber informiert, dass alle während der Untersuchung erhobenen Daten streng vertraulich behandelt werden und anonymisiert sind. Der Name meines Kindes wird nicht dokumentiert.

Ich bestätige durch meine Unterschrift, dass ich die Informationen verstanden habe und mit der Teilnahme meines Kindes an dieser Studie einverstanden bin.

Geburtsdatum des Kindes _____/_____/_____(TT/MM/JJ)____

Muttersprache : ☐ Deutsch.

☐ Deutsch und _____(bitte angeben).

☐ Andere Sprache/n _____(bitte angeben).

---------- (Ort/ Datum/ Unterschrift der Erziehungsberechtigten)

[September 9, 2024 at 19:08 – classicthesis version 2]

Herzlichen Dank, dass Sie das Forschungsvorhaben unterstützen.

Beste Grüße,
Alejandra Keidel Fernández

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LINGUISTIC MATERIAL: STUDY 1, EXPERIMENT 1

Table 52: Linguistic material experiment 1, Catalan

Item	Stimuli	Translation	Condition
1	La dona camina	The woman walks	Filler
1	El nen dibuixa	The boy draws	Full-DP
2	Els nens dibuixen	The boys draw	Full-DP
3	Dibuixen	Draw (they)	Null-subject
4	Dibuixa	Draw (he/she)	Null-subject
6	El nen està assegut	The boy is sitting	Filler
5	El nen salta	The boy jumps	Full-DP
6	Els nens salten	The boys jump	Full-DP
7	Salta	Jump (he/she)	Null-subject
8	Salten	Jump (they)	Null-subject
11	La dona pinta	The woman paints	Filler
9	El gos menja	The dog eats	Full-DP
13	Els gossos mengen	The dogs eat	Full-DP
14	Menja	Eat (he/she)	Null-subject
15	Mengen	Eat (they)	Null-subject
16	L'home menja	The man eats	Filler
17	L'ànec corre	The duck runs	Full-DP
18	Els ànecs corren	The ducks run	Full-DP
19	Corre	Run (he/she)	Null-subject
20	Corren	Run (they)	Null-subject
21	El gat està assegut	The cat is sitting	Filler

Item	Stimuli	Translation	Condition
22	El gat dorm a terra	The cat sleeps on the ground	Full-DP
23	Els gat dormen a terra	The cats sleep on the ground	Full-DP
24	Dorm a terra	Sleep on the ground (he/she)	Null-subject
25	Dormen a terra	Sleep on the ground (they)	Null-subject
26	La dona beu	The woman drinks	Filler
27	El nen juga a pilota	The boy plays with the ball	Full-DP
28	Els nens juguen a pilota	The boys play with the ball	Full-DP
29	Juga a pilota	Play with the ball (he/she)	Null-subject
30	Juguen a pilota	Play with the ball (they)	Null-subject
31	La dona salta	The woman jumps	Filler
32	La nena patina	The girl skates	Full-DP
33	Les nenes patinen	The girls skate	Full-DP
34	Patina	Skate (he/she)	Null-subject
35	Patinen	Skate (they)	Null-subject
36	L'home camina	The man walks	Filler
37	El gat beu llet	The cat drinks milk	Full-DP
38	Els gats beuen llet	The cats drink milk	Full-DP

Item	Stimuli	Translation	Condition
39	Beu llet	Drink milk (he/she)	Null-subject
40	Beuen llet	Drink milk (they)	Null-subject
41	La dona menja	The woman eats	Filler
42	La nena llegeix	The boy reads	Full-DP
43	Les nenes llegeixen	The boys read	Full-DP
44	Llegeix	Read (he/she)	Null-subject
45	Llegeixen	Read (they)	Null-subject
46	L'home beu	The man drinks	Filler
47	L'ocell vola	The bird flies	Full-DP
48	Els ocells volen	The birds fly	Full-DP
49	Vola	Fly (he/she)	Null-subject
50	Volen	Fly (they)	Null-subject

LINGUISTIC MATERIAL: STUDY 1, EXPERIMENT 2

Table 53: Linguistic material experiment 1, Catalan

Item	Stimuli	Translation	Condition
1	Tres nens dibuixen	Three kids paint	Filler
1	El nen dibuixa	The boy draws	FULL-DP
2	Els nens dibuixen	The boys draw	FULL-DP
3	Dibuixen	Draw (they)	Null-subject
4	Dibuixa	Draw (he/she)	Null-subject
6	Tres nens salten	Three boys jump	Filler
5	El nen salta	The boy jumps	Full-DP
6	Els nens salten	The boys jump	Full-DP
7	Salta	Jump (he/she)	Null-subject
8	Salten	Jump (they)	Null-subject
11	Tres gossos mengen	Three dogs eat	Filler
9	El gos menja	The dog eats	Full-DP
13	Els gossos mengen	The dogs eat	Full-DP
14	Menja	Eat (he/she)	Null-subject
15	Mengen	Eat (they)	Null-subject
16	Tres ànecs corren	Three ducks run	Filler
17	L'ànec corre	The duck runs	Full-DP
18	Els ànecs corren	The ducks run	Full-DP
19	Corre	Run (he/she)	Null-subject
20	Corren	Run (they)	Null-subject

Item	Stimuli	Translation	Condition
21	Tres gats dormen a terra	Three cats sleep on the ground	Filler
22	El gat dorm a terra	The cat sleeps on the ground	Full-DP
23	Els gat dormen a terra	The cats sleep on the ground	Full-DP
24	Dorm a terra	Sleep on the ground (he/she)	Null-subject
25	Dormen a terra	Sleep on the ground (they)	Null-subject
26	Tres nens juguen a pilota	Three play with the ball	Filler
27	El nen juga a pilota	The boy plays with the ball	Full-DP
28	Els nens juguen a pilota	The boys play with the ball	Full-DP
29	Juga a pilota	Play with the ball (he/she)	Null-subject
30	Juguen a pilota	Play with the ball (they)	Null-subject
31	Tres nenes patinen	Three girls skate	Filler
32	La nena patina	The girl skates	Full-DP
33	Les nenes patinen	The girls skate	Full-DP
34	Patina	Skate (he/she)	Null-subject
35	Patinen	Skate (they)	Null-subject

Item	Stimuli	Translation	Condition
36	Tres gats beuen llet	Three cats drink milk	Filler
37	El gat beu llet	The cat drinks milk	Full-DP
38	Els gats beuen llet	The cats drink milk	Full-DP
39	Beu llet	Drink milk (he/she)	Null-subject
40	Beuen llet	Drink milk (they)	Null-subject
41	Tres nenes llegeixen	Three girls read	Filler
42	La nena llegeix	The girl reads	Full-DP
43	Les nenes llegeixen	The girls read	Full-DP
44	Llegeix	Read (he/she)	Null-subject
45	Llegeixen	Read (they)	Null-subject
46	Tres ocells volen	Three birds fly	Filler
47	L'ocell vola	The bird flies	Full-DP
48	Els ocells volen	The birds fly	Full-DP
49	Vola	Fly (he/she)	Null-subject
50	Volen	Fly (they)	Null-subject

Table 54: Experimental Sentences of Study 2, Experiment 1

Initial Presentation	
Mira, ho veus? És el gos	Look, do you see? It's the dog
Mira, ho veus? És la vaca	Look, do you see? It's the cow
Mira, qui hi ha aquí? És l'ovella	Look, who is here? It's the sheep
Mira, ho veus? És el llop	Look, do you see? It's the wolf
Mira, què és això? És un porc	Look, what's this? It's the pig
Familiarizing with the Simultaneous Presentation	
Mira, veus el gos? On és el gos?	Look, do you see the dog? Where is the dog?
Mira, veus la vaca? On és la vaca?	Look, do you see the cow? Where is the cow?
Mira, veus l'ovella? On és l'ovella?	Look, do you see the sheep? Where is the sheep?
Mira, veus el llop? On és el llop?	Look, do you see the wolf? Where is the wolf?
Mira, veus el porc? On és el porc?	Look, do you see the pig? Where is the pig?
Attention Marker	
Mira, què passa?	Look, what is happening?
Experimental Set 1 – Jugar	
Els animals juguen.	The animals are playing.
L'animal juga.	The animal is playing.
Jugen	They are playing.

Juga	It is playing.
Experimental Set 2 – Ballar	
Els animals ballen	The animals are dancing.
L'animal balla	The animal is dancing.
Ballen	They are dancing.
Balla	It is dancing.

Table 55: Linguistic Material for Study 2, Experiment 2

Familiarizing with the Puppets	
Schau, siehst du? Das ist ein Hund.	Look, do you see? It's the dog.
Schau, siehst du? Das ist eine Kuh.	Look, do you see? It's the cow.
Schau, siehst du? Das ist ein Schaf.	Look, do you see? It's the sheep.
Schau, siehst du? Das ist ein Wolf.	Look, do you see? It's the wolf.
Schau, siehst du? Das ist ein Schwein.	Look, do you see? It's the pig.
Familiarizing with the Simultaneous Presentation	
Schau mal, siehst du einen Hund? Wo ist der Hund?	Look, do you see the dog? Where is the dog?
Schau mal, siehst du eine Kuh? Wo ist die Kuh?	Look, do you see the cow? Where is the cow?
Schau mal, siehst du ein Schaf? Wo ist das Schaf?	Look, do you see the sheep? Where is the sheep?

Schau mal, siehst du einen Wolf? Wo ist der Wolf?	Look, do you see the wolf? Where is the wolf?
Schau mal, siehst du ein Schwein? Wo ist das Schwein?	Look, do you see the pig? Where is the pig?
Attention Marker	
Schau mal, was ist hier los?	Look, what is happening?
Experimental Set 1 – Spielen	
Die Puppen spielen.	The puppets are playing.
Die Puppe spielt.	The puppet is playing.
Sie spielen.	They are playing.
Sie spielt.	She is playing.
Experimental Set 2 – Tanzen	
Die Puppen tanzen.	The puppets are dancing.
Die Puppe tanzt.	The puppet is dancing.
Sie tanzen.	They are dancing.
Sie tanzt.	She is dancing.

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DECLARATION

I, *Alejandra Keidel Fernández*, hereby declare that this thesis, titled *Parsing of Subject-Verb Agreement in the Acquisition of Catalan and German*, is my original work. I submit this thesis to fulfill the requirements for the degree of Doctor of Philosophy (PhD) in Cognitive Science and Language at the Universitat Autònoma de Barcelona. The research presented in this thesis was conducted under the supervision of Prof. Anna Gavarró, following the university's regulations and guidelines. Part of the results reported in this thesis are included in a paper accepted for publication: Gavarró and Keidel, 2024. Subject-verb agreement: Three experiments on Catalan. I confirm that this thesis has not been previously submitted for any other degree or qualification at any other university or educational institution. Furthermore, I affirm that this thesis does not infringe upon the rights of others. Throughout this work, I have diligently acknowledged and attributed the work of others by appropriately referencing their contributions within this thesis. Any direct quotations or paraphrasing from external sources are clearly identified and cited, ensuring the transparency and integrity of this research.

Barcelona, July 31st 2024

Alejandra Keidel Fernández