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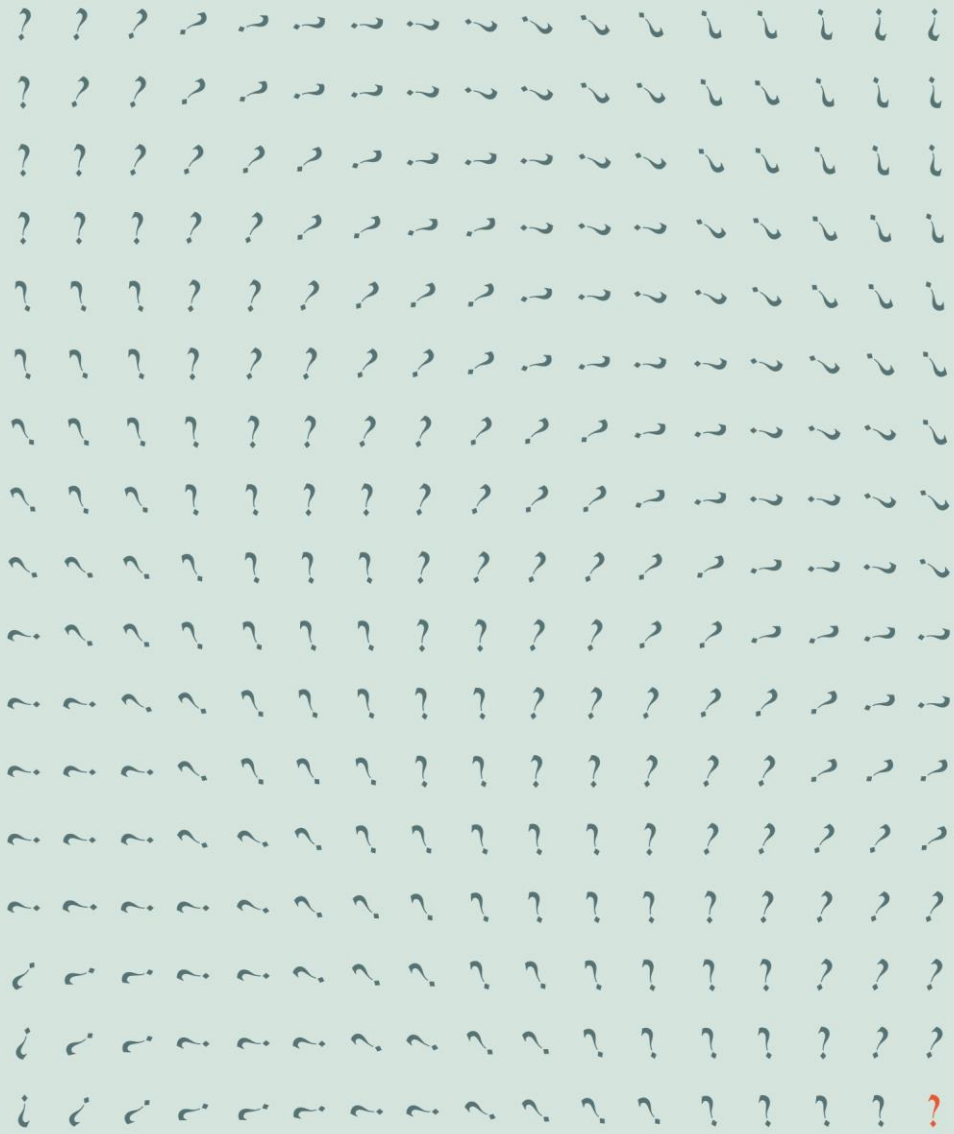

COMPREHENSION OF *YES/NO-* AND *WH-*QUESTIONS ACROSS AUTISM SPECTRUM CONDITIONS

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Abstract

Understanding questions is key for successful communication. Although deficits in communication are the hallmark of Autism Spectrum Conditions (ASC), how both *yes/no*-questions and *wh*-questions are understood by children with ASC has been poorly investigated in Spanish, a language with *ex-situ-wh*-questions and *yes/no*-questions that are different from declaratives only prosodically. Nevertheless, questions play an important role in ASC diagnostic tests and neurocognitive assessments. In addition, although there is a widespread assumption of visual support easing linguistic production and comprehension, this visual ease assumption has not been extensively investigated in question comprehension research.

The aim of this thesis is to contribute to a more comprehensive picture of language impairments in ASC by targeting questions as a specific and neglected dimension of language in ASC. Specific research questions concern the impact of syntactic differences in question type, syntactic complexity and other linguistic, cognitive and age factors on question comprehension. Finally, the role of visual support as a facilitator of question comprehension is targeted.

34 children with ASC–ID (autism without intellectual disability, mean age = 9.99) were recruited and matched on VMA (verbal mental age) with 34 TD (typically developing) participants (mean age = 8.85). 14 individuals with ASC+ID (autism with intellectual disability, mean age = 12.95) were also recruited so as to assess question comprehension across all verbal profiles on the spectrum. These were compared to 7 ID (intellectual disability) participants without ASC (mean age = 12.86). The task design of the experiment used narratives to control the context in which *yes/no*-questions and

different types of *wh*-questions (namely *wh*-questions in simple and complex sentences, long-distance *wh*-questions in complex sentences and local *wh*-questions in complex sentences) were asked. Participants responded immediately after having been exposed to narratives with either visual support or audio support only. Participants' ability to answer questions about these narratives was assessed as a measure of their question comprehension.

Significant results showed that both ASC and TD groups had greater difficulties in *wh*-questions than *yes/no*-questions. Compared to TD, ASC–ID also had lower *wh*-question comprehension. In addition, the ASC+ID group showed a lower level of question comprehension in *yes/no*-questions and in *wh*-questions compared to the ASC–ID and ID groups. All *wh*-questions in complex sentences and local *wh*-questions in complex sentences were more difficult for the ASC–ID group in comparison to the TD group. The ASC+ID group underperformed in all types of *wh*-questions comprehension in comparison to the ASC–ID participants and had greater difficulties to comprehend local *wh*-questions in complex sentences in comparison to the ID group.

In line with the visual ease assumption, visual support aided question comprehension not only in ASC but also in TD. However, in between-group comparisons, significantly greater question comprehension difficulties in tasks with visual support in the ASC–ID relative to the TD group remained. Moreover, the ASC+ID group scored significantly lower in both visual and non-visual tasks in comparison to both ASC–ID and ID groups. VMA and VIQ (verbal intelligence quotient) correlated with *yes/no*-question comprehension in TD and in ASC–ID participants. In the TD group, there was a correlation with these variables and *wh*-question comprehension as well. In the ID group, working memory and VIQ had a positive relation with the comprehension of some

types of *wh*-questions.

These results provide novel evidence for a question comprehension impairment in ASC with and without ID, which specifically centers on *wh*-questions. The effect of syntactic complexity, which was identified to the presence of clausal embedding, only negatively affected *wh*-question comprehension in the ASC–ID group. Importantly, the results also show that visual support does not offset these specific deficits in question comprehension in ASC. As age and cognitive factors were more related to question comprehension in TD and ID groups than in ASC, different underlying cognitive mechanisms across these groups may be involved in this pattern.

Overall, this thesis contributes to a more comprehensive picture of language deficits across the autism spectrum, which emerge even in older children and adolescents, in the absence of ID, and against a TD group matched on VMA. At a practical level, they incite reflection on the roles of question types both in diagnostic assessments and interventions.

Resum

La comprensió de les preguntes és essencial per a la comunicació. Tot i que els dèficits en la comunicació són característics de les Condicions de l'Espectre Autista (CEA), la manera com els infants i adolescents amb CEA entenen tant les preguntes *sí/no* com les preguntes *qu-* ha estat poc investigada en castellà, una llengua amb preguntes *qu-ex-situ* i amb preguntes *sí/no* que només es diferencien de les oracions declaratives per la prosòdia. Tot i això, les preguntes tenen un paper important en les proves diagnòstiques i en els testos neurocognitius destinats a les persones amb CEA. A més, tot i la idea generalitzada que el suport visual facilita la producció i la comprensió lingüístiques, no s'ha investigat el seu efecte en la comprensió de preguntes.

L'objectiu d'aquesta tesi és contribuir a una visió més completa de les deficiències lingüístiques en les CEA, en concret de les preguntes, una part del llenguatge que no ha estat investigada en aquesta població. Més específicament, aquesta investigació se centra en l'impacte de les diferències sintàctiques en el tipus de pregunta, la complexitat sintàctica i altres factors lingüístics, cognitius i d'edat en la comprensió de les preguntes. Finalment, també s'estudia el paper del suport visual com a facilitador de la comprensió de les preguntes.

34 infants i adolescents amb CEA–DI (autisme sense discapacitat intel·lectual, edat mitjana = 9,99) van participar en aquest estudi. Aquest grup es va relacionar a través de l'EMV (edat mental verbal) amb 34 participants de DT (desenvolupament típic) (edat mitjana = 8,85). També es va comptar amb 14 individus amb CEA+DI (autisme amb discapacitat intel·lectual, edat mitjana = 12,95) per tal d'avaluar la comprensió de les preguntes en tots els perfils verbals de l'espectre. Aquest grup es va comparar amb 7 participants amb DI (discapacitat intel·lectual) sense CEA (edat mitjana = 12,86). En el

disseny d'aquesta investigació es van fer servir 4 narracions amb l'objectiu de controlar el context en què es demanaven les preguntes *sí/no* i les *qu-* en els diferents tipus que presenten (preguntes *qu-* en frases simples i complexes, preguntes *qu-* de llarga distància en frases complexes i les preguntes *qu-* locals en frases complexes). Els participants responien immediatament després d'haver estat exposats a les narracions, 2 amb suport visual i 2 orals. La comprensió de preguntes es va avaluar segons les respostes dels participants.

Els resultats significatius van demostrar que tant els grups amb CEA com amb DT van tenir més dificultats en la comprensió de les preguntes *qu-* que en la de les preguntes sí/no. En comparació amb el grup amb DT, el grup amb CEA–DI va mostrar un nivell de comprensió de les preguntes *qu-* menor. A més a més, el grup amb CEA+DI va resultar tenir un nivell de comprensió de preguntes inferior tant en preguntes *sí/no* com en les *qu-* en comparació amb els grups amb CEA–DI i DI. Totes les preguntes *qu-* en oracions complexes i les preguntes *qu-* locals en frases complexes van ser més difícils per al grup amb CEA–DI que per al grup amb DT. El grup ASC+ID va tenir un rendiment baix en tots els tipus de comprensió de preguntes *qu-* en comparació amb els participants amb CEA–DI. També va mostrar dificultats importants per comprendre les preguntes *qu-* locals en frases complexes en comparació amb el grup amb DI.

El suport visual va afavorir a la comprensió de preguntes no només a les persones amb CEA, sinó també al grup amb DT. No obstant això, en les comparacions entre grups, el grup amb CEA–DI va mostrar dificultats significativament majors de comprensió de preguntes en tasques amb suport visual en relació amb el grup amb DT. A més, el grup amb CEA+DI va obtenir puntuacions significativament inferiors tant en les tasques visuals com no en les no visuals en comparació amb els grups amb CEA–DI i DI. L'EMV

i el QIV (quocient d'intel·ligència verbal) van estar correlacionats amb la comprensió de preguntes *sí /no* en els grups amb DT i amb CEA–DI. En el grup amb DT, aquestes variables també es van relacionar significativament amb la comprensió de les preguntes *qu-*. En el grup amb DI, la memòria de treball i el QIV es va relacionar significativament amb la comprensió d'alguns tipus de preguntes *qu-*.

Els resultats d'aquesta tesi proven que hi ha un deteriorament de la comprensió de preguntes en les CEA amb i sense DI, sobretot en les preguntes *qu-*. L'efecte de la complexitat sintàtica identificada amb la presència d'oració subordinada en la frase només va afectar negativament la comprensió de les preguntes *qu-* en el grup CEA–DI. És important destacar que els resultats també mostren que el suport visual no compensa aquests dèficits específics en la comprensió de les preguntes en les CEA. L'edat i els factors cognitius es correlacionen amb la comprensió de les preguntes en els grups amb DT i amb DI en més mesures que no pas en els grups amb CEA, fet que fa pensar que els mecanismes cognitius subjacents en les CEA i en els grups amb DT i amb DI són diferents.

En conclusió, aquesta tesi aporta una visió més completa dels dèficits de llenguatge en tot l'espectre autista, que apareixen fins i tot en absència de discapacitat intel·lectual en infants i adolescents, i no pas en persones de DT amb la mateixa EMV. A nivell clínic, els resultats presentats conviden a plantejar-se la importància de les preguntes tant en el diagnòstic com en la intervenció.

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Dedication

I dedicate this thesis to my parents, M. Carme and Ramon.

"And why were you holding the dog?" he asked.
This was a difficult question. It was something I wanted to do. I like dogs. It made me sad to see that the dog was dead.
I like policemen, too, and I wanted to answer the question properly, but the policeman did not give me enough time to work out the correct answer.
"Why were you holding the dog?" he asked again.
"I like dogs," I said.
"Did you kill the dog?" he asked.
I said, "I did not kill the dog."
"Is this your fork?" he asked.
I said, "No."
"You seem very upset about this," he said.
He was asking too many questions and he was asking them too quickly. They were stacking up in my head like loaves in the factory where Uncle Terry works.

Extract from *The Curious Incident of the Dog in the Night-time* by Mark Haddon

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List of abbreviations

Abbreviation	Full form
ADI-R	Autism Diagnostic Interview-Revised
ADOS	Autism Diagnostic Observational Schedule
ASC	Autism Spectrum Conditions (synonymous to ASD)
ASC–ID	Autism Spectrum Conditions without Intellectual Disability (synonymous to high-functioning ASC)
ASC+ID	Autism Spectrum Conditions with Intellectual Disability
ASD	Autism Spectrum Disorders (synonymous to ASC)
AQ	Autism Spectrum Quotient
CA	Chronological Age
DSM-V	Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition
ESK	External Merge of a Question Marker *Est-Ce Que* Insertion
FB	False Belief
ICD-10	International Classification of Diseases - 10th

	edition
ID	Intellectual Disability
IQ	Intellectual Quotient
JA	Joint Attention
KBIT	Kaufman Brief Intelligence test
NP	Noun Phrase
PPVT-III	Peabody Picture Vocabulary Test - 3rd edition
TD	Typically Developing
ToM	Theory of Mind
VIQ	Verbal Intelligence Quotient
VMA	Verbal Mental Age
WCC	Weak Central Coherence
WISC	Wechsler Intelligence Scale for Children
WPPSI-III	Wechsler Preschool and Primary Scale of Intelligence
WM	Working Memory

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Chapter 1. General introduction

1.1 Starting points

The aim of this thesis is to study the comprehension of questions in Autism Spectrum Conditions (ASC). My interest in this specific issue is rooted both in an intellectual fascination for language in autism and my experience as a teacher. As for the former, I devoted my bachelor's degree final project to investigate first and second language acquisition of children with ASC. As for the latter, my experience teaching children with typical development (TD) but also some children with ASC in a mainstream school allowed me to observe language difficulties of ASC children in comparison to their TD classmates. Their interaction with teachers and classmates was affected and most of the times their problems involved question-answering turn-taking.

Against this background, some years ago, it became clear to me that looking into the comprehension of questions in ASC was timely. I wanted to find out whether the communicative difficulties of children and adolescents with ASC might be due in part to a poor comprehension of questions. Aiming at that goal, a research plan was set up with four components: my dissertation had to shed light on (1) question comprehension in ASC in comparison with children with both TD and intellectual disability (ID) without autism, where (2) comprehending a question is meant to have the capacity to answer it, (3a,3b) in a structured setting with and without visual support, and (4) taking into account its form (*yes/no* vs. *wh-;* plus *wh-* subtypes). Such a research plan was not as much inspired by a preconceived theoretical framework but as by my experience-led intuition that the deficits in communicative interaction in ASC could to some extent derive from a formal difficulty in understanding questions and that the role of visual support was an important issue in this regard. This thesis has broadly confirmed this expectation.

It took a long time to gather all the pieces to make the study possible. Initially our main efforts were devoted to designing the experiments, recruiting the different participant groups and testing the participants. At that point, we were already aware of the almost non-existence of a similar research agenda —even discarding the issue of visual support. By then, we were knowledgeable about a short series of studies (Huang & Oi, 2013; Oi, 2005, 2008, 2010) centered mainly on the differences in the understanding of *yes/no*- and *wh*- questions, in Taiwanese and Japanese, by ASC children. Although in these studies comprehending a question was considered equivalent to the capacity to answer it, the fact that all the aforementioned languages are East Asian languages with *in-situ-wh*-questions (i.e. no change in word order regarding the corresponding declarative sentence), which contrasts with *ex-situ-wh*-questions in Spanish, constituted an additional motivation for our research.

Our research plan was designed to avoid a number of fundamental dichotomies that have marked generative linguistics from the beginning, such as knowledge/competence *vs*. use/performance; thought *vs*. communication and grammar *vs*. pragmatics. Our stance by going through the (1)-(4) components of our study is clear in this regard. In particular, the (in)correctness of answers to questions, i.e. use of language (involving turn-taking, production and comprehension), is taken as the dependent variable with respect to the formal structure of questions (linguistic knowledge) acting as the independent variable. We therefore let knowledge and use of language come together. Although language use is addressed in our design, pragmatics is somewhat bypassed because of the structured setting in our tasks, which avoids issues of contextual appropriateness. In sum, the present dissertation presents itself as a contribution to the issue of language in ASC, and to questions in ASC in particular, under

the assumption that a non-divisive, integrative approach constitutes the best strategy to reach true understanding.

Focusing on questions, we hope to contribute to a less dichotomous view. As discussed below, even ASC diagnostics might be wrongly sensitive to the dichotomies above. Moreover, further research on questions could shed light not only on questions themselves —and their acquisition and use in typical development and ASC— but also on the role that the handling of questions (production and comprehension) might play in behavioral and cognitive domains known to be atypical in ASC (ToM, weak central coherence and joint attention), thus influencing theories of autism and in gold-standard and cognitive assessment measures in ASC. We will now clarify these points in the following three subsections.

1.2 The vision of language in ASC in the DSM-5, the current nosological view

In the fifth edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-5; American Psychiatric Association, 2013), the language profile is not a core item for an autism diagnosis anymore, but a specifier. ASD[1] (Autism Spectrum Disorders) is diagnosed on the basis of (1) deficits in social interaction and communication and (2) presence of restricted and repetitive behaviors and interests. A language disorder, crucially understood in the DSM as an "impairment in structural language", is secondary to ASC, which is a novelty with respect to previous versions of ASC, where a language disorder was considered a core diagnostic criterion of ASC. Again, the structural language

[1] In this thesis, we use the term ASC as a synonym of ASD in line with other researchers such as Simon Baron-Cohen in order to consider that autism has impairments (i.e. in social interaction and communication) but also strengths, presenting itself as a form of neurodiversity rather than a 'disorder'.

is split from its social use, and the latter is instead considered a hallmark of ASC. In this regard, the American Speech-Language-Hearing Association (2012) made the following recommendation, which is worth quoting in full:

> If a language disorder is not part of the ASD criteria, children with ASD could be misidentified as only having a language disorder and would not receive all of the interventions that they need.
>
> If language disorder is not part of the ASD criteria, all children with ASD would also have to be diagnosed as having a language disorder because by definition ASD encompasses language disorders.
>
> **Rationale**
>
> Disorders of language are a hallmark of autism and include all language components to some degree: content (i.e., semantics), form (i.e., phonology, morphology, syntax), and use (i.e., pragmatics, social communication) in all modalities (e.g., oral and sign). To collapse the diagnostic criteria to only include social language use would result in an inaccurate description of the fundamental nature of autism. Language disorders are a distinct element of ASD.
>
> In the proposed revision of the diagnostic criteria for ASD, the following rationale is provided for elimination of the criteria related to spoken language:
>
> > Delays in language are not unique nor universal in ASD and are more accurately considered as a factor that influences the clinical symptoms of ASD, rather than defining the ASD diagnosis.
>
> ASHA concurs that delays in language are not unique to ASD. However, the literature clearly indicates that spoken language disorders are a hallmark feature of ASD and are often the critical indicators for early identification of ASD. Some children with ASD demonstrate unaffected early language development and their problems manifest themselves only with higher order language tasks, whereas other children demonstrate profound language deficits from the onset of the language acquisition process.
>
> Even children with ASD who are verbal do not possess a generative language system (infinite capacity with finite means). They have not internalized the rules for generating novel language forms. Lack of generative language persists over time in children with ASD.
>
> Although social communication is an important component of ASD, deficits in language form and content also are defining features and need to be included as diagnostic criteria. Failure to include

spoken language in the diagnostic criteria would result in a fundamental mischaracterization of ASD that would run counter to an extensive body of research, such as the following major studies [references to such studies]

Recommendation

Add a fifth diagnostic criterion for autism spectrum disorder: Deficit in oral language [as described below]

A. Persistent deficits in comprehension and expression of language across contexts and modalities (e.g., spoken and manually coded), not accounted for by general developmental delays, and manifested as deficits in language form (phonology, morphology, syntax) and language content (semantics) ranging from limited language acquisition to total lack of comprehension and expression of language (as defined in section on language disorders). (p.11-12)

The recommendation above did not have the desired effect, so that the DSM-5 aligns with the assumption that ASC must be specified according to whether autism concurs with language impairment or not. In either case, this manual recognizes that "the use of language for reciprocal social communication is impaired in autism spectrum disorder." Therefore, we can observe that the use of language (i.e. spoken language mainly) as such does not enter the further specifier (with *vs.* without accompanying language impairment) in the diagnosis. As a consequence, some atypical/abnormal spoken language features are forcibly placed under the DSM-5's category of restricted and repetitive patterns of behavior, interests, or activities. That is the case for echolalia but also for the stereotyped use of words, phrases or prosodic patterns. In the same vein, the failure to consider the use of language has the consequence that speech intonation is classified as falling within nonverbal communicative behaviors. Impaired intonation whether in production or comprehension might damage question production and comprehension. Both *yes/no*- and *wh*-questions have a prosodic contour that differentiates them from declarative sentences, to the point that there are languages like Spanish where *yes/no*-questions only differ from declaratives in terms of prosodic contour. Entering the specifier with or without language

impairment also engenders a conceptual confusion, namely that language turns into speech: if there is linguistic impairment, a doctor must further specify whether there is “no intelligible speech (nonverbal) or “phrase speech”, while if there is no linguistic impairment, he should state whether there is “sentential speech" or “fluent speech”.

A final important ingredient in questions in its default conversation setting is turn-taking. This pattern, which is seen from birth onward (Bloom et al., 1987; Dominguez et al., 2016), is a deceivingly simple multimodal way of interaction that holds up conversation and specifically the question-answer interplay. In the diagnostic manual a deficient turn-taking is mentioned by the name of “failure of normal back-and-forth conversation” and appears as A.1 in the diagnostic criteria (A, “persisting deficits in social communication and social interaction”; 1, “deficits in social-emotional reciprocity.”). Thus, again, it seems that turn-taking does not involve language according to the manual.

In conclusion, questions do not seem to naturally fit into the DSM-V vision of language in this disorder, due to the dichotomous viewpoint of language it adopts, even when considered from the present viewpoint, which combines a study of structural language in utterances addressed to participants with their answers to these questions as evidence of their comprehension. Our results demonstrate that there is a covariation between the structural language in *wh*-questions and the degree of understanding as manifest in the responses, with a lowered comprehension occurring across the whole autism spectrum. Crucially, by being instantiated in a structured setting, such a diminished performance in question comprehension cannot be attributed to problems with the social use of language.

1.3 Questions are key in relation to the most prominent deficits and theories of ASC

The current research approach to ASC consists in attempting to unify the social and communicative impairments characteristic of autism into a single underlying deficit that would explain why and how these two impairments overlap. This approach has given rise to three theories of autism, centered respectively on ToM (Theory of Mind), Weak Central Coherence and Joint Attention. In this subsection, some evidence will be presented that, in these three aspects, conversational interaction including the question-answer interplay has a role that has not been taken enough into consideration.

1.3.1 Questions in relation to ToM theory

The role of language in the development of mature ToM, the ability to recognize and understand other's beliefs and intentions, has been widely defended in research (Astington & Baird, 2005). Most of this research has been focused on complex embedded sentence structures, which has been the most significant predictor to pass false-beliefs (FB) tasks (Tager-Flusberg & Joseph, 2005). However, this competence on clausal embedding has been studied at the level of structural language rather than in interactional language or conversation. The latter kind of language influence starts earlier in development and seems to be constant and host the former to a significant extent. De Villiers and de Villiers (2014) argue (1) that conversation itself provides the child with constant opportunities to understand the different perspectives people have on the same events in a much more explicit and rich manner than eye gaze, and nonverbal communication and behavior in general; (2) that the use by the learner of the relevant grammatical structures (*John thought that X did Y but it was Z who did it*) might work as the "medium in which to think" and, more crucial for us given our interest in questions,

(3) that the content of ToM is revealed to the infant by the oral explanations that caregivers give to him or her, which often present with questions:

> A child who does not yet have language has clear wants and feelings, and practiced caregivers can "read" his or her behaviors and interpret them, providing food, or assistance, or comfort. Parents usually accompany this with explanations and labels, saying things like: "Do you want this juice? Or "Is your finger hurting? (p.313)

Reading children's minds and speaking out their desires, feelings and thoughts must help children label their mental states even before they perform a whole question-answer turn-taking, which seems the optimal way to ascertain the interlocutors' mental states at all stages of human life. An impairment in question comprehension could therefore be damaging for the attainment of solid ToM skills. If so, the facet of language use consisting in interacting through question-answering would need to be considered among aspects influencing ToM development. This is particularly true on recent theories of ToM such as Heyes and Frith (2014) and Heyes et al. (2020), which argue for a cultural evolution of mind-reading, noting the critical role of language and parental tutoring, though scarcely reflecting on the significance of its specific properties.

1.3.2 Questions in relation to the Weak Central Coherence theory

Uta Frith coined the term Weak Central Coherence (WCC) to refer to an ASC bias toward local processing lacking integration and coherence. WCC also assumes a deficit in integrating context in conversation (and written discourse). In this domain, difficulties in grasping non-literal meaning in ASC (e.g. irony, jokes, inferencing and indirect requests) show a deficit integrating information from different sources into context, according to WCC. However, concrete investigations seem to have arrived to contradictory results on that. For example, comprehension of indirect requests, that is declarative or interrogative sentences (conventionally) interpreted as commands, has been found to be intact in high-

functioning autism (Deliens et al., 2018). Regarding inferencing, Saldaña and Frith (2007) obtained results which were not supportive of any deficit in high-functioning autism, unlike Norbury and Bishop (2002), who interpreted their results as consistent with the WCC. Interestingly, neither the former nor the latter controlled for question understanding independently, despite that the inferencing capacities investigated were assessed by means of questions. Intriguingly, *yes/no*-questions were used in the former while *wh*-questions were used in the latter. It seems likely that the *yes/no*- *vs*. the *wh*-format of the questions may have been a confound. In addition, the previously mentioned studies did not look at integration into context in a conversation, the most naturalistic setting for discourse building.

1.3.3 Questions in relation to the Join Attention theory

A deficit in joint attention (JA), seen independently of or as a component of ToM, lies at the heart of autism according to the Joint Attention theory. Occurrences of JA are established as those in which a dyad of infant and adult coordinate in alternating visual attention to each other and a third entity in the world. In instances of JA, according to this definition, eye gaze is key, and head turns and pointing will commonly concur. Bruner (1981), however, noted that speech is primordial in JA and it is present since its first instances:

> The first phase of managing joint attention, very much under the control of the mother, appears to result in the child learning that there are signals in the mother's speech envelope that indicate that there is 'something to look at' that the mother is attending to. It is hard to date the end of the phase but 6 or 7 months seems a good point at which to talk about the peak of this period of mastering the attentional vocative or 'undifferentiated' (p. 165)

In line with Bruner, Marno et al. (2015) report that 4-months-old children expect that speech stimuli refer to the world in a way that other auditory stimuli do not, as shown by their faster visual orienting towards objects. Moreover, they state that "the object-directed gaze of the speaker is helpful to find the referent of the speech only if it is preceded by speech." (Marno et al., 2015, p. 4).

Bruner (1981) also points out how the primeval questions in language acquisition involving *what* and *where* are linked to JA, a statement that we have not been able to find in more recent literature:

> Once pointing and PCFs [the phonologically constant form by which the child comes to 'indicate' objects] appear, they immediately become embedded in ritualized dialogue of the familiar 'Where' and 'What' games. Long before, both our mothers had established a 'slot' for points and PCFs, Jonathan's mother beginning with questions like Where's the X? Where did it go? even as early as 4 months and Richard's mother with What's this? as she presented objects at 9 months —neither case with any possibility of appropriate response (i.e. point to the object or give label). Once pointing appears, Where's the X? becomes a real demand for a point to a specific object (well-established for Jonathan by 12 months and for Richard by 13-14 months). At 15 months, this query is embodied for both children in the formatted game procedure of pointing to body parts. At about the same time, What's that? becomes a demand for a PCF and, later, for a specific name. (p. 166)

In sum, the vocal part of human communication would be primary for referencing objects in the world, with *what* and *where* questions playing a foundational role in the establishment of the referential function of language in language acquisition. Thus, it could be expected that a question comprehension impairment in ASC may affect JA.

1.4 The practical significance of question comprehension in ASC

Although a difficulty in answering questions (especially to *wh*-questions) in children with ASC has been demonstrated in research, as reviewed in the next chapter, questions and its answers are used in different tests and assessments in ASC regardless of the difficulties

they may pose in virtue of their intrinsic features. For example, the Autism Diagnostic Observation Scale (ADOS; Lord et al., 1989) uses questions in its module 3 for participants who have fluent language. In more specific terms, this module includes four tasks where the individual needs to answer questions about different feelings (e.g. *What scares you?*), social difficulties (e.g. *Have you ever been bullied*?), loneliness (e.g. *Have you ever felt alone?*) and abstract concepts such as friendship (e.g. *What does it mean to you to be friends?*). The objective of these tasks is to obtain a detailed description of the individual's feelings, assess his or her personal insight of possible social difficulties and his or her understanding of the concept of friendship. In addition, in the Autism Diagnostic Interview-Revised (ADI-R; Le Couteur et al., 2003), parents are asked whether their child can ask questions to build a conversation or if he or she asks or makes inappropriate social questions or comments.

Furthermore, answers to questions have also been used to assess ToM, which an extensive literature reports to be impaired in ASC (Baron-Cohen et al., 1985; Mathersul et al., 2013; Peterson et al., 2012). One of the most common tasks to assess ToM are FB tasks. They consist in orally answering a question about a character's knowledge of a situation and actions, in which his or her knowledge is incomplete. One of the most renowned FB tasks is the Sally-Anne test (Baron-Cohen et al., 1985). The participant watches Sally placing a marble into her basket. Then, she goes out and Anne places the marble to her box. Finally, Sally comes back. Then, the experimenter asks to the child the critical Belief Question "*where will Sally look for her marble*?". If the child answers or points to the basket and has correctly answered a reality question (*Where is the marble really?*) and a memory question (*Where was the marble in the beginning?*), it is assumed that he or she understands FB and has ToM abilities. Regarding the complexity of the structure of these questions, Baron-Cohen et al. (1985) state that "there is no reason to

believe that the three questions differ from each other in terms of *psycholinguistic* complexity, but of course we hypothesize that they differ in terms of *conceptual* complexity" (p.42). Therefore, it is assumed that questions are fully understood and the only assessed issue is the conceptual understanding. However, the two control questions (the memory and the reality ones) are copular *wh*-questions, whereas the critical belief question is a non-copular *wh*-question. In addition, the latter involves more argumental dependents and there is an anaphoric relation. Thus, equal complexity among these sentences and similar ones used in this kind of tasks would need to be proved and not just assumed because children's performance in such tasks could be biased due to question complexity. Rubio-Fernández (2015) suggested that young children fail FB tasks because they lose the protagonist's perspective and not because they attribute their own knowledge to the protagonist by default. This suggestion was supported by the results obtained in a task named the Duplo task. In this task, 3-year old children were able to pass FB questions if they were focused on the protagonist throughout the narrative (e.g. *What is the girl going to do now?*), although they fail it when the target object was mentioned in the test phase, in a control question (e.g. *Where are the bananas now?*) or to make the protagonist's goal explicit (e.g. *Now Lola is very hungry and wants a banana. What happens next? What is Lola going to do now?*). This study suggests that children are sensitive to the structure of the question. This may influence the standard ToM tests.

In conclusion, questions are present in several ASC diagnostic and cognitive assessments, often without consideration that individuals with ASC may not answer appropriately because they do not understand the questions *per se*. As discussed in this section, question complexity may matter to results of these tests. Thus, question comprehension abilities should be subjected to separate study.

Chapter 2. Questions: their form and acquisition

As mentioned in Chapter 1, the central aim of this thesis is to study question comprehension in ASC. We will do this by quantifying correct answers to *yes/no* and *wh*-questions[2], and to different types of *wh*-questions that exhibit different forms of syntactic complexity. These types of questions will be discussed in Section 2.1. In this way, we approach questions from a syntactic point of view. In addition, we study question-answer pairs as discourse units, because answers can show us if the question is understood and whether the syntactic complexity of the question may affect this comprehension. In agreement with the pragmatic view, we understand questions as requests of some information to a receiver by a speaker, i.e. as interrogative acts (Searle, 1969). However, we do not consider questions from a semantic perspective.

As will be elaborated in Section 2.2, studies so far have largely only targeted the chronological order of the acquisition of different *wh*-question, the onset of long-distance dependencies, and the children's inversion errors in non-subject *wh*-questions in English. Furthermore, there is not a commonly accepted theory of questions. Although existing semantic and syntactic theories point to a higher degree of complexity in *wh*-questions in comparison to *yes/no*-questions, little literature has been devoted to the difference in production and comprehension of these different types of questions (see further Section 2.3).

In turn, only few authors have studied question comprehension in ASC, although this type of structure plays an important role in standardized tests such as ADOS or ADI-

[2] From now on, we will refer to total or polar questions as *yes/no*-questions and partial questions as *wh*-questions.

R. The available literature is discussed in Section 2.4 of this chapter. Finally, Section 2.5 reviews biological and cognitive factors that might affect question comprehension.

2.1 Question types

There are two main types of questions cross-linguistically, *yes/no*-questions and *wh*-questions. Other minor types have been distinguished, such as *A-not-A* questions (e.g. *Can you open or cannot you open the bag of cookies?*), which are present in some Chinese dialects such as Mandarin or Cantonese and in Taiwanese, and *choice* questions (e.g. *Are the glasses on the table or on the chair?*). Here we will focus on the properties of the two main types, i.e. *yes/no*- and *wh*- questions, which are the relevant ones for our study. We will ignore differences between *wh*-expressions that solely concern the *wh*-word involved (*what, where, who,* etc.), or their phrasal complexity, as in *which film, at what place, which student from the Netherlands*, etc., where the *wh*-element has 'pied-piped' an NP. The latter will not play a role in what follows because in our pool of tested questions there is no *wh*-expression encompassing anything other than the *wh*-element itself. This choice is pertinent since bare *wh*-expressions (*what, where, who,* etc,) are considered simpler than those with a pied-piped accompaniment (*which book, which student*) for the reason that only the latter are discourse-linked in the sense that unlike the former, they contain a discourse presupposition (Avrutin, 2000). Compare in this regard *What will you read tomorrow?* with *Which book will you read tomorrow?*

In what follows, a set of concepts and terms used will be cast in the framework of transformational/Chomskyan generative grammar (TGG). This framework has pioneered the formal description of questions as they appear in adult grammars. Yet, in accordance with the rationale presented in the first chapter, we use it here more for practical convenience than endorsement. In this regard it is both paradoxical and revealing that

questions have been so central to the TGG framework (see footnote 5). It is paradoxical because questions have their *raison-d'être* in an interactional, communicative setting, which as said in Chapter 1 is not centrally thematized in TGG; it is revealing because even in relation to questions, the thesis of the autonomy of formal syntax is maintained. To our knowledge, in TGG standard practice on adult grammars[3], responses to questions are only alluded to when dealing with multiple *wh*-questions that emerge in configurations like *Who saw what?* but not in *Who knows what she saw?,* a contrast which can only be demonstrated by comparing the paired *who-what* response required by the former and the single one associated to the latter. Putting aside the limits of such an approach for an integral understanding of questions, we take advantage here of TGG's exclusive focus on the form of questions to shape and classify the questions in our pool according to its criteria. In this way we will trace the influence of the syntactic form of interrogative sentences (especially of *wh*-questions) on question comprehension in the ASC population in comparison with TD and ID groups.

2.1.1 Wh-questions

Wh-questions can present themselves *in situ* or *ex situ* with respect to the order of the valued constituent in the corresponding response or equivalently with respect to the canonical appearance in declarative sentences of the constituent type being questioned. This means that in an *in-situ* question, word order does not change with respect to the corresponding declarative sentence. *In-situ* questions (*You want what?*) are likely present

[3] Had "on adult grammars" be missing, the claim in the main text would be an overstatement. Looking at responses in order to test question comprehension is a method that can be found in research on language acquisition within the GGT framework. See for instance Kotfila & de Villiers 2019.

in all languages but when occuring in a language which canonically has *ex-situ* questions (*What do you want?*), they are not always appropriate and interpretively exchangeable with the *ex-situ* ones. Thus, regarding canonical questions languages can be classified as belonging to the *in-situ* or *ex-situ* types. The *in-situ* type is widespread in East Asian languages while *ex-situ-wh*-questions are the rule in Indo-European languages, either exclusively or predominantly —like in French, where *in-situ-wh*-questions are also possible. The *ex-situ* arrangement consists of the *wh*-word occurring at the beginning of the sentence, in the initial periphery —also called left periphery, a misnomer induced by the left-to-right writing characteristic of Indo-European languages[4]. A minimal representation of both arrangements in the framework of TGG would be as in (1) and (2) where V means verb and X and Y are variables; TP stands for Tense Phrase and CP stands for Complementizer Phrase —which corresponds to the ordinary notion of *sentence*:

(1) *In situ*: [$_{CP}$ [$_{TP}$ X (V) wh (V) Y]]

(2) *Ex situ*: [$_{CP}$ wh __ [$_{TP}$ X (V) ~~wh~~ (V)Y]]

In both of the possible arrangements, *wh*-words play a double role: They are both the vehicle of interrogative force when appearing in main clause —as represented directly in (1) and by a double occurrence in (2) —an overt one at the front and a silent one in the argument or adjunct position. In TGG, this double role is understood in terms of the notion of movement, which is widely assumed to be overt in *ex-situ-wh* languages and

[4]A different *ex situ* occurrence is shown in sign languages, where in general —with the exception of ASL, which is more similar to spoken languages— the *wh*-word appears at the end of the sentence preferentially and can either alternate with a single *in situ* presentation or be concurrent with an *in situ* instance in a doubled *in-situ* + *ex-situ* display.

covert in *in-situ-wh* languages. Independently of the controversial issue of whether there is anything like movement in syntax[5], it is clear that *ex-situ-wh*-questions often yield a non-adjacent relation between a fronted *wh*-expression and a lexical verb, which is needed for the *wh*-expression to be linked to its argument or adjunct role in the sentence. Compare in this regard *John bought a book* and *What did John buy*? In the declarative sentence, the theme/patient argument, *a book*, is adjacent to the verb while in the interrogative one, *what* and *buy* are not adjacent any more. In English, this is the general pattern in simple (i.e. monoclausal) interrogative sentences with the exception of subject questions (*John bought a book* and *Who bought a book?*). Yet, despite the distance between the initial *wh*-expression and the verb form in non-subject questions, all *wh*-questions in simple sentences (i.e. without embedded clauses) are considered local in comparison to *wh*-questions in complex sentences, where the (verbal) predicate semantically linked to the *wh*-expression is the embedded one. In such complex *wh*-sentences, the distance is thus larger than in simple *wh*-sentences. To illustrate this point, in (3) we have two local *wh*-questions, a local subject *wh*-question (3a) and a local object *wh*-question —(3b), (3c)—, while in (4) we have a long-distance *wh*-question, a long-distance subject *wh*-question in (4a) and a long-distance object *wh*-question in (4b).

(3) a. Who said that?

b. What will John say?

c. What has John said?

(4) a. Who do you think said that?

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[5] The centrality of *wh-questions in* TGG relates to the issue of long-distance dependencies being treated as involving movement, which is the hallmark of a derivational theory like TGG. Foundational pieces along its history revolve precisely around *wh*-questions: wh-movement in *On Wh-movement* (Chomsky, 1977), the bounding module with its subjacency principle in *Lectures on Government and Binding* (Chomsky, 1981) and barriers in *Barriers* (Chomsky, 1986), among others.

b. What do you think he said?

Since the difference between local and non-local/long-distance *wh*-questions depends on the semantic (argument/adjunct) link with either the main predicate or an embedded predicate, respectively, the notion of local *vs*. long-distance applies to all *ex-situ-wh-* languages in the same way irrespectively of the fact that in English and similar languages the *wh*-expression is actually detached from the lexical verb in local non-subject questions.

In Spanish, like in Romance null-subject languages in general, in simple *wh*-interrogative sentences the *wh*-expression is always adjacent to the verb (and its clitics), so that the local *vs*. long-distance distinction is closer to the raw data, as shown below in (5). Note that in this language, in contrast to English, the *wh*-expression and the verb are adjacent both in subject and object simple *wh*-interrogative sentences ((5a), and (5b), (5c), respectively), while, like in English, they are not adjacent any more in either (6a) or (6b), which are both examples of long-distance *wh*-questions:

(5) a. ¿Quién dijo esto? (*Who said that?)*

b. ¿Qué dirá Juan? (*What will John say?)*

c. ¿Qué ha dicho Juan? (*What has John said?*)

(6) a. ¿Quién crees que lo dijo? (*Who do you think said that?*)

b. ¿Qué crees que dijo? (*What do you think he said?)*

Finally, it is convenient to make clear that a complex *wh*-interrogative sentence does not necessarily present with a long-distance-*wh*-dependency. Thus (7a) for English and (7b) for Spanish illustrate that despite sentences being complex, the *wh*-dependency is local according to the definition: in both cases the *wh*-expression is interpreted as the goal argument of the main predicate:

(7) a. To whom did you say that John was not there?

b. ¿A quién dijiste que Juan no estaba?

The difference between (3) and (5) deserves a further comment. As (3b) and (3c) *vs*. (5b) and (5c) show, the arrangement of the initial periphery is not the same in English and Spanish. The contrast between (3c) and (5c) is especially relevant in this regard, as it illustrates how in English the auxiliary and the verb split, yielding the characteristic subject auxiliary inversion which, except for main subject *wh*-questions, is found in all kind of questions — *yes/no* questions included as we will see next. Such a split does not occur in Spanish. This notwithstanding, the fact that *Juan* in (5b) and in (5c) cannot appear preceding the verb (**Qué Juan dirá/ ha dicho?*) has been interpreted as showing subject-auxiliary inversion, albeit of a different kind. To our understanding, this view is unlikely to be correct as it is at odds with the fact that, unlike children acquiring English, children acquiring Spanish and other Romance null subject languages attain the adult form of the initial sentence periphery from the very beginning, which is reported below by de Villiers and Roeper (2011):

> In stark contrast to English, in children acquiring Romance languages, there is no individual variation in subject-aux inversion: children in several languages show a 100% adult-like inversion rate from their very first production of *wh*-questions (Goodall 2004). This pattern has been attested in Catalan (Serrat and Capdevila 2001), European Portuguese (Soares 2003), Italian (Guasti 2000), and Spanish (Pérez-Leroux and Dalious 1998; Serrat and Capdevila 2001). Why might this be so? (p.202)

To face this striking difference, there have been different proposals in the TGG framework. There are those that propose that in Spanish questions there is no inversion but an unmoved subject internal to VP, which would also account for the fact that, unlike English, the verb-subject order in embedded *wh*-clauses in Spanish is the same as in the main ones (Pérez-Leroux and Dalious, 1998). A slightly different and similarly apt

approach is that of Spinner and Grinstead (2006), according to which in Romance null subject languages *wh*-expressions, topicalization and "subjects" compete for the same preverbal position. Be that as it may, one must conclude that the initial sentential periphery in those languages should be considered less complex than in English, particularly in the light of acquisition facts, which we consider especially relevant in our study. Accordingly, transferred to developmental conditions, one should expect that *wh*-questions were also simpler for the affected null-subject Romance language speaking populations.

2.1.2 Yes/no-questions

The form of *yes/no*-questions has not received as much attention *per se* as that of *wh*-questions. Yet the subject-auxiliary verb inversion they present with (*John was watching TV* vs. *Was John watching TV*), when occurring in a sentence whose subject is modified by a subject relative clause also containing an auxiliary (*Is the boy who is sick watching TV?*), has been one of the main empirical data points around which the debate about the innateness of structure dependence (Tyack and Ingram, 1977; de Villiers, 1991) has been constructed.

From the point of view of TGG, the structure of *yes/no*-questions is the same as that of *wh*-questions once the *wh*-element is subtracted. That way one can say that they are structurally simpler than *wh*-questions, since they consist of the otherwise sister constituent of the *wh*-fronted element in *wh*-questions. Thus if (8) above, repeated below, is the schematic representation of a *wh*-question, the structure in the square in (9) is that corresponding to *yes/no*-questions. In both cases, the empty slot __ is mandatorily

occupied by the auxiliary —except for subject *wh*-questions other than those with the *be* or *have* auxiliaries.

(8) *Wh*-question

[$_{CP}$ wh __ [$_{TP}$ X (V) ~~wh~~ (V)Y]]

Where V includes copulas and X and Y are variables; ~~wh~~, wh in its argument or adjunct position.

(9) *Yes/no*-question

[$_{CP}$ __ [$_{TP}$ X V Y]]

Where V includes copulas and X and Y are variables.

Regarding subject-auxiliary inversion, the structure posited for *yes/no*-questions in English translates into the Spanish with the same pattern as the one seen in *wh*-questions, namely no auxiliary-verb splitting by the subject. Furthermore, the absence of a *wh*-fronted constituent can yield *yes/no* interrogative sentences, which in their surface structure are exactly the same as the correspondent declarative ones except for their distinctive prosody —as is the case for all *yes/no*-questions used in the present study.

2.2 Production of *yes/no*- and *wh*-questions in TD children

Since the 1970s, there has been a lot more research on the production and order of acquisition of different interrogative structures, than on their comprehension (Moradlou et al., 2020). However, we can assume that in general, linguistic comprehension is acquired earlier than production because comprehension requires that the child has access to a stored representation from the sounds it has perceived, whereas production additionally requires a successful generation of that representation (Huttenlocher, 1974).

In the 1980s, the acquisition of questions started to be studied, especially the structure of *wh*-questions in English. Most of these studies were couched within either the usage-based theory (Bybee, 1995; Tomasello, 2006) or the nativist one (Chomsky, 1968, 1980). From the point of view of the former, children do not have access to adult language constructions from the beginning, but they acquire grammatical structures following two processes. In the first, children produce *wh*-questions containing concrete structures that are very frequent in the input (e.g., *Where is* + NP[6]). Children use the first part of the question, *where is*, as a fixed structure and they only exchange the NP. These first productions moreover occur in specific, concrete contexts. In the second process, children learn a generalization to produce more complex and abstract *wh*-questions.

According to nativism, by contrast, children use Universal Grammar (UG) to understand and produce linguistic structures with little exposure to them (Chomsky, 1968, 1980). Following this point of view, children would have available grammar rules about *wh*-movement, which allow them to produce *wh*-questions with little previous adult input. Regarding questions, this position is controversial because children do not acquire all *wh*-questions at the same time.

In particular, it is established that TD children first produce *what* and *where wh*-questions by the age of 27-29 months (Bloom et al., 1982; Stromswold, 1995). Bloom et al. (1982) explained why these are the first *wh*-questions with a theory based on complexity. According to it, children first acquire *wh*-questions that ask for identities of things and places and occur primarily with the copula. These first type of questions are formulaic and used for social routines (*What is that? or Where is the [NP]*?). Until the

[6] NP= Noun Phrase.

age of 3, children do not produce more complex questions such as subject and object *wh*-questions, inverted auxiliaries and the ones used to request information (Ambridge et al., 2006; Stromswold, 1995). It is not until around the age of 5 that children are fully competent to produce all kinds of *wh*-questions (Serra et al., 2000, Serrat & Capdevila, 2001, Tomasello, 2006). The same age of onset for *wh*-questions production has been documented in French (Hamman, 2006). In this language, it is also reported that at the age of four to five years, French children produce more *ex-situ-wh*-questions (which are more syntactically complex) than *in-situ-wh*-questions (Hulk & Zuckermman, 2000).

In order to be able to produce this type of questions, children need to already have grammar (e.g. interrogative expressions ─e.g. *what*, *where* and *who*, among others), semantics (e.g. concepts about time, mode, cause and location) and pragmatic knowledge (i.e., they need to know the particular use of these structures). Undoubtedly some other cognitive capacities such as working memory (WM) and the capacity of abstraction and generalization (Aveledo & Martins, 2009, p.7) must also be in place.

As for the acquisition (production) of questions in Spanish in particular, there are fewer studies than in English. In the eighties, Hernández-Pina (1984) reported similar acquisition processes of *wh*-questions in Spanish and English. In her longitudinal study of one case, she found that the *wh*-questions most produced by the child were those with *what* and *where*. Then, at the age of 30 months, the child started to produce *wh*-questions with *who*. According to their results, from this age on, children start to produce more diverse *wh*-questions (they produce *wh*-questions with different *wh*-elements). Aguado (1988) also supports the findings that *wh*-questions with *what* are the most used ones and that 30 months old children produce *wh*-questions. Finally, Serrat and Capdevila (2001) also coincide with the onset age of *wh*-production in Spanish and with the fact that *what* *wh*-questions are the most frequent ones (83% of the total number of *wh*-questions). They

also agree with the aforementioned studies about the acquisition path of different *wh*-questions, with *what*- and *where*-questions the first to be produced at the age of 2 years, especially *What is [NP]?* or *Where is the [NP]*? From 25 to 28 months, children start to produce their first questions with *who* and *how* as *wh*-elements. Later, at 30 months old, children produce examples of *which, why* and *when wh*-questions as well. This study would also be in line with Bloom et al. (1982), confirming that the first *wh*-questions produced by children would be more formulaic than the later ones.

A difference in the acquisition of *wh*-questions in Spanish and in English documented by Serrat and Capdevila (2001) concerns errors. These authors did not find any syntactic errors in the production of *wh*-questions. In more specific terms, they did not observe any omission of the main verb as found in English (Bloom et al., 1982); neither errors in the syntactic structure, such as children's inversion errors in non-subject *wh*-questions, as observed in English (Ambridge et al., 2006).

Although studies about questions have been more focused on the acquisition process, there is also evidence about the frequency with which these types of structures appear in children's language. Newport et al. (1977) analysed children from 12 to 27 months in interaction with their mothers. They found that 44% of child-directed utterances were questions (15% *wh*-questions, 21% *yes/no*-questions and 8% deictic questions ─this last type signifying questions that contain one or more elements whose identification depends on the context (for example, the question *Is there a ball here*?, where *here* needs to be interpreted according to the situation of communication where it occurs). As these are results from interactions between mothers and their children, it is worth noting the amount of input of this type of structures that children receive. Cameron-Faulkner et al. (2003) reported that questions are 31% of maternal utterances, with 16% being *wh*-questions and 15% being *yes/no*-questions. Therefore, questions are

prominently present both in children's language and in their communication with parents and caregivers.

In conclusion, questions represent about one third of children's linguistic production, which is a similar percentage of the input of questions they receive from adults. Linguistic research focused on the acquisition of *wh*-questions coincide that TD children start to use *wh*-questions around the age of 27-29 months and the first ones are *what*- and *where*-questions. Later, children start to produce *who*-questions and the process of questions acquisition finishes at the age of 5, when TD children are able to produce all types of questions. Although most of these studies are in English, the time course of the production of *wh*-questions has been replicated in other languages including Spanish. The difference between English and Spanish in this respect is that regarding the initial sentence periphery, which are mainly related to the subject-auxiliary inversion in English and other languages, are nonexistent in Spanish where the fronted *wh*-expression is usually adjacent to the (auxiliary +) verb (and its clitics).

2.3 Comprehension of *yes/no*- and *wh*-questions in TD children

As noted there are fewer studies about question comprehension in comparison to production, especially if we consider the amount of research on *wh*-question acquisition. Furthermore, while *yes/no*-questions and *wh*-questions have been extensively studied from syntactic and formal-semantic points of view, there remains a point of debate about which of these types of question is easier to understand relative to the other. Thus, while in syntactic and semantic theories the dominant view is that *yes/no*-questions are simpler than *wh*-questions, a recent study on the acquisitions of *wh*-question comprehension by Moradlou et al. (2020) presents evidence against this view as presented below summarily.

In syntactic theories *yes/no*-questions are viewed as simpler than *wh*-questions with the former structurally realized as the *wh*- ones once the specifier position occupied by the *wh*-expression is subtracted —see 2.1.2. some semantic theories, such as the partition (Groenendijk & Stokhof, 1997) and the propositional (Ginzburg & Sag, 2000) theories, *yes/no*-questions are also simpler to understand than *wh*-questions. In more concrete terms, in the partition theory, a *yes/no*-question denotes a binary partition (the question can only be resolved positively or negatively) but a *wh*-question has a less determinate partition because it depends on the number of possible entities that could answer it. In this conceptual framework, Casillas et al. (2016) suggest that a *yes/no*-question is easier to understand than a *wh*-question because "*yes/no*-questions minimally require assent or denial, whereas *wh*-questions require that the answer contain specific pieces of information" (Casillas et al., 2016, p. 7). According to the propositional theory, a *yes/no*-question "denotes a constant function, whose value is the queried proposition. A unary *wh*-interrogative denotes a function from possible candidate entities into the answers where they instantiate the property in question" (Moradlou et al., 2020, p. 2).

As announced, the results of the study by Moradlou et al. (2020) are contrary to what syntactic and semantic theories would predict, since the authors reported that the children in their study understood *wh*-questions before *yes/no*-questions. Such results were obtained by means of a design using a picture book task with 17 German-speaking (ages 1.2-3.1, mean 1.9) and 27 Chinese-speaking children (ages 1.5-2.9, mean 2.0), who had to answer different questions about the drawings of objects and animals they saw. As of now, Moradlou et al. (2020) is to our knowledge the only study where *wh*-questions are comprehended before *yes/no*-questions. As said, there are however few studies devoted to this issue and they are not recent. Ervin-Tripp (1970) also conducted one study about comprehension in *yes/no*-questions and *wh*-questions. In this study, answers of

children from 1.9-2.5 years old were analysed. Her results show that children first understand *yes/no*, *what* and *where* questions. These results are in line with the findings in Tyack and Ingram (1977). *Wh*-questions containing *why*, *who*, *how* and *when* are comprehended later according to these studies.

These findings suggest a similar pattern in production and comprehension of questions, but it has also been shown that typically developing (TD) children understand subject and object *wh*-questions earlier than their production starts (e.g. De Villiers & de Villiers, 1995; Seidl et al., 2003). For example, Seidl et al. (2003) found that TD children could understand object and subject *what wh*-questions and *where wh*-questions at 20 months of age in a preferential looking task. In this study, it was also reported that children at 13 months of age did not show the ability to comprehend any of these three types of questions and it seems that children at 15 months could understand subject *what wh*-questions and *where wh*-questions but not object *wh*-questions. Authors explain this last result due to the difficulty of either representing or processing the longer dependency between the filler and the gap in an object *wh*-question, as compared to a subject *wh*-question. In this regard, authors also pointed to the idea that children at 15 months old do not have sufficient WM for processing long-distance dependencies.

Gagliardi et al. (2016) designed a similar study as Seidl et al. (2003) but with more trials of each object and subject questions. In particular, the study consisted of six trials in which an event occurred twice. For example, a dog bumped a cat, who then bumped a different dog. Then, children saw images of both dogs and heard either a subject or object *wh*-question or relative clause. Their results show that 15-month old children apparently comprehend both subject and object *wh*-questions and subject and object relative clauses. Their 20-months old participants also succeeded in comprehending both types of *wh*-questions. However, they performed surprisingly worse with relative clauses than their

younger peers. The authors explained these results by considering that children at 15 and 20 months old used different strategies. Specifically, infants at 15 months could be able to predict an argument of a sentence in a particular position and notice when it is missing. They would be using a gap-driven heuristic which does not entail the computation of the filler-gap dependency.

Perkins and Lidz (2020) reported similar results as Gagliardi et al. (2016). In more specific terms, they found that at 15 months some children comprehended *wh*-questions and relative clauses. What was key is that only 15-month-olds that had learned enough verbs were to deploy the gap-driven heuristics were those that appeared to understand questions.

Finally, the processing time of answering different types of questions has also been analysed. Casillas et al. (2016) found in a longitudinal study with 5 children from age 1.8 to 3.5 that *yes/no*-questions were answered faster and that *what* and *where wh*-questions (the ones acquired first) had shorter latencies than *who*.

In conclusion, evidence regarding *yes/no*- and *wh*-question comprehension is still incomplete. It is also evident that there are studies with different results regarding which type of question comprehension develops first. However, several studies mentioned above coincide that *wh*-question comprehension follows a similar development pattern as production, with *what*- and *where*-questions being the first ones to be understood by children. Nevertheless, the onset age when *wh*-questions start to be comprehended is not well-established. Most authors coincide that children start to comprehend *wh*-questions at 20 months, but there are some studies that show that children at 15-months-old could understand *where* and *who*-questions, although this could be related to their level of vocabulary for verbs, which would allow them to know that there is a gap in the structure

to be filled. If that was the case, one could not conclude that they understand questions *per se*.

2.4 Question production and comprehension in ASC

According to the fifth edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM; American Psychological Association, 2013), autism is a spectrum of neurodevelopmental conditions whose diagnostic criteria are (i) deficits in social interaction and communication and (ii) presence of restricted and repetitive behaviours and interests. As mentioned in Section 1.2, a language disorder understood as an "impairment in structural language" is secondary to ASC, which is a novelty with respect to previous versions of the DSM where such a disorder was considered a core diagnostic criterion of ASC. Questions matter in this respect. Asking questions is required in order to be considered socially competent during conversations (Koegel, 2000). Vicker (2004a) reported that the ability to answer questions is a common deficit in many children with ASC. In addition, Sanders et al. (2016) found that preschool-aged children with ASC in inclusive classrooms were asked fewer cognitively challenging questions than their peers, and students with ASC with higher language levels were asked more cognitively challenging questions than children with ASC and lower language levels. This lower input reduces the opportunities of ASC children to develop questions production and comprehension.

Regarding question production, Tager-Flusberg et al. (1990) studied language samples of six ASC children (five out of six of them without ID) who were matched on age and mean length of utterance with six children with Down syndrome. Both groups' production was compared with TD children's using the Index of Productive Syntax, a test

with four subscales: noun phrase, verb phrase, question (it includes mostly *wh*-questions but also *yes/no*-questions) and negation and sentence structure. ASC and Down syndrome children only differ significantly from the TD's production in the question and negation subscale. Eigsti et al. (2007) used the same test with 16 ASC children from 3 to 6 years old matched on non-verbal intelligence quotient (IQ), gender and chronological age (CA) with 16 developmentally delayed (DD) children and matched on non-verbal IQ (ASC mean = 80; DD mean= 82) and gender. Results of this show that ASC children were significantly lower in all the four subscales in comparison to the TD but the only difference between production in ASC and DD children was in the question and negation subscale, where it was shown that ASC children produced significantly fewer question and negation structures than the DD group.

Several studies (Kjelgaard & Tager-Flusberg, 2001; Allen & Rapin, 1992) have reported higher scores for expressive measures rather than receptive ones in ASC. Therefore, if production of questions is impaired in ASC as Tager-Flusberg et al. (1990) and Eigsti et al. (2007) found, more impaired levels of question comprehension would be expected. Furthermore, it has been found that even if individuals with ASC have the ability to offer an answer to a question, these answers are not always relevant to the social or communicative context (Adams et al., 2002; Happe, 1993; Volden, 2004). Despite the knowledge about this deficit, researchers have given little attention to their production and comprehension process in ASC, specially to *yes/no*-questions, because most of the studies are focused on *wh*-question, as seen below.

Regarding *wh*-questions, Goodwin et al. (2012) found, in a longitudinal study, that comprehension of subject and object *wh*-questions was delayed in ASC children (from 26 to 37 months of age in the first test) in comparison to age-matched TD children, but not when matched on overall language levels. They also conclude that both TD and ASC

groups comprehended *wh*-questions before producing similar forms, indicating that development occurred in a similar manner. Jyotishi et al. (2017) also studied *wh*-questions comprehension in TD and ASC children. The authors used the intermodal preferential looking (IPL) paradigm with 14 children with ASC and 17 TD children matched on language level. In more concrete terms, a video was shown, in which participants saw a costumed horse and bird serving as agents or patients of familiar transitive actions. During the test trials, they were displayed side by side with directing audios (e.g., *What did the horse tickle?* or *What hugged the bird*?). Authors coded children's eye movements offline. They found that TD children comprehended both subject and object *wh*-questions at 32 months of age. Comprehension of object *wh*-questions emerged chronologically later in children with ASC compared to their TD peers, but at similar levels of language. Performance on word order and social-pragmatic scores independently predicted both groups' later performance on *wh*-question comprehension. With respect to grammar, the authors justified a "grammatical-origins" account based on the fact that the ASC group did not reveal earlier and stable comprehension of *wh*-questions. Furthermore, their performance on subject-verb-object (SVO) word order predicted their later success in linguistic processing of *wh*-questions. With respect to pragmatics, the authors gave support to a "pragmatic-origins" argument because children's earlier socialization and communication scores strongly predicted their successful performance on *wh*-question comprehension.

Durrleman et al. (2016) also conducted a study about comprehension of syntactic complexity of *wh*-questions and relative clauses in ASC and TD in French but with older children than the two studies before mentioned. The authors measured syntactic complexity based on movement, intervention and feature similarity in subject and object *in-situ*- and *ex-situ*-*wh*-questions and relative clauses in French. Their participants were

45 TD participants from three school levels (mean ages = 4.9, 6.8, and 8.8). A subgroup of 15 TD of these three groups was matched with 15 ASC children on nonverbal reasoning, which was tested with Raven's Progressive Matrices. Their results revealed that ASC and TD children were affected by the same pattern of syntactic complexity, but ASC children had more difficulties to understand these linguistic structures. ASC performance correlated with non-verbal IQ. By contrast, TD performance was related to chronological age (CA).

Tanaka and Oi (2007) found that ASC–ID children answered properly virtually to all *wh*-questions, which referred to contextual information presented in a cartoon. Nevertheless, they failed to answer *wh*-questions produced by their mothers, which were very similar to those presented virtually. These findings could suggest that the greater difficulty in responding to *wh*-questions might not only come from the question format but also from contextual demands imposed when *wh*-questions are casually given during conversations.

Wh-question comprehension and production in ASC has been also compared to other atypical populations such as children with SLI. With this purpose, Prévost et al. (2017) conducted a study in French with 20 ASC children with and without ID and, according to the authors, with and without language impairment. Their CA was from 6 to 12 compared to age-matched children with SLI. There were also two TD groups: one group of 17 4-year-old TD children (who were approximately language controls for the SLI group) and another group of 12 6-year-old TD children. Significant results showed that ASC children produce less *wh*-questions than the other groups. Instead they used more *yes/no*-questions or tried to guess the answer to the question they were asked to formulate. In addition, ASC and SLI groups used significantly more *in-situ-wh*-questions, which were the least complex *wh*-questions, in comparison to the older TD group. No

significant results were reported between ASC and the youngest TD group about production of this type of *wh*-questions. In the comprehension task, ASC and SLI groups had no difficulties in object *wh*-questions comprehension with a certain degree of complexity, with *wh*-fronting and external merge of a question marker *est-ce que* insertion (ESK) (e.g. *Qui est-ce que le pingouin pousse*? "Who[m] is the penguin pushing?"). However, both groups displayed poorer performance with the most complex *wh*-questions, the ones that apart from *wh*-fronting, ESK and stylistic inversion (e.g., *Qui est-ce que pousse le pingouin*? "Who[m]ESKpushes the penguin?"). Both groups did not show greater effects of complexity in comprehension than in production and non-verbal abilities was not related to *wh*-question comprehension and production. However, accuracy in comprehension of subject *wh*-questions was lower in ASC than in SLI.

Cognitive factors such as WM may have an impact on *wh*-question comprehension. According to Goodall (2004): "A well-known finding from the processing literature is that filler-gap structures (such as *wh*-questions) strain working memory capacity, because the filler (*wh*-phrase) must be held in working memory until it can be assigned to a gap" (p.102). Individuals with ASC may have impaired WM abilities (Bennetto, Pennington & Rogers, 1996). This may have a negative effect on their *wh*-question comprehension as well.

Regarding the distinction between *yes/no*- and *wh*-questions, Tager-Flusberg (1994) studied this difference from a perspective of production of questions. Results of this study showed that ASC children (whose IQ range was from 61 to 108) used more *yes/no*-questions to seek information, agreement, and clarification than children with Down syndrome who used *wh*-questions far more frequently. Curcio and Paccia (1987) conducted one study about answers to *yes/no*-questions and *wh*-questions in English with ASC children with mild-to-moderate ID. They were the first to conclude that English

ASC children have greater difficulties in responding to *wh*-questions than *yes/no*-questions. According to these authors, the difference might be explained on the basis of the difficulties with generating information internally, which is a demand that only *wh*-questions would impose. With their own words:

> One would expect an increased need for externally imposed structure to result in greater difficulty with question forms where the child must generate the requested information himself rather than simply affirm or negate the truth value of information provided by the adult. (p. 91)

In turn, Hewitt (1998) described four English type of questions that were the most difficult to answer for adults with ASC and mild-to-borderline range of ID. These questions had more than seven words in length and were multi-clause sentences, inferential requirements and indirect requests for information.

Apart from these two last articles in English, answers to different types of questions (including *yes/no*-questions and *wh*-questions) in ASC have only been studied in Japanese (Oi 2005; 2008; 2010) and in Taiwanese (Huang and Oi, 2013), using a semi-structured setting to analyse children's response to maternal questions. In his first study about answers to *wh*-questions and *yes/no*-questions, Oi (2005) studied the answers of two ASC–ID boys. They were unable to make their intentions clear when they answered *wh*-questions, which assistants asked for clarification. However, they could clarify their intention with their answers to *yes/no*-questions. Later, the same author replicated these results in a single case study with a six-year-old Japanese ASC–ID child. According to Oi (2008), the results cannot be explained by the type of questions because, in this study, *yes/no*-questions were mainly used to ask about specific actions. On the other hand, *wh*-questions were used to handle cognitive or meta-cognitive matters. For this reason, differences in question content may also be more relevant than the type of questions.

In a most recent study, Oi (2010) reported that 12 ASC participants without ID (age range: 7.3 to 14.8 years old) had greater difficulty in responding to *wh*-questions than *yes/no*-questions to their mothers. In a significantly milder way, TD children also showed the same pattern. In addition, ASC children had most inappropriate answers to both types of questions in comparison to TD children. These findings were later replicated using a larger sample (Oi & Tanaka, 2011).

Huang and Oi (2013) studied question comprehension impairments in ASC in Taiwanese and Japanese. In this study, semi-structured conversations between 12 Taiwanese children with ASC–ID (age range from 7.1 to 14.9) and their mothers were analysed. They were compared with 12 TD children matched on age, sex, IQ and mean length of utterances in syllable. Results again confirmed greater difficulties in question comprehension for ASC–ID children in comparison to TD. In particular, ASC–ID children had more inappropriate answers to *wh*-questions than TD. But Taiwanese children did not show greater ease of answer to *yes/no*-questions, as the Japanese children with ASC–ID did. Instead, the Taiwanese children with ASC–ID showed relative ease in responding to A-not-A (e.g. *Are you happy or not?*) and choice questions (e.g. *Do you want to read a book or do you want to watch a film?*). The authors explained this last result assuming that A-not-A and choice questions in the Taiwanese are polar-type questions, like *yes/no*-questions. Authors also explored some hypotheses to explain why Taiwanese children with ASC–ID showed a greater ability to answer *yes/no*-questions in comparison to *wh*-questions. It seems that it could be an effect of one type of *yes/no*-question in Taiwanese, the ma-Q construction (e.g. *Tamen dou xihuan kai che ma?* (Taiwanese) / *Do they all like to drive?* (English)). Apparently, the expectation of obtaining a positive response from the respondent of the ma-Q in Mandarin and Taiwanese is less than 50% (Huang and Oi, 2013, p.5). Another possible explanation is

due to the Taiwanese *yes/no*-question form. This type of question in Taiwanese not only requires a *yes/no*-answer but verbally stating the proposition again (redundantly). Thus, an answer to a *yes/no*-question without this repetition could be evaluated as irrelevant in Taiwanese. Finally, the authors also considered that *yes/no*-questions in Taiwanese are more often used as directives than in Japanese. For this reason, both an answer and an action obeying could be expected to this type of question and it is well-established that ASC children have difficulties handling ambiguous language.

From the literature mentioned above, it can be concluded that questions have not been a prominent topic in ASC research, despite of their importance in interaction and social communication. In comparison to TD, children with ASC produce less questions and their comprehension of object and subject *wh*-questions is delayed. They also have greater difficulties in question comprehension, especially in *wh*-questions in comparison to *yes/no*-questions. There is no research about ASC question comprehension in Spanish, a language with *ex-situ wh*-questions and *yes/no*-questions that are different from declarative only prosodically. So, in ASC, it is still uncertain whether Spanish *ex-situ wh*-questions are also more difficult to comprehend than *yes/no*-questions, since ASC deficits in prosody may well affect *yes/no*-question comprehension in Spanish. In more concrete terms, individuals with ASC have deficits in perception and production of stress, intonation and phrasing (Paul et al., 2005). In addition, Rutherford et al. (2002) found aberrant perception of prosody in the speech of high-functioning or Asperger individuals, who scored lower rates in extracting mental state information from vocalizations.

Chapter 3. The role of visual support in language comprehension

Across human history, sequential images have been present, from cave paintings in prehistory to comics and picture books nowadays. Telling stories with them has been a frequent human activity but the role of this visual support for narratives has not been studied with much attention (Coderre, 2020, p. 225). However, there is a common presupposition that visual support can enhance language production and comprehension. It is referred to as the Visual Ease Assumption in Coderre (2020). This theory relies on the idea that pictures are more concrete representations of objects, less abstract than language (Quill, 1995). In addition, picture-based stimuli are more permanent than linguistic stimuli because they remain accessible perceptually while encoding the information whereas linguistic stimuli require faster and analytical processing (Quill, 1997). Therefore, according to this assumption, processing a story with visual support should be cognitively less demanding than without visual support.

The same assumption predicts that visual support should help clinical populations with language impairments, such as people with ASC. Visual-spatial processing has traditionally been viewed as a strength in ASC (Gately, 2008; Styslinger, 2012). For this reason, visual support is present in a lot of tests and assessments in ASC. For example, modules 2, 3 and 4 of the ADOS (Lord et al., 1989) include visual support in a narrative production task, where the child needs to tell a story from a picture book. ToM tests are also commonly based on visual information. One of the most common tasks to assess ToM are FB tasks, as mentioned in Subsection 2.4.1. They consist in answering verbally a question about a character's knowledge of a situation and actions, in which his or her knowledge is incomplete. Most of these tasks, including the well-known Sally-Anne test

(Baron-Cohen et al., 1985) and the ToM Task Battery (Hutchins et al., 2008), use visual information as well as language processing.

The most common types of intervention in ASC also use visual support to improve linguistic skills. For example, in the 'Social Stories' intervention, the child listens to a story with pictures to better understand a personal experience of a social situation and improve social responses. However, although these stories are generally told with visual stimuli (Hutchins and Prelock, 2013), Gray and Garand (1993) suggested that pictures could be distracting in this type of intervention. Another treatment method is the Picture Exchange Communication System (PECS) (Bondy and Frost, 2001). This method consists of using pictures to reference objects, people or actions, which individuals with severe language impairments can use to make requests to their caregivers. There are other interventions that are visually organized, such as the TEACH method (Shopler and Olley, 1982), according to which the use of pictures increases comprehension by reducing the need for abstract words and concepts. Roger and Myles (2001) also reported that children with limited verbal skills benefit from Comic Strip Conversations because these rely on extensive use of visual materials.

Temple Grandin (1995) claimed based on personal experience that people with ASC are "visual thinkers". In particular, she stated "… words are like a foreign language to me. I translate them into full-color movies, complete with sound, which run like a videotape in my head" (Grandin, 1995, p.23) Grandin emphasizes that individuals with autism have difficulty learning things that cannot be thought about in pictures. Individuals who work with children with autism need to understand how concepts can be formed visually to best teach their students (Eldred, 1998). However, in the second edition of her book in Grandin (2006), she corrects herself pointing out that "some -not all- ASC individuals are visual thinkers".

There are also studies finding good visual-spatial processing in ASC relative to other capacities. Hermelin and O'Connor (1970) found that visuospatial processing is superior to auditory processing skills for individuals with ASC. Since then, other studies have been conducted showing the same asymmetry. Kanna et al. (2006) conducted a fMRI study to observe which brain areas were activated in a computer screen task in which different true and false sentences with low imagery (for example, the sentence '*Addition, subtraction, and multiplication are all math skills*') or with high imagery (e.g. the sentence '*The number eight when rotated 90º degrees looks like a pair of eyeglasses*') were shown to participants who had to judge if they were true or false. Their results showed that, in comparison to the TD group, the ASC–ID group used more visual-spatial processing because they used it not only to comprehend high imagery sentences but also low imagery sentences. Kamio and Toichi (2000) also reported that visual-spatial processing is a strength in ASC. Their study used two different conditions: a word-word task and a picture-word task. A word or a picture (depending on the condition) was shown to the participants and they had to fill them with a gap in a fragment. Results showed that ASC–ID participants were better in the picture-word task than in the word picture task but TD participants performed similarly in both tasks. The authors interpreted these results as indicating that ASC–ID participants have better visual semantic memory than verbal. In turn, Sahyoun et al. (2010) compared ASC–ID participants with TD ones in a pictorial reasoning task under three conditions: visual, language and visual+language. In this fMRI study, they found that the ASC–ID group activated more visual-spatial brain areas and showed impaired activation of frontal language areas more in the language and visual+language conditions than in the visual condition. They also showed a reduced connectivity between frontal and ventral temporal areas. The authors claimed that these

findings support reliance on visual mediation in ASC, even when the task is not primarly visual.

However, all of the above studies above involved participants with normal IQ. We have not found any empirical study of this kind with an ASC+ID group, despite of the fact that this subgroup represents a large part of the ASC spectrum (in the USA, 31% of children with ASC have intellectual disability, while 25% of children are in the borderline range (IQ 71-85), and only 44% have IQ above 85, which is considered the average range (Baio et al., 2018)). This gap in research needs to be covered so as to have a completely overview of the role of visual support across the spectrum.

Chapter 4. General aims, research questions and hypotheses

4.1 Aims and research questions

The main aim of this thesis is to study how individuals across the entire (verbal) spectrum of ASC understand and respond to questions. In more specific terms, this project aims to explore whether difficulties faced by these individuals are sensitive to syntactic differences in question type, that is to say in *wh*-questions (*¿Qué hace la mujer?* (Sp.); What is the woman doing?) vs. *yes/no*-questions (*¿El hombre pone las gafas encima de la silla?* (Sp.); *Does the man put his glasses on the chair?*). In addition, we would like to know whether there is any *wh*-question complexity effect (depending on whether sentences contain embedding or not, that is to say *wh*-questions in complex sentences (*¿Por qué el hombre no sabe dónde están las gafas al final?* (Sp.); *Why doesn't the man know where his glasses are at the end?*) vs. in simple sentences (*¿Qué hace la mujer?* (Sp.); *What is the woman doing?*) and in long distance *wh*-questions (*¿Dónde cree el hombre que están las gafas? (Sp.)*; *Where does the man think his glasses are?*) vs. local questions (*¿Por qué el hombre no sabe dónde están las gafas al final?* (Sp.); *Why doesn't the man know where his glasses are at the end?*)). This will allow us to obtain a more comprehensive view of the profile of linguistic comprehension in ASC, extending to interrogatives and going beyond the comprehension of declarative sentences, which has been more widely studied. The specific research questions are:

1. Do children with ASC with and without ID perform worse on a task probing into their comprehension of questions, as compared to VMA-matched groups without ASC (TD and idiopathic ID)?

2. Are these group differences sensitive to syntactic question type?

3. Within each of the groups, is performance different across question types, and are these differences modulated by *wh*-question complexity?

A further goal was to elucidate the role of visual support as a potential factor in addressing the research questions above. I aimed to test whether performance in answering questions about stories improves in the ASC and TD groups and whether there is any significant difference between groups when visual support is provided.

4. Does visual support contribute to better question comprehension in ASC, TD and ID groups? Is there any significant difference between groups?

In order to illuminate the cognitive basis of a possible linguistic comprehension deficit in ASC, the last aim was to identify possible correlations between question comprehension and age (both CA and verbal mental age (VMA)), on the one hand, and general cognitive factors (verbal intelligence quotient (VIQ) and WM), on the other. Regarding WM, it is an aspect of executive functioning that might be associated with language processing. Therefore, we also aimed to answer the following research question:

5. Are there any cognitive and age factors related to question comprehension?

Given the importance of phonology in interrogatives in Spanish, we also inspected segmental phonological skills (with the pseudoword repetition tasks) along with the suprasegmental ones (prosody and, in more concrete terms, intonation). This was to address potential phonological confounds affecting question comprehension. This last aim could be summarized in this final research question:

6. Is phonology related to question comprehension?

4.2 Hypotheses

Regarding our hypotheses, based on previous studies of question answering in ASC (Jyotishi et al., 2017 and Durrleman et al., 2016), we hypothesized that ASC individuals would answer fewer questions correctly than TD and ID groups. We specially predicted:

1. ASC participants with and without ID will have lower correct answer scores compared to TD and ID groups, respectively, regardless of question type.

2. All groups of participants will answer better *yes/no*- than *wh*-questions.

3. ASC participants will have fewer correct answers to *wh*-questions in complex sentences than in simple sentences and in long-distance *wh*-questions than in local questions. This within-group pattern will be similar in TD and both ID groups.

4. Questions about stories presented with visual support will be answered better in comparison to the questions without visual support by all groups.

5. Some age and cognitive factors will be related to question comprehension. In more specific terms, VIQ and VMA will be related to all groups' question comprehension because other verbal abilities such as higher levels of vocabulary can improve question comprehension (Perkins & Lidz, 2020). WM will also be related to all groups' question comprehension as Aveledo and Martins (2009), Seidl et al. (2003) and Goodall (2004) suggest. On the contrary, CA will be related with question comprehension only in the TD group but not for the other groups as Durrleman et al. (2016) showed in their results. Question comprehension will be relative to the IQ-matched non-ASC because these linguistic deficits will be also seen in the ASC–ID group.

6. Deficits in prosody and phonology will affect the understanding of *yes/no*-questions in the ASC–ID and the ASC+ID groups. For this reason, the ASC–ID group will have significant difficulties in comparison to the TD group in the intonation task. The same pattern will be seen in the ASC+ID group in comparison to the ID group.

Chapter 5. Methodology

5.1 Participants

89 children participated in this study, which were divided in four groups. The first group was formed by 34 ASC children without ID (ASC–ID). They were recruited from Fundació Orienta's juvenile mental health centers (http://www.fundacioorienta.com) in the province of Barcelona and from Institut Pere Mata (http://www.peremata.cat), a psychiatric hospital in Reus. All participants were native bilinguals of Spanish and Catalan. The second group was 34 TD controls from Escola Xarxa in Berga. They were matched with the ASC children based on VMA, as measured by the Peabody Picture Vocabulary Test (PPVT-III), a receptive vocabulary test.

In order to increase the extent of the autism spectrum covered, we broadened recruitment by a third group of 14 ASC children with ID (ASC+ID), based on a cutoff of an IQ score below 70. All of them were diagnosed with ASC and were able to speak at least two-word utterances. They were recruited from different special-needs schools in the province of Barcelona.

Finally, 7 participants with ID but without ASC were recruited from two different special-needs schools in the province of Barcelona in order to test question comprehension in ID in the absence of ASC. All of them were reported or assessed to have an IQ score below 70. Table 1 presents the CA, sex and standardized test scores for all participants.

Table 1. Participant information

	ASC–ID (n = 34)	TD (n = 34)	ASC+ID (n = 14)	ID (n = 7)
CA				
M (SD)	9.99 (1.68)	8.85 (1.65)	12.95 (4.97)	12.86 (1.27)
range	7.33-12.91	7.00-11.41	6.16-20.66	11.91-15.58
Sex	2 girls, 32 boys	6 girls, 28 boys	4 girls, 10 boys	3 girls, 4 boys
VMA				
M (SD)	9.92 (2.43)	9.42 (2.08)	6.22 (2.37)	7.16 (1.78)
range	5.42-16.75	6.58-13.75	3.75-12.08	5.08-10.08
IQ				
M (SD)	99.65 (19.46)	108.21 (9.06)	51.18 (9.58)	48.14 (6.17)
range	73.00-147.00	91.00-127.00	43.00-67.00	41.00-56.00
Working Memory				
M (SD)	99.19 (17.77)	104.00 (14.58)	58.63 (10.40)	59.14 (9.14)
range	65.00-133.00	85.00-130.00	50.00-75.00	50.00-72.00
Verbal Comprehension				
M (SD)	102.11 (18.24)	101.57 (8.24)	54.00 (8.98)	56.71 (9.81)
range	68.00-142.00	81.00-113.00	45.00-70.00	45.00-70.00

CA = Chronological Age; VMA = Verbal Mental Age; IQ = Intelligence Quotient

ASC participants (with or without ID) were diagnosed with ASC by psychologists following ICD-10 (International Classification of Diseases - 10th edition) guidelines. In addition, they had to be able to speak at least two-word utterances and reached the diagnostic thresholds for ASC in the ADOS and/or in the ADI-R. Their IQ score was measured by WISC (Wechsler Intelligence Scale for Children) in its IV or V edition, WPPSI-III (Wechsler Preschool and Primary Scale of Intelligence) or KBIT (Kaufman Brief Intelligence test).

All TD participants went to ordinary schools, none had a report of any developmental disorder, nor of being visited by a speech pathologist. Due to time and resource constraints, we were only able to test the IQ and the WM of a subgroup of these TD participants in Reus (n=14) using WISC-V or WISC–IV, WPPSI-III or KBIT. All of them passed the PPVT-III and were selected because they matched with ASC–ID group according to their VMA score.

Finally, regarding the ID group, the participants' parents or tutors answered the Autism Spectrum Quotient (AQ) test. The objective of this test is to reject that participants' behaviors and interests might be related to ASC.

5.1.1 Matching procedure

The ASC–ID group was individually matched to the TD group on their VMA as scored by PPVT-III. An independent-samples t-test was run to determine if there were differences in VMA between these two groups. As expected, there was not a statistically significant difference, $t(66) = -.182$, $p = .856$. Furthermore, no significant CA differences were found when both groups were compared, $t(66) = 1,089$, $p = .280$.

Comparing the IQ scores of the ASC–ID group and of the TD subgroup where IQ scores were available, an independent-samples t-test showed that the TD participants had a significantly higher IQ than the ASC–ID group, $t(43.061) = -2{,}229$, $p = .031$. Different areas of the WISC, one of the IQ tests used in this study, were also analysed and compared between these two groups. Independent-samples t-tests revealed no significant differences in WM between these two groups, $t(40) = 1{,}008$, $p = .319$. In addition, no significant differences in the area of verbal comprehension were found, $t(44.558) = -.484$, $p = .631$.

Due to difficulties in recruiting ID participants, we have a smaller number of participants in the ID group than in the ASC+ID group we were not able to match individually the ASC+ID and ID groups. However, an independent-sample t-test showed no significant differences in VMA between these groups, $t(19) = -1{,}050$, $p = .307$. Furthermore, a Mann-Whitney U test was run to determine if there were differences in CA between these two groups. Distributions of the CA for ASC+ID and ID participants were similar, as assessed by visual inspection. Medians of CA were not statistically significantly different between ASC+ID and ID groups, $U = 49$, $z = .00$, $p = 1.00$.

A Mann-Whitney U test was run to determine whether there were differences in IQ scores between the ASC+ID and ID groups. Distributions of the IQ scores for ASC+ID and ID participants were not similar, as assessed by visual inspection. IQ scores for ASC+ID (mean rank = 11.71) and ID (mean rank = 9.57) were not statistically significantly different, $U = 39$, $z = -.750$, $p = .488$. The same test reported no significant differences in WM scores between ASC+ID (mean rank = 9.55) and ID participants (mean rank = 9.43), $U = 38$, $z = -.047$, $p = 1.00$. Distributions of the WM scores for ASC+ID and ID participants were not similar, as assessed by visual inspection. In

addition, an independent-samples t-test suggested that these two groups did not differ significantly in verbal comprehension either, $t(19) = -,464$ $p = .648$.

5.1.2 Ethical procedure

All participants' families signed informed written consent forms approved for this study by the ethical board of the University Hospital Vall d'Hebron (Barcelona).

5.2 Materials and procedure

All participants were tested individually in a quiet room. Tests were video-recorded to be able to double-check their answers in case of need. All tasks and the instructions were in Spanish (see Annex 1). First, three pre-tests were passed. The first was a picture naming task with eight pictures that would appear in the following question-answer tasks. In this first pre-test, the researcher asked the participant to name black and white pictures. If the participant did not start naming the pictures within two minutes, the researcher asked directly 'what's this?' and pointed to the picture. In seven pictures, the participant was expected to answer with a noun but the verb *ladrar* [bark] was required in one case. The aim of this task was to check the knowledge of vocabulary that would appear in the subsequent question-answering tasks.

After that, we administered a frequent and non-frequent pseudoword repetition task, extracted from Aguado (2006) and according to the Spanish frequency list by Alameda and Cuetos (1995). In this task, participants listened to an audio recording of 20 pseudowords with different amounts of syllables: 5 pseudowords with 2 syllables, 5 with

3 syllables, 5 with 4 syllables and 5 with 5 syllables. Each pseudoword was played twice and they had to repeat it immediately after each one. Half of the participants listened first to the frequent pseudoword repetition task, while the other half listed first to the non-frequent one in order to avoid order effects in the tasks. The aim of this task was to obtain phonological working memory scores to test for effects of these on question comprehension.

Between the frequent and the non-frequent pseudowords tasks, participants further passed an intonation task. We ensured a break between the pseudowords tasks to deactivate phonological working memory. We replicated in Spanish the task by Patel et al. (1998). The participant listened to 12 declaratives and 12 interrogatives, which were identical syntactically and lexically but differed in prosody. They were presented one at a time and in random order. Participants were required to classify each sentence as either a question or not, immediately after they heard them. For example, they heard 'Habla francés.' [She or he speaks French], and they needed to say that it was not a question. However, when they heard 'Habla francés?' [Does he/she speak French?], they needed to say that it was a question. As its authors mention, 'this test checked the ability of a subject to map prosodic information onto a pragmatic category when no other cues (e.g., lexical, contextual) were available' (Patel et al., 1998: 133).

After these pre-tests, participants passed four question-answering tasks. In two tasks, participants were asked to listen carefully to an audio which was played once. The first was a 25 seconds audio, in which we recorded a story version of the classical Sally-Anne object displacement task (Baron-Cohen et al., 1985) used to determine a person's social cognitive capacity to attribute false beliefs to others. We used this classical task because it has been used to give support to a ToM deficit in ASC but it has not been questioned if question comprehension could affect it. In our design, the participants

listened to a story about two girls, Sally and Anne in Spanish. Sally has a basket and a marble and Ann has a box. Then, Sally puts the marble in the basket and leaves the room. After that, Ann takes the marble and hides it in the box while Sally is away.

In the second task, participants had to listen carefully to a 30 seconds audio, also played only once, which explained an invented story that did not involve false beliefs. Specifically, participants listened to a story in Spanish about a girl who was walking with her mum at the park. They find a man with his dog. The girl wants to touch the dog but her mum says that it might bark. Then, the man explains that the dog does not bark at all. For this reason, the girl touches the dog in the end.

Immediately after participants finished listening to each audio, the experimenter suggested to talk about the story and started asking questions about it. Experimenters were instructed not to specify to participants that they would answer questions. For each of these first two tasks, there were 12 questions, 6 *yes/no*-questions and 6 *wh*-questions. Within this last group of questions, there was 1 *wh*-question in the Sally-Anne task involving a sentence with a complex *wh*-dependency (*¿Dónde piensa Sally que está la canica?* (Sp.); *Where does Sally think the marble is?*). In more specific terms, it is a long-distance *wh*-question because the *wh*-element *(¿dónde […]?* (Sp.); *where […]*?) is connected to the embedded clause (*[…] está la caninca?* (Sp.); *[…] the marble is?*). The other 5 remaining in this task were *wh*-questions in simple sentences. In the other audio task, all 6 *wh*-questions were *wh*-questions in simple sentences.

The remaining two question-answer tasks were each visually supported with a black and white comic strip without text (see Figures 11 and 12 in the Annexes). One of these (based on Monfort and Monfort, 2001) involved false beliefs, the other did not (based on Whelon, 2011). In each task, participants were asked to look at the comic and

explain it orally once they were ready. They could not look at the comic while they were explaining the story, in order to balance the memory load they needed for the audio tasks. Their oral narratives were used to check if they had understood the story. If they had not comprehended the story or they had missed some parts, the instructor would explain it again. After that, the experimenter suggested to talk about the story and started asking questions about it. There were 6 *yes/no*-questions and 6 *wh*-questions in each of these tasks as well. Within this last group of questions, there were 3 *wh*-questions in complex sentences (with embedding) in the question-answering task involving the story with false beliefs (1. *¿Qué hace el hombre cuando vuelve?* (Sp.); *What does the man do when he comes back?*, 2. *¿Dónde cree el hombre que están las gafas?* (Sp.); *Where does the man think that the glasses are?* and 3. *¿Por qué el hombre no sabe dónde están las gafas al final?* (Sp.); *Why doesn't the man know where the glasses are at the end?*). In fact, the second question is a long-distance *wh*-question because the *wh*-element *(¿dónde […]?* (Sp.); *where […]*?) is connected to the embedded clause (*[…] están las gafas?* (Sp.); *[…] the glasses are?*). However, the first and the third questions are local *wh*-questions in complex sentences because their *wh*-elements (*¿qué* […]? (Sp.); *what* […]? and *¿por qué* […]? (Sp.); *why* […]?) are connected to the main clause of the question (*hace el hombre* […]? (Sp.); *does the man do* […] and *¿el hombre no sabe* […]? (Sp.); *doesn't the man know* […]?) In the other task with visual support but without false beliefs, all 6 *wh*-questions were *wh*-questions in simple sentences.

Half of the participants first passed the audio-based question-answer tasks. The other half of them first explained the question-answer tasks with visual support in order to avoid order effect in the tasks.

5.3 Analysis

Participants' answers in all tasks were scored as described below. First, correct answers for all three tasks in the pretests were counted. In the picture naming task, some participants named some objects in the pictures in Catalan ─for instance, one participant said *taula* (Cat.) instead of *mesa* (Sp.) for *table*. In these cases, they were counted as correct answers too. Furthermore, close hyponyms of *woman* and *man* such as *girl* or *boy* respectively, were also counted as correct answers. However, the onomatopoeia *guau-guau* (Sp.) [bow-wow] was not counted as a valid response for the picture of a dog barking. It is also important to mention that only the completely correct repeated pseudowords were counted as correct responses.

In the question-answering tasks, if participants nodded or shook their head to answer *yes/no*-questions, their gestures were counted. Firstly, we counted all the correct answers to *yes/no*-questions and *wh*-questions. Then, we split the *wh*-questions variable in two further variables: *wh*-questions in simple sentences and *wh*-questions in complex sentences. This last variable was further divided between long-distance *wh*-questions and local *wh*-questions in complex sentences variables (see Figure 1).

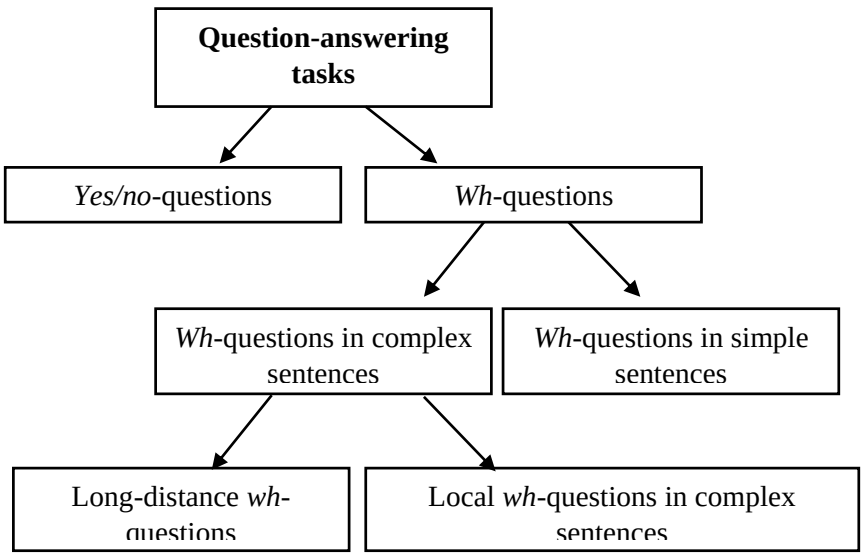


Figure 1. Question-answering tasks analysis plan

Results were analysed using SPSS, version 24. We ran within-group and between-group comparisons. In more specific terms, we compared ASC–ID participants versus TD participants in order to determine the ASC effect, the ASC–ID versus the ASC+ID groups to analyse the effect of IQ in ASC, and the ASC–ID and the ID group to observe the ASC effect in the presence of ID. Correlations between age, general cognitive and other linguistic factors were also conducted to explore the relation between them and question comprehension.

Sign tests (when the variable was not normally distributed and did not have a symmetrical shape), Wilcoxon signed-rank tests (when the variable was not normally distributed but has a symmetrical shape) and paired-sample t-tests (when the difference between variables was normally distributed and had a symmetrical shape) were used for within-group comparisons. Non-parametric bi-lateral Mann-Whitney U tests were applied for between-group comparisons, when there were significant outliers and given the skewedness of the data and a relatively small group sizes for the groups with ID. A Welch t-test was also used between group comparisons when variables were normally distributed but their variances were not equal. Finally, correlational analyses were run between age (CA and VMA, general cognitive factors (VIQ and WM), language (intonation and pseudowords repetition tasks) and task success. In more specific terms, Pearson's product-moment correlations were run to assess the relationship between these variables when. preliminary analyses showed the relationship to be linear with both variables normally distributed, as assessed by Shapiro-Wilk's test ($p > .05$). Spearman's rank-order correlations were also run when variables were not normally distributed but their relationship was monotonic, as assessed by visual inspection of a scatterplot. Bonferroni corrections were applied for multiple correlations. Results were provided in

box-plots and bar graphs to illustrate the distribution of correct responses across and within groups.

Chapter 6. Results

6.1 Comprehension of *yes/no*-questions and *wh*-questions

6.1.1 Within-group comparisons

A sign test was conducted to determine if there was any significant difference between correct answers to *yes/no*-questions and *wh*-questions within the ASC–ID group, because the distribution of differences between paired observations was neither normal nor symmetrical, respectively. Of the 34 participants recruited in this group, 24 answered *yes/no*-questions better relative to *wh*-questions, whereas 7 of them did not show this pattern. There was a statistically significant median increase of correct answers (median = 2.50) when individuals answered *yes/no*-questions (median = 23 correct answers) compared to *wh*-questions (median = 20 correct answers), $z = 2.87$, $p = .004$.

In the case of the ASC+ID group, a paired-sample t-test was used to determine whether there was a statistically significant mean difference between correct answers to *yes/no*-questions in comparison to *wh*-questions because the assumption of normality was not violated, as assessed by a Shapiro-Wilk's test ($p = .224$). One outlier was detected which, was more than 1.5 box-lengths from the edge of the box in a boxplot (see Figure 2). Inspection of its value did not reveal it to be extreme because it was no more than 3 box-lengths away from the edge of the box and it was kept in the analysis.

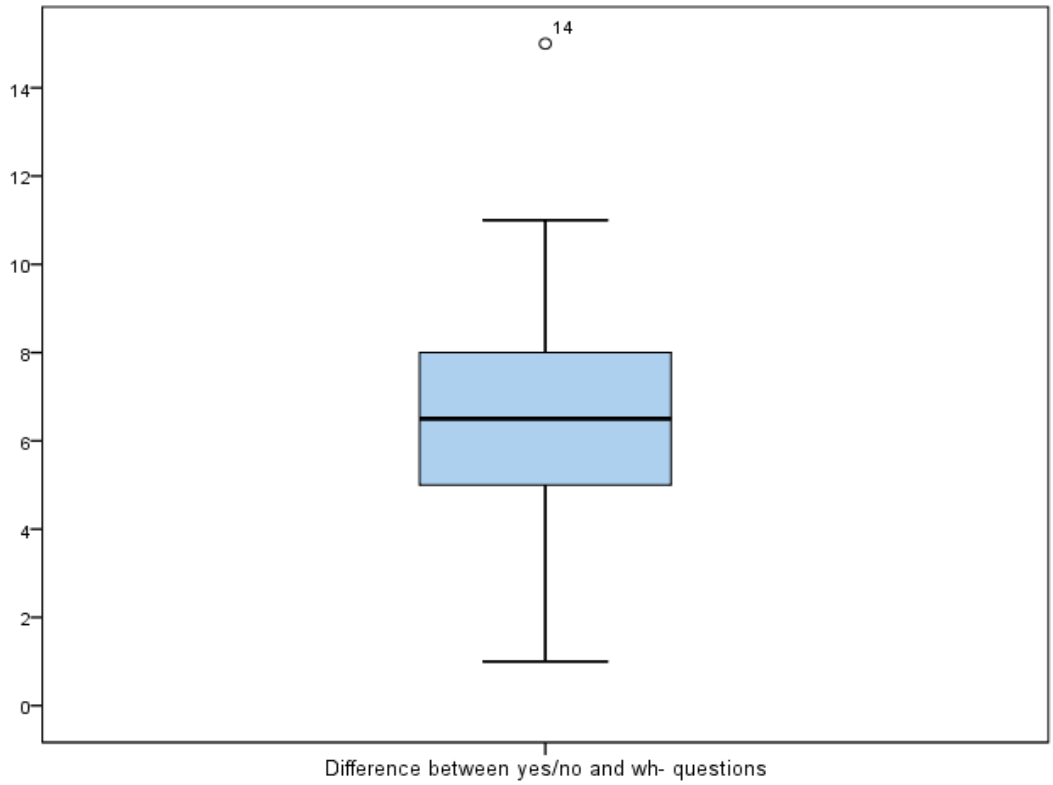


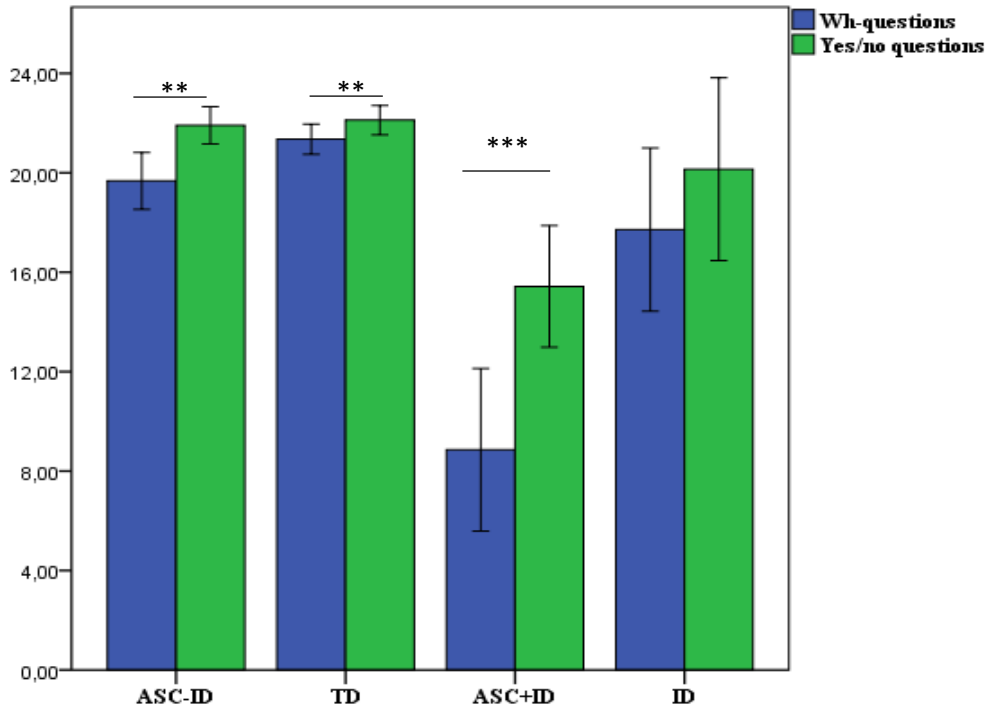
Figure 2. Boxplot to detect outliers in the difference between *yes/no*-questions and *wh*-questions.

Like the ASC–ID group, this group also answered *yes/no*-questions (M ± SD = 15.42 ± 4.23) significantly better than *wh*- questions (M ± SD = 8.85 ± 5.66), a statistically significant increase of 6.571 (95% CI, 4.500 to 8.643) correct answers ($t(13) = 6.851$, $p < .0005$, $d = 2.98$).

The same test was run within the TD group because the assumption of normality was not violated, as assessed by Shapiro-Wilk's test ($p = .146$). No outliers were detected. TD participants, like the ASC participants with or without ID, gave significantly more correct answers to *yes/no*-questions (M ± SD = 22.117 ± 1.701) in comparison to *wh*-questions (M ± SD = 21.352 ± 1.738), a statistically significant increase of 0.764 (95% CI, 0.169 to 1.360) correct answers, $t(33) = 2.613$, $p = .013$, $d = 0.448$.

Finally, a sign test was conducted to determine if there was any significant difference between the correct answers to *yes/no*-questions and *wh*-questions within the ID group because the distribution of differences between paired observations was neither normal nor symmetrical. Of the 7 ID participants recruited to the study, 5 gave more correct answers to *yes/no*-questions than *wh*-questions. 1 participant did not show any difference with regard to the two different types of questions and 1 participant answered more *wh*-questions correctly than *yes/no*-questions. There was no statistically significant median increase of more correct answers (median = 4.00 correct answers) when subjects answered *yes/no*-questions (median = 23.00 correct answers) compared to the *wh*-questions (median = 19.00 correct answers), $z = -1.22$, $p = .219$.

In conclusion, ASC with or without ID and the TD groups answered *yes/no*-questions significantly more correctly than *wh*-questions, while there was no significant difference between these variables in the ID group (Figure 3). It can also be observed that the largest variability is in ASD+ID group.



*** indicates $p \leq .001$; ** indicates $p \leq .03$

Figure 3. Comparison of correct answer scores within groups between *yes/no*-questions and *wh*-questions.

6.1.2 Between group comparisons

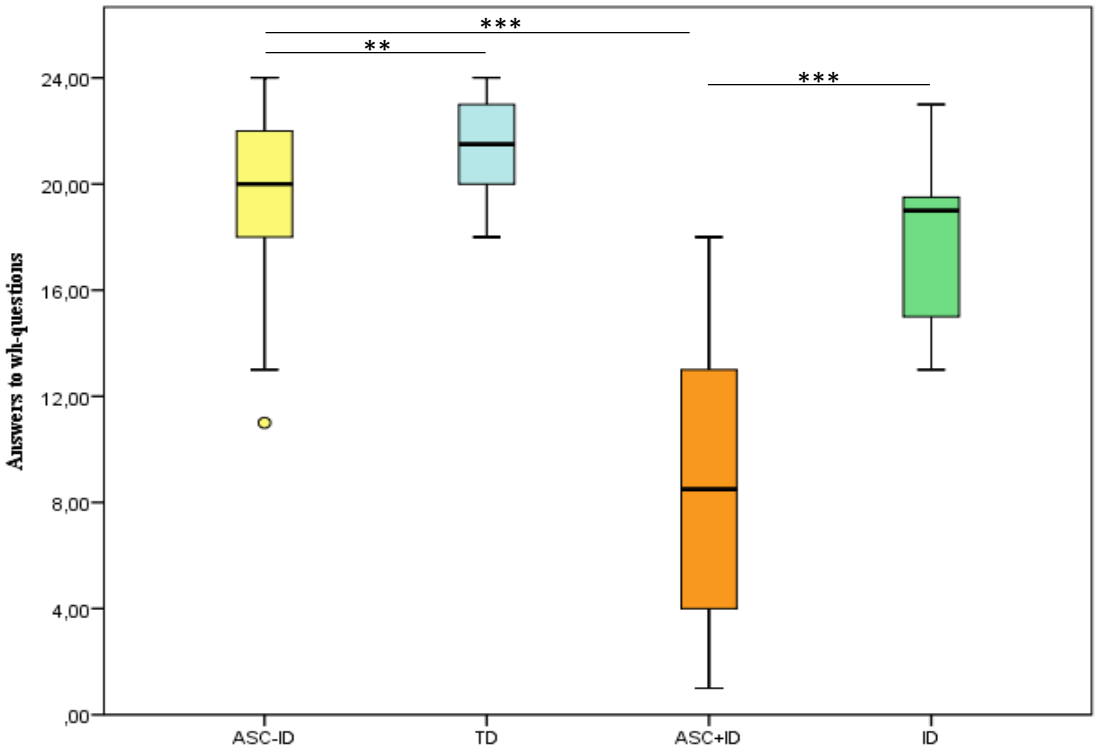
a) Wh-questions

A Mann-Whitney U test was run to determine if there were differences in answers to *wh*-questions between ASC–ID and TD. Distributions of the answers to *wh*-questions for both groups were not similar, as assessed by visual inspection. ASC–ID participants showed significantly greater difficulties (mean rank = 29.32) to comprehend *wh*-

questions in comparison to the TD group (mean rank = 39.68), $U = 754$, $z = 2.178$, $p = .029$.

The same test was run to compare the two ASC groups (one with and one without ID). Distributions of the answers to *wh*-questions for both groups were not similar, as assessed by visual inspection. The ASC–ID group was able to answer correctly more *wh*-questions (mean rank = 30.87) than the ASC+ID one (mean rank = 9.04), $U = 21.50$, $z = -4.930$, $p < .001$. There was a greater range of variability among the ASC+ID group.

Finally, a Welch t-test was run to determine if there were differences in answers to *wh*-questions between ASC+ID and ID groups due to the assumption of homogeneity of variances being violated, as assessed by Levene's test for equality of variances ($p = .044$). There were no outliers in the data, as assessed by inspection of a boxplot, and *wh*-question answer scores for each group were normally distributed, as assessed by Shapiro-Wilk's test ($p > .05$). ASC+ID group answered correctly significantly less *wh*-questions (8.85 ± 1.51) than the ID group (17.71 ± 1.34) a statistically significant difference of -8.85 (95% CI, -13,11 to -4,60), t (17.753) = -4.379, $p < .001$. See Figure 4.



***indicates $p \leq .001$; ** indicates $p \leq .03$

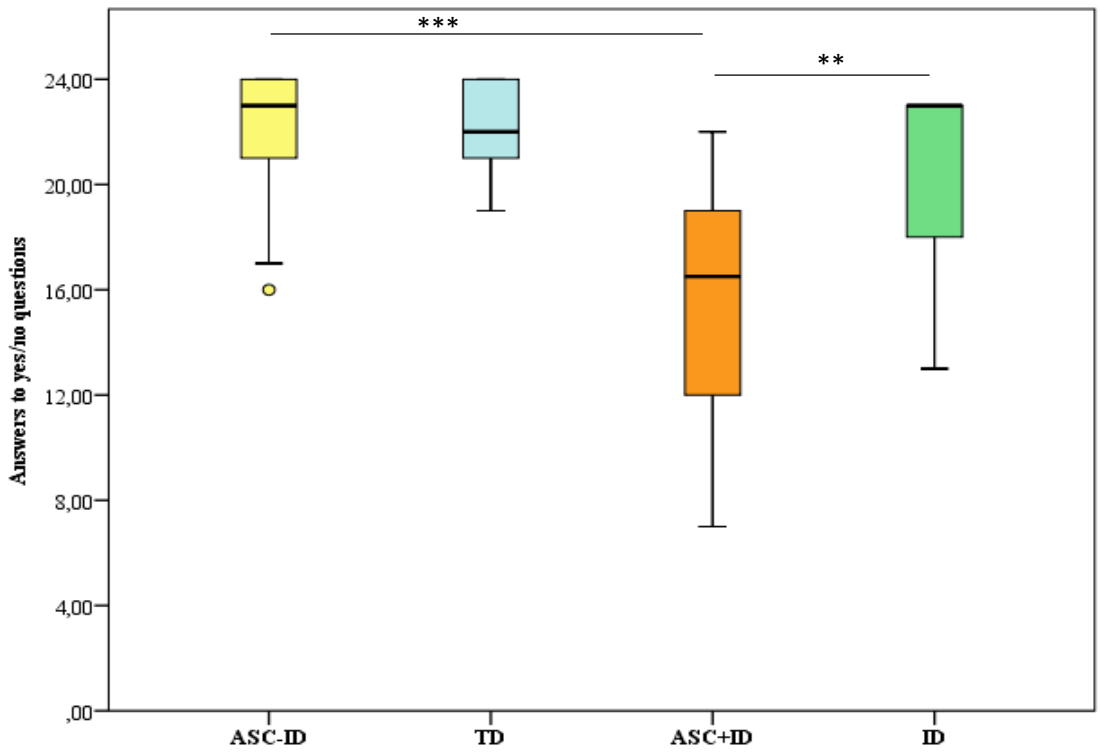
Figure 4. Comparison of correct answer scores between ASC–ID and TD groups; ASC–ID and ASC+ID groups and ID and ASC+ID groups on *wh*-questions.

b) Yes/no-questions

A Mann-Whitney U test was used to determine if there were differences in answers to *yes/no*-questions between ASC–ID and TD. Distributions of the answers to *yes/no*-questions for both groups were not similar, as assessed by visual inspection. The number of correct answers to *yes/no*-questions for the ASC–ID (mean rank = 34.16) and for the TD (mean rank = 34.84) was not statistically significantly different, $U = 589$, $z = 0.144$, $p = .885$. A Mann-Whitney U test was also run to compare the two ASC groups (one with

and one without ID). Distributions of the answers to *yes/no*-questions for both groups were not similar, as assessed by visual inspection. The ASC–ID group correctly answered more *yes/no*-questions (mean rank = 30.53) than the ASC+ID one (mean rank = 9.86), $U = 33.00$, $z = -4.693$, $p < .001$.

Finally, the same test was also used to determine possible differences between the ID and the ASC+ID groups. Distributions of the answers to *yes/no*-questions for both groups were not similar, as assessed by visual inspection. ID participants (mean rank = 15.36) scored significantly better than the ASC+ID ones (mean rank = 8.82), $U = 79.50$, $z = 2.290$, $p = .020$. See Figure 5.



***indicates $p \leq .001$; ** indicates $p \leq .03$

Figure 5. Comparison of correct answer scores between ASC–ID and TD groups; ASC–ID and ASC+ID groups and ID and ASC+ID groups on *yes/no*-questions.

6.2 Comprehension of *wh*-questions in complex and in simple sentences

6.2.1 Within-group comparisons

A paired-sample t-test was used to determine whether there was a statistically significant mean difference between correct answers to *wh*-questions in complex sentences in comparison to *wh*-ones in simple sentences within the ASD-ID group. Variables were normalized to a 0-1 range in order to be able to be compared not only within this group but also in all of them. There were no outliers detected. The assumption of normality was not violated, as assessed by a Shapiro-Wilk's test (p = .151). This group answered *wh*-questions in simple sentences (M ± SD = .851 ± .131) significantly better than *wh*-questions in complex sentences (M ± SD = .661 ± .287), a statistically significant increase of .190 (95% CI, .981 to .281) correct answers ($t(33) = 4.214$, $p < .0005$, $d = .722$).

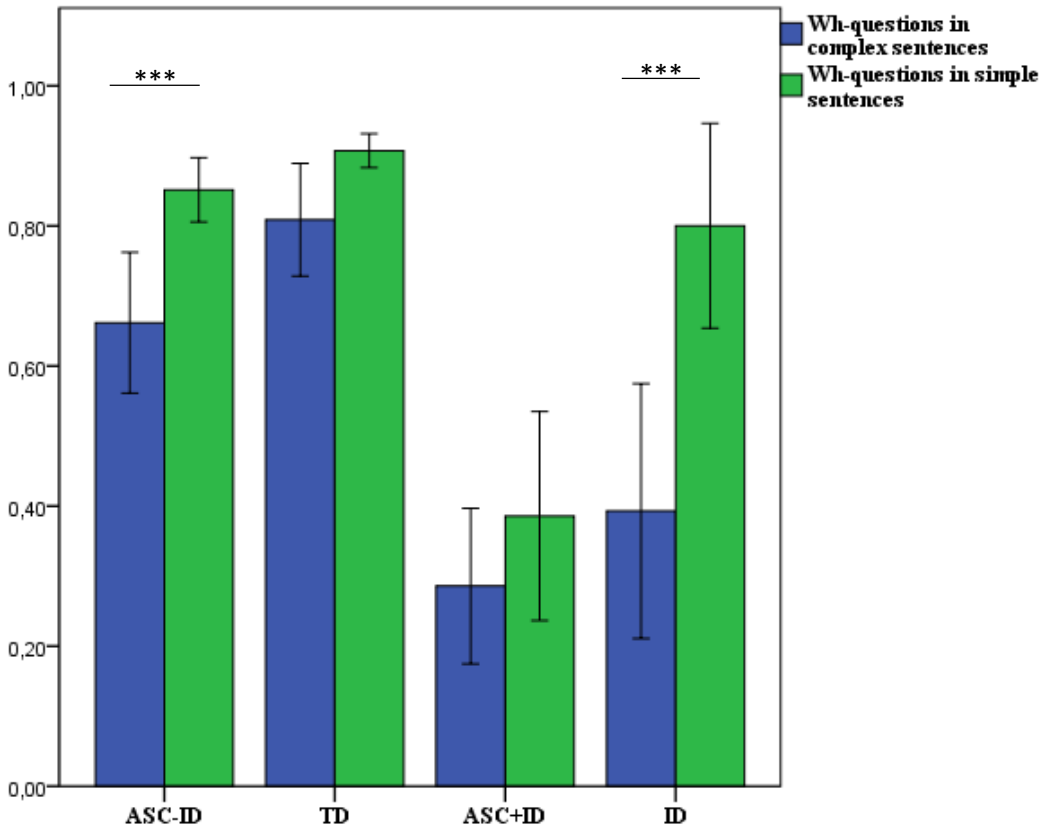
Regarding the ASC+ID group, the same test was run to determine whether there was any significant difference between *wh*-questions in simple and this type of questions in complex sentences. There were no outliers detected and the difference scores between variables were normally distributed, as assessed by a Shapiro-Wilk's test (p = .583). Although this group answered correctly more *wh*-questions in simple sentences (M ± SD = .386 ± .258) than *wh*-questions in complex sentences (M ± SD = .286 ± .192), there was not a significant difference between them ($t(13) = 1.803$, p = .095, d = -.10).

A sign test was conducted to determine if there was any significant difference between correct answers to *wh*-questions in simple sentences and *wh*-questions in complex sentences within the TD group, because the distribution of differences between paired observations was neither normal nor symmetrical, respectively. Of the 34 participants recruited in this group, 18 showed greater ability to answer *wh*-questions in simple questions in comparison to *wh*-questions in complex sentences, whereas 12 of

them did not show this pattern. There was not a statistically significant median increase of correct answers (median = .050) when individuals answered *wh*-questions in simple sentences (median = .90 correct answers) compared *to wh*-questions in complex sentences (median = .75 correct answers), z =.91, p = .361.

Finally, a paired-sample t-test was used to determine whether there was a statistically significant mean difference between correct answers to *wh*-questions in complex sentences in comparison to *wh*-questions in simple sentences within the ID group. There were no outliers detected. The assumption of normality was not violated, as assessed by a Shapiro-Wilk's test (p = .463). This group answered *wh*-questions in simple sentences (M ± SD = .800 ± .158) significantly better than *wh*- questions in complex sentences (M ± SD = .216 ± .599), a statistically significant increase of .407 (95% CI, .981 to .281) correct answers ($t(6)$ = 5.203, p = .002, d = 1.96).

In conclusion, while the ASC–ID and ID groups answered *wh*-questions in simple sentences significantly more correctly than *wh*-questions in complex sentences, there was no significant difference between these variables in the ASC+ID and the TD groups, as seen in Figure 6. It can also be observed that the largest variability was in ASD+ID and the ID groups. The ASD+ID group had also the lowest scores in answering both types of questions.



***indicates $p \leq .001$

Figure 6. Within groups rate of correct answers to *wh*-questions in complex sentences and *wh*-questions in simple sentences (normalized in a 0-1 range).

6.2.2 Between group comparisons

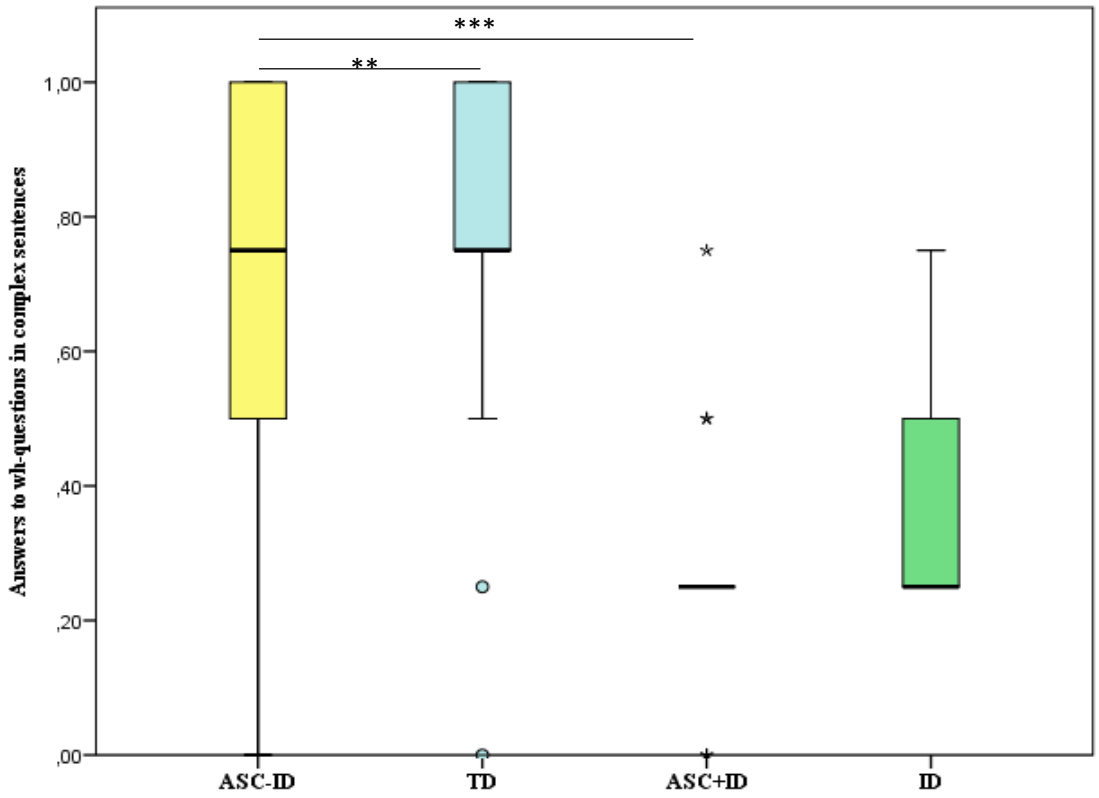
a) Wh-questions in complex sentences

A Mann-Whitney U test was run to determine if there were differences in answers to *wh*-questions in complex sentences between ASC–ID and TD. Distributions of the answers to *wh*-questions for both groups were not similar, as assessed by visual inspection. ASC–ID participants showed significantly greater difficulties (mean rank = 29.37) to

comprehend *wh*-questions in complex sentences in comparison to the TD group (mean rank = 39.63), $U = 752$, $z = 2.254$, $p = .024$.

The same test showed that the ASC+ID group (mean rank = 12.71) answered correctly less *wh*-questions in complex sentences in comparison to the ASC–ID group (mean rank = 29.35), $U = 73$, $z = 3.849$, $p < .0005$. Distributions of the answers to *wh*-questions for both groups were not similar, as assessed by visual inspection.

Regarding the ID and the ASC+ID groups, the same test was used to compare these groups' answers to *wh*-questions in complex sentences. Distributions of the answers to *wh*-questions for both groups were similar, as assessed by visual inspection. Median answers score to *wh*-questions in complex sentences for the ID (0.25) and the ASC+ID participants (0.25) was not statistically significantly different, $U = 63.50$, $z = 1.244$, $p < .287$. This group comparison and the other two last mentioned are visualized in Figure 7. As it can be appreciated in this figure, the ASC+ID group presented the most variability within-group in comparison to the other groups.



***indicates $p \leq .001$; ** indicates $p \leq .03$

Figure 7. Comparison between ASC–ID and TD groups; ASC–ID and ASC+ID groups and ID and ASC+ID groups on *wh*-questions in complex sentences (normalized in a 0-1 range).

It is worth to mention that these results could be affected by the task design because all the four examples of *wh*-questions in complex sentences were in visual and non-visual tasks with FB. There was not any *wh*-question in complex sentence in tasks without false beliefs. In order to see if this limitation of the study affected the lower grade of the ASC–ID group in *wh*-question comprehension in complex sentences in comparison to the TD group, a Mann-Whitney U test was run to determine if there were differences in the total number of answers to all tasks with FB between ASC–ID and TD. Distributions of the answers to questions of tasks with FB for both groups were similar,

as assessed by visual inspection. Median answer scores to questions of tasks with FB for ASC–ID (19.50) and TD group (19.00) were not statistically significantly different, U = 645, z = .833, p = .405.

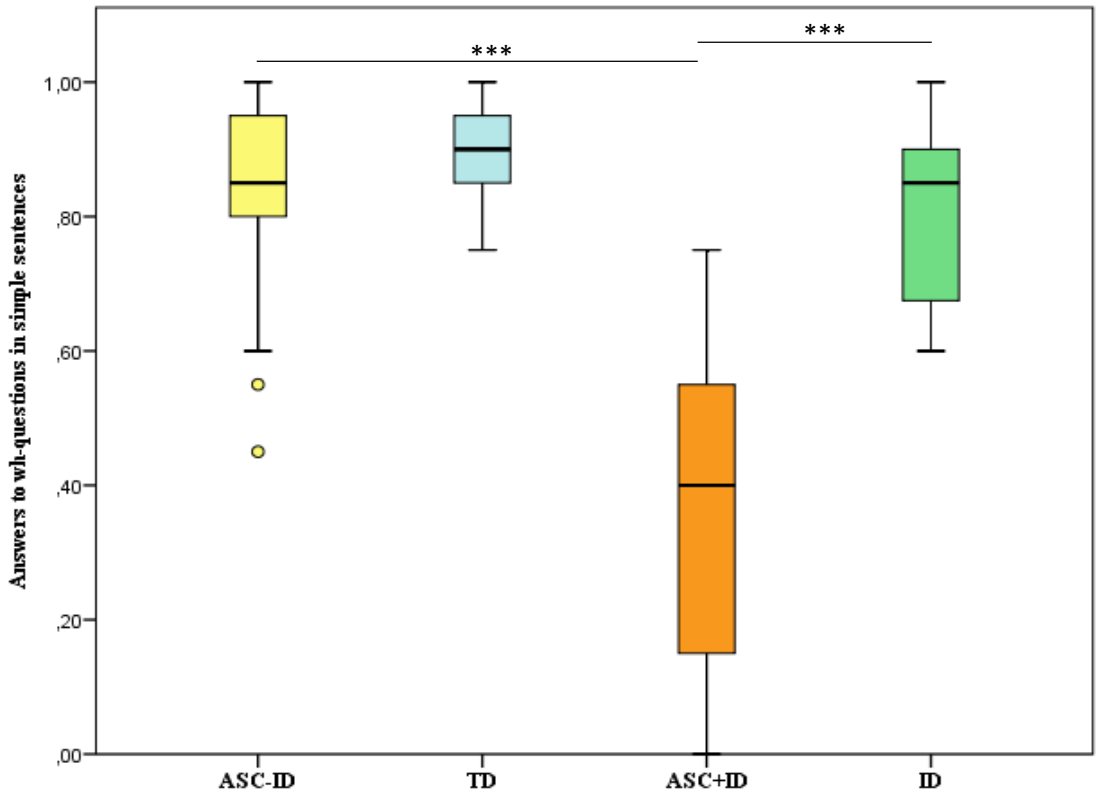
b) Wh-questions in simple sentences

A Mann-Whitney U test was run to determine if there were differences in answers to *wh*-questions in simple sentences between ASC–ID and TD. Distributions of the answers to *wh*-questions in simple sentences for both groups were similar, as assessed by visual inspection. Median *wh*-questions in complex sentences answer scores for ASC–ID (.85) and TD group (.90) were not statistically significantly different, U = 718, z = 1.746, p = .081.

The same test was used to compare ASC+ID and ASC–ID groups in answers to *wh*-questions in simple sentences. Distributions of the answers to *wh*-questions in simple sentences for both groups were not similar, as assessed by visual inspection. ASC+ID participants showed significantly greater difficulties (mean rank = 8.79) to comprehend *wh*-questions in simple sentences in comparison to the ASC–ID group (mean rank = 30.97), U = 18.00, z = 5.023, p < .0005.

A Welch t-test was run to determine if there were differences in answers to *wh*-questions in simple sentences between ASC+ID and ID groups due to the assumption of homogeneity of variances being violated, as assessed by Levene's test for equality of variances (p = .034). There were no outliers in the data, as assessed by inspection of a boxplot, and *wh*-question in simple sentences answer scores for each group were normally distributed, as assessed by Shapiro-Wilk's test (p > .05). ID group answered correctly

significantly more *wh*-questions in simple sentences (.80 ± .15) than the ASC+ID group (.40 ± .25) a statistically significant difference of -.41 (95% CI, -.60 to -.22), t (17.946) = -4.538, $p < .0005$. This group comparison and the other two last mentioned are visualized in Figure 8.



***indicates $p \leq .001$

Figure 8. Comparison between ASC–ID and TD groups; ASC–ID and ASC+ID groups and ID and ASC+ID groups on *wh*-questions in simple sentences (normalized in a 0-1 range).

6.3 Comprehension of long-distance and local *wh*-questions in complex sentences

6.3.1 Within-group comparisons

A Wilcoxon signed-rank test was conducted to determine if there was a significant difference between answers to long-distance and local *wh*-questions in complex sentences within the ASC–ID group. The difference scores were approximately symmetrically distributed, as assessed by a histogram with superimposed normal curve.

Of the 34 participants of this group, 12 participants answered better local *wh*-questions in complex sentences than long-distance questions, whereas 9 of them answered better long-distance *wh*-questions than local questions in complex sentences and 13 of them did not show any difference answering these two different types of questions. There was no a statistically significant difference, $z = 820$, $p = .412$.

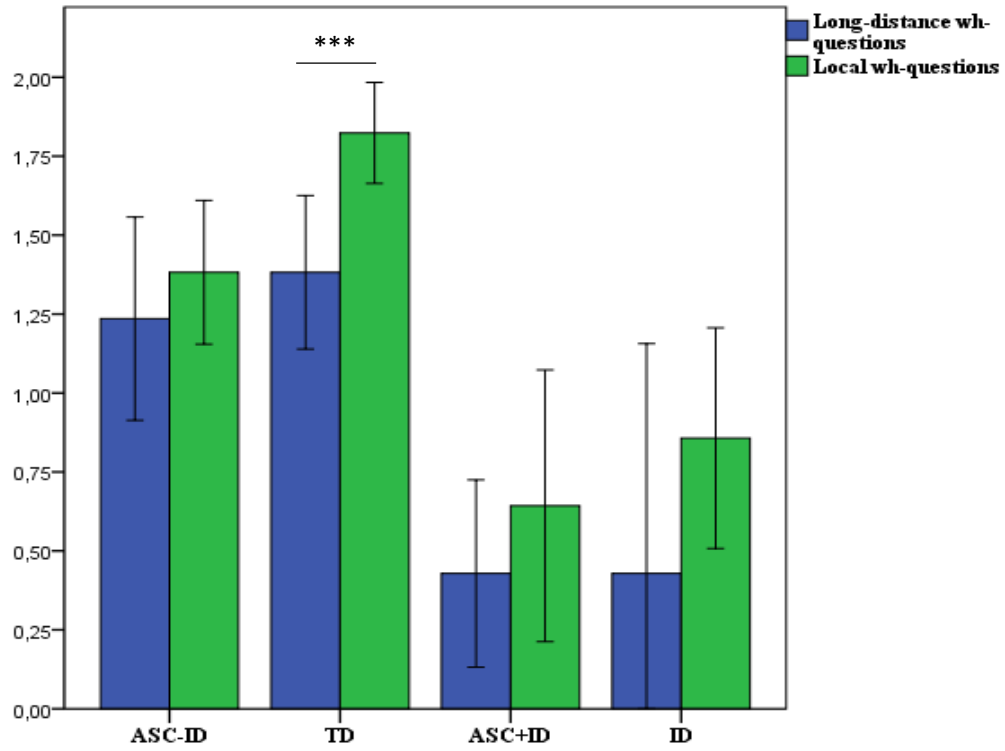
The same test was used within the TD group. Of the 34 participants of this group, 15 participants answered better local *wh*-questions in complex sentences than long-distance questions, whereas 2 of them answered better long-distance *wh*-questions than local questions in complex sentences and 17 of them did not show any difference answering these two different types of questions. There was a statistically significant median increase answering local (median = 2.00 correct answers) than long-distance *wh*-questions (median = 1.50 correct answers) in complex sentences, $z = 3.12$, $p = .002$.

A sign test was conducted to determine if there was any significant difference between the correct answers to long-distance and local *wh*-questions in complex sentences within the ASC+ID group because the distribution of differences between paired observations was neither normal nor symmetrical. Of the 14 ASC+ID participants recruited to the study, 7 were able to answer better long-distance *wh*-questions in complex

sentences than local *wh*-questions in complex sentences. 2 participants did not show any difference to answer the two different types of questions and the last but not the least 5 could answer more local *wh*-questions than long-distance *wh*-questions in complex sentences. There was no statistically significant median increase of comprehension (median = .50 correct answers) when subjects answered local *wh*-questions (median = .50 correct answers) compared to the long-distance *wh*-questions (median = .00 correct answers), $z = .289$, $p = .774$.

Finally, also a sign test was conducted to determine if there was any significant difference between the correct answers to long-distance and local *wh*-questions in complex sentences within the ID group because the distribution of differences between paired observations was neither normal nor symmetrical. Of the 7 ID participants recruited to the study, 4 were able to answer better local *wh*-questions in complex sentences than long-distance *wh*-questions in complex sentences. 2 participants did not show any difference to answer the two different types of questions and the last but not the least 1 could answer more long-distance *wh*-questions than local *wh*-questions in complex sentences. There was no statistically significant median increase of comprehension (median = 1.00 correct answers) when subjects answered local *wh*-questions (median = 1.00 correct answers) compared to the long-distance *wh*-questions (median = .00 correct answers), $z = .894$, $p = .375$.

In conclusion, although all groups scored more correct local *wh*-questions in complex sentences than long-distances questions, this difference was only significant in the TD group as seen in Figure 9.



***indicates $p \leq .001$

Figure 9. Within groups rate of correct answers to long-distance *wh*-questions in complex sentences and local *wh*-questions.

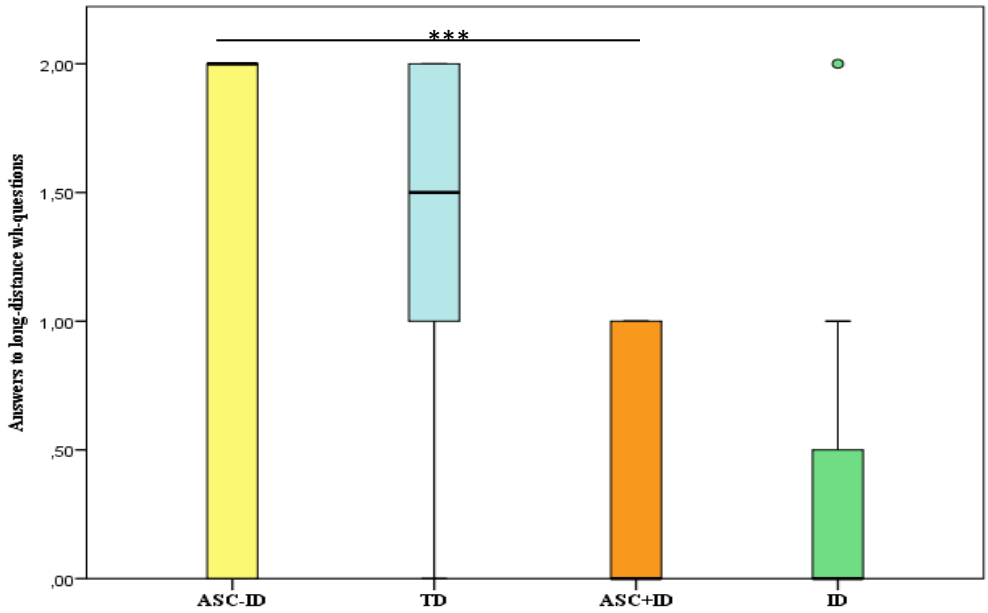
6.3.2 Between group comparisons

a) Long-distance wh-questions in complex sentences

A Mann-Whitney U test was run to determine if there were differences in the ability to answer long-distance *wh*-questions in complex sentences between ASC–ID and TD. Distributions of the answers to long-distance *wh*-questions in complex sentences for both groups were not similar, as assessed by visual inspection. Correct answers to long-distance *wh*-questions for ASC–ID participants (mean rank = 33.63) and for the TD group (mean rank = 35.37) were not statistically significantly different, $U = 607.50$, $z = -.398$, $p = .690$.

The same test was used to compare the question comprehension of this type of *wh*-questions between ASC participants (ASC+ID and ASC–ID groups). Distributions of the answers to long-distance *wh*-questions in complex sentences for both groups were not similar, as assessed by visual inspection. Correct answers to long-distance *wh*-questions for ASC–ID participants (mean rank = 27.91) were statistically significant higher than for the ASC+ID group (mean rank = 16.21), $U = 122$, $z = -2.825$, $p = .005$.

Finally, the same test was used for the comparison of the participants with ID (ASC+ID and ID groups). Distributions of the answers to long-distance *wh*-questions in complex sentences for both groups were similar, as assessed by visual inspection. Median answer scores of long-distance *wh*-questions for the ASC+ID group (.00) and for the ID group (.00) were not statistically significantly different, $U = 45.00$, $z = -.350$, $p = .779$. See Figure 10.



***indicates $p \leq .001$

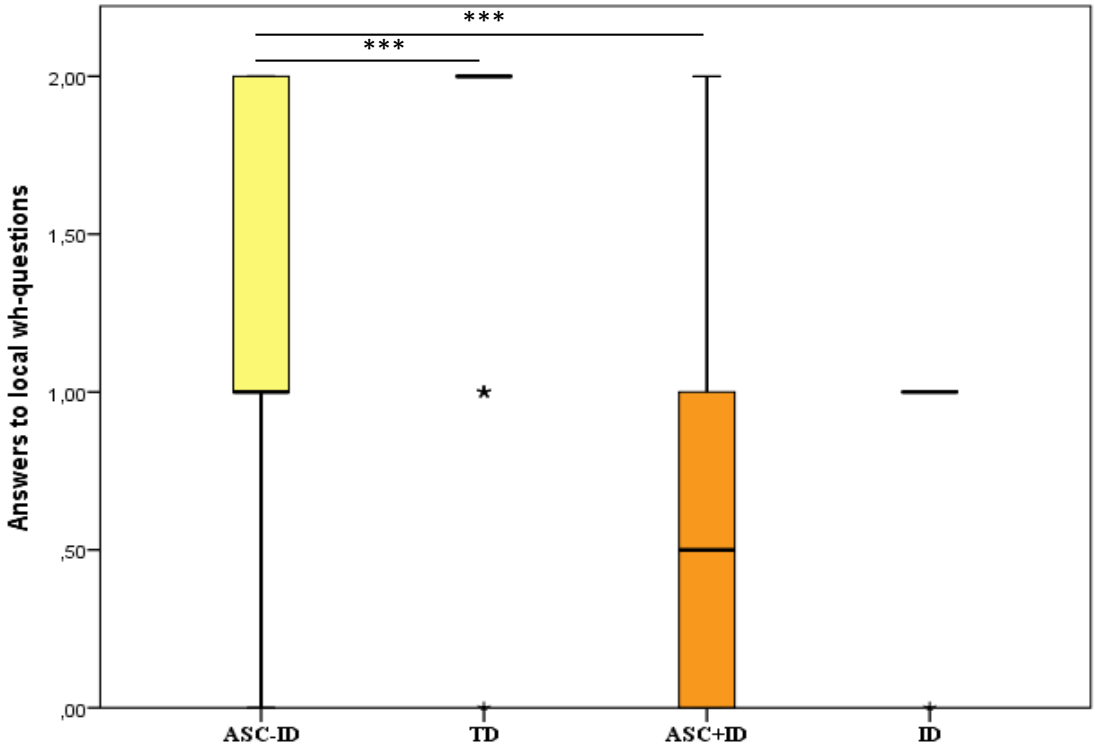
Figure 10. Comparison of correct answer scores between ASC–ID and TD groups; ASC–ID and ASC+ID groups and ID and ASC+ID groups on long-distance *wh*-questions in complex sentences.

b) Local wh-questions in complex sentences

A Mann-Whitney U test was run to determine if there were differences in the ability to answer local *wh*-questions in complex sentences between ASC–ID and TD. Distributions of the answers to local *wh*-questions in complex sentences for both groups were similar, as assessed by visual inspection. Median answer scores of local *wh*-questions were statistically significantly higher for the TD group (2.00) than for the ASC–ID group (1.00), $U = 797.50$, $z = 3.245$, $p = .001$.

The same test was used to compare the question comprehension of this type of *wh*-questions between ASC participants (ASC+ID and ASC–ID groups). Distributions of the answers to local *wh*-questions in complex sentences for both groups were not similar, as assessed by visual inspection. Correct answers to local *wh*-questions for ASC–ID participants (mean rank = 28.12) were statistically significant higher than for the ASC+ID group (mean rank = 15.71), $U = 115$, $z = -2.998$, $p = .003$.

Finally, the same test was used for the comparison of the participants with ID (ASC+ID and ID groups). Distributions of the answers to local *wh*-questions in complex sentences for both groups were not similar, as assessed by visual inspection. Correct answers to local *wh*-questions in complex sentences for ASC+ID participants (mean rank = 10.18) and for the ID group (mean rank = 12.64) were not statistically significantly different, $U = 60.50$, $z = .958$, $p = .400$. This group comparison and the other two last mentioned can be visualized in Figure 11.



***indicates $p \leq .001$

Figure 11. Comparison of correct answer scores between ASC–ID and TD groups; ASC–ID and ASC+ID groups and ID and ASC+ID groups on local *wh*-questions in complex sentences.

6.4 Question comprehension with and without visual support

6.4.1 Within-group comparisons

A paired-sample t-test was used to determine whether there was a statistically significant mean difference between correct answers to questions of a story with visual support and one listened through an audio within the ASD-ID group. There were no outliers detected. The assumption of normality was not violated, as assessed by a Shapiro-Wilk's test (p = .130). This group answered questions of a story with visual support (M ± SD = 22.00 ± 1.77) significantly better than questions of a story without visual support (M ± SD = 19.76

± 3.99), a statistically significant increase of 2.23 (95% CI, 1.186 to 3.284) correct answers ($t(33) = 4.336$, $p < .0005$, $d = .74$).

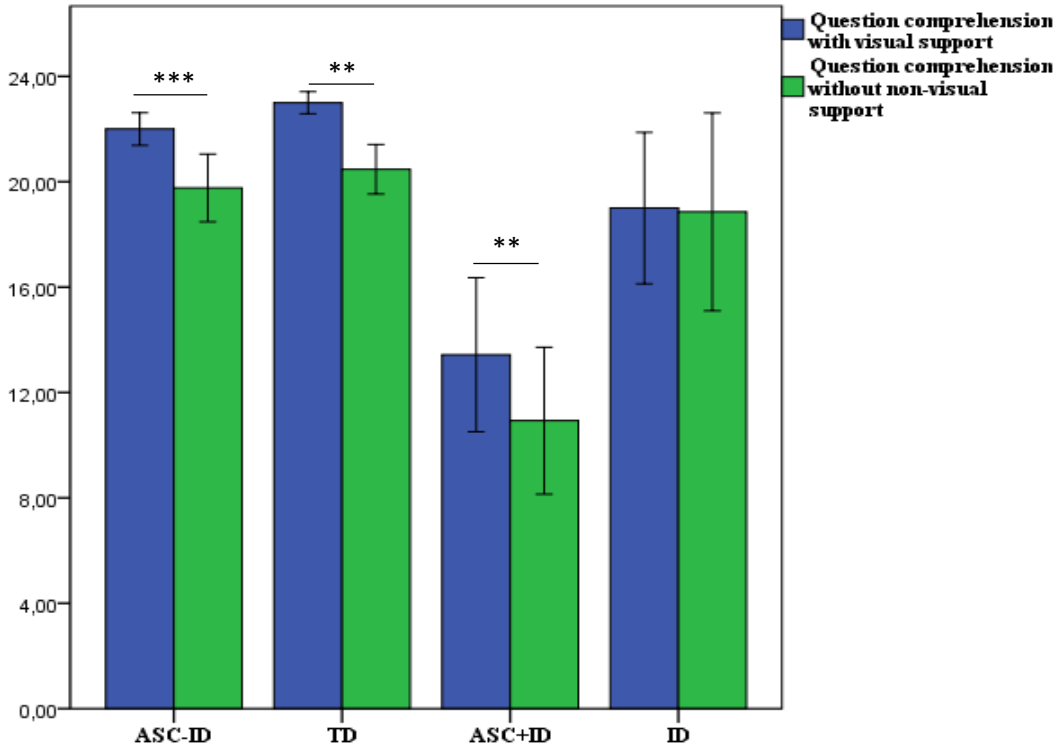
Regarding the TD group, a sign test was conducted to determine whether there was any significant difference between correct answers to questions a story with visual support and one without visual support within this group, because the distribution of differences between paired observations was neither normal nor symmetrical, respectively. Of the 34 participants recruited in this group, 21 answered better questions of a story with a visual support in comparison to questions of a listened story, whereas 6 of them showed the opposite pattern and 7 of them answered the same amount of correct answers to both conditions. There was a statistically significant median increase of correct answers (median = 2.00) when individuals answered questions of a story with visual support (median = 23 correct answers) compared to answering questions of a story without visual support (median = 20 correct answers), $z = 2.70$, $p = .007$.

Within the ASD+ID group, there were no outliers detected and the assumption of normality was not violated, as assessed by a Shapiro-Wilk's test ($p = .920$). A paired-sample t-test reported that this group also answered questions of a story with visual support (M ± SD = 13.42 ± 5.06) significantly better than questions of a story without visual support (M ± SD = 10.92 ± 4,82), a statistically significant increase of 2.50 (95% CI, .809 to 4.190) correct answers ($t(13) = 3.194$, $p = .007$, $d = .85$).

In the ID group, the assumption of normality was not violated, as assessed by a Shapiro-Wilk's test ($p = .228$). One outlier was detected but it was kept because it was not extreme. A paired-sample t-test showed no significant difference between the total number of correct answers to questions with visual support (M ± SD = 19.00 ± 3.11) and

without it (M ± SD = 18.86 ± 4.05) within this group a non-statistically significant increase of .14 (95% CI, -1.662 to 1.947) correct answers ($t(6) = .194$, $p = .853$, $d = .07$).

In conclusion, all groups except for the ID group were able to answer better questions of stories with visual support rather than stories with the audio condition. The ASC+ID group correctly answered fewer questions in both conditions, as can be visually seen in Figure 12.



***indicates $p \leq .001$, ; ** indicates $p \leq .03$

Figure 12. Within groups rate of answers to all types of questions of stories with visual support and with non-visual support.

6.4.2 Between group comparisons

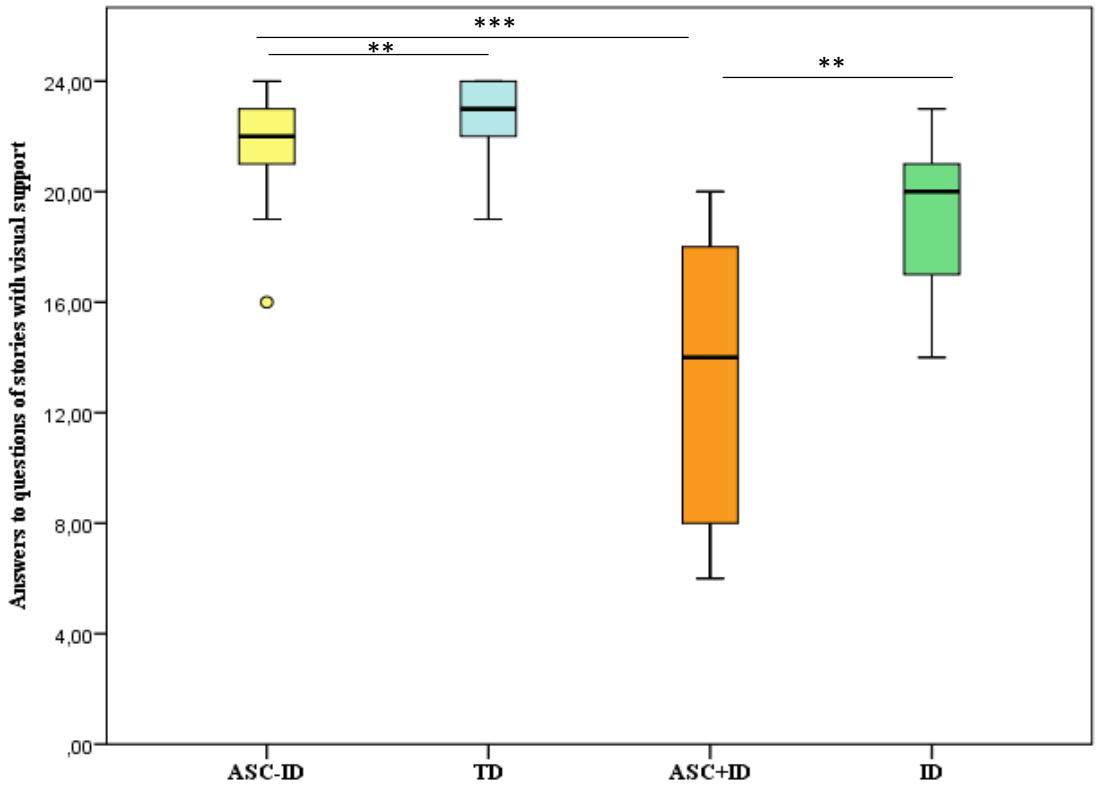
a) Question comprehension of stories with visual support

A Mann-Whitney U test was run to determine if there were differences in the ability to answer questions of stories with visual support between ASC–ID and TD. Distributions of the answers to stories with visual support for both groups were similar, as assessed by visual inspection. Median answer scores in tasks with visual support for ASC–ID (22.00) TD group (23.00) were statistically significantly different, $U = 650.00$, $z = 2.475$, $p = .013$.

The same test was used to compare ASC+ID and ASC–ID groups. Distributions of the answers to stories with visual support for both groups were not similar, as assessed by visual inspection. ASC+ID participants showed significantly greater difficulties (mean rank = 8.32) to comprehend questions of stories with visual support in comparison to the ASC–ID group (mean rank = 31.16), $U = 11.50$, $z = -5.176$, $p < .0005$.

Finally, an independent-samples t-test was run to determine if there were differences in answering questions to stories with visual support between ASC+ID and ID groups. The ASC+ID group answered correctly fewer questions in this condition (13.42 ± 1.35) than the ID group (19.00 ± 1.17), a statistically significant difference of -5.60 (95% CI, -9.33 to -1.80), $t(17.922) = -3.108$, $p = .006$.

In conclusion, there were significant differences in all group comparisons. In more specific terms, TD participants had better question comprehension in visual tasks than the ASC–ID group. The ASC+ID group scored significantly lower in question comprehension of visual tasks than the ASC–ID group and the ID group, as visualized in Figure 13.



***indicates $p \leq .001$; ** indicates $p \leq .03$

Figure 13. Comparison of correct answers scores between ASC–ID and TD groups; ASC–ID and ASC+ID groups and ID and ASC+ID groups on answering questions of stories with visual support.

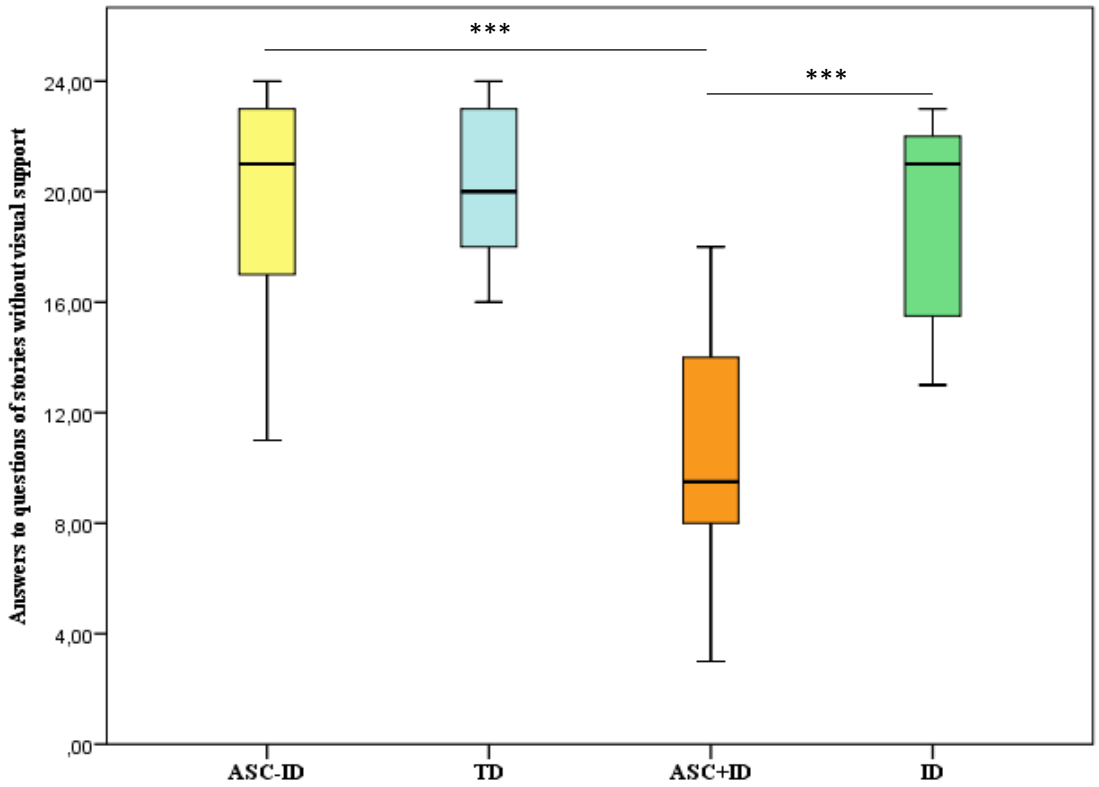
b) Question comprehension of stories without visual support

A Mann-Whitney U test was run to determine if there were differences in the ability to answer questions of stories without visual support between ASC–ID and TD. Distributions of the answers to stories with visual support for both groups were not similar, as assessed by visual inspection. Question scores of stories without visual support for the TD (mean rank = 32.27) and for the ASC+ID groups (mean rank = 31.73) were not statically significantly different, $U = 473.50$, $z = -1.00$, $p = .921$.

The same test was used to compare ASC+ID and ASC–ID groups. Distributions of the answers to stories without visual support for both groups were not similar, as assessed by visual inspection. ASC+ID participants showed significantly greater difficulties (mean rank = 10.29) to comprehend questions of stories with visual support in comparison to the ASC–ID group (mean rank = 30.35), $U = 39.00$, $z = -4.534$, $p < .0005$.

Finally, an independent-samples t-test was run to determine if there were differences in answering questions to stories with visual support between ASC+ID and ID groups. The ASC+ ID group answered correctly less questions in this condition (10.92 ± 1.29) than the ID group (18.85 ± 1.53), a statistically significant difference of -7.92 (95% CI, -12.38 to -3.473), $t(19) = -3.725$, $p < .005$.

In conclusion, no significant differences were found between TD and ASC–ID groups in tasks without visual support. As visualized in Figure 14, the ASC+ID group had significantly greater difficulties in question comprehension of tasks without visual support in comparison to the ASC–ID and the ID groups.



**indicates $p \leq .001$

Figure 14. Comparison of correct scores of answers between ASC–ID and TD groups; ASC–ID and ASC+ID groups and ID and ASC+ID groups on answering questions of stories without visual support.

6.5 Correlational analyses

6.5.1 Age factors

Pearson's product-moment and Spearman's rank-order correlations were run to assess the relationship between CA and answers to different types of questions within the four different groups. Within the TD group, a Spearman's rank-order correlation was run to assess the relationship between CA and correct answers to *yes/no*-questions. Preliminary analysis showed the relationship to be monotonic, as assessed by visual inspection of a

scatterplot. There was a statistically significant, positive correlation between these variables, $r_s(32) = .421$, $p = .013$. The same test also showed a statistically significant correlation between CA and correct answers to local *wh*-questions in complex sentences within the ASC+ID group, $r_s(12) = .54$, $p = .011$. No other correlation showed significant results within the ASC–ID and the ID group as seen in Table 2.

Table 2. Correlations between CA and different types of question comprehension

	CA			
	TD	**ASC–ID**	**ASC+ID**	**ID**
Yes/no-questions	.013*	.659	.658	
Wh-questions	.089	.535	.318	.635
Wh-questions in simple sentences		.436	.350	.426
Wh-questions in complex sentences		.411	.268	
Local *wh*-questions in complex sentences			.011*	
Long-distance *wh*-questions in complex sentences				

Statistically significant *p*-values after Bonferroni's correction is .025 for the TD and ID, .012 for the ASC–ID and .011 for the ASC+ID.

Regarding the relation between VMA and question comprehension, a Spearman's rank-order correlation was run to assess the relationship between VMA and correct answers to *yes/no*-questions within the TD group. Preliminary analysis showed the relationship to be monotonic, as assessed by visual inspection of a scatterplot. There was a positive statistically significant correlation between these variables, $r_s(32) = .562$, $p = .001$. The same test also showed a positive statistically significant correlation between VMA and correct answers to *wh*-questions within this group, $r_s(32) = .454$, $p = .007$.

Within the ASC–ID group, a Spearman's rank-order correlation was run to assess the relationship between VMA and correct answers to *yes/no*-questions. Preliminary

analysis showed the relationship to be monotonic, as assessed by visual inspection of a scatterplot. There was a positive statistically significant correlation between these variables, $r_s(32) = .492$, $p = .003$.

No other correlation showed significant results within the ASC+ID and the ID group as seen in Table 3.

Table 3. Correlations between VMA and different types of question comprehension

	VMA			
	TD	**ASC–ID**	**ASC+ID**	**ID**
Yes/no-questions	.001**	.003*	.030	.035
Wh-questions	.007*	.106	.023	.054
Wh-questions in simple sentences		.039	.026	.091
Wh-questions in complex sentences				
Local *wh*-questions in complex sentences				
Long-distance *wh*-questions in complex sentences				

Statistically significant *p*-values after Bonferroni's corrections is .025 for the TD and .016 for all the other groups.

6.5.2 Cognitive factors

Pearson's product-moment and Spearman's rank-order correlations were run to assess the relationship between VIQ and answers to different types of questions within the four different groups. Within the TD group, a Spearman's rank-order correlation was run to assess the relationship between VIQ and correct answers to *yes/no*-questions. Preliminary analysis showed the relationship to be monotonic, as assessed by visual inspection of a scatterplot. There was a statistically significant positive correlation between these variables, $r_s(32) = .411$, $p = .016$. The same test also showed a statistically significant,

positive correlation between VIQ and correct answers to *wh*-questions, $r_s(32) = .414$, $p = .015$.

Within the ASC–ID group, a Spearman's rank-order correlation was run to assess the relationship between VIQ and correct answers to *yes/no*-questions. Preliminary analysis showed the relationship to be monotonic, as assessed by visual inspection of a scatterplot. There was a statistically significant, strong positive correlation between these variables, $r_s(32) = .674$, $p < .0005$.

In the case of the ID group, only a Spearman's rank-order correlation was run to assess the relationship between VIQ and correct answers to *wh*-questions in complex sentences. Preliminary analysis showed the relationship to be monotonic, as assessed by visual inspection of a scatterplot. There was a statistically significant, strong positive correlation between these variables, $r_s(4) = .920$, $p = .009$. The same test was used to assess a possible relationship between VIQ and long-distance *wh*-questions in complex sentences (after applying a reflect and logarithmic transformation this last variable). This test showed a significant, strong positive correlation between these variables, $r_s(4) = -.920$, $p = .009$. No other correlation could be run between VIQ and the rest of answers to different types of questions within the ASC+ID because their relationship was neither monotonic nor linear upon visual inspection as seen in Table 4.

Table 4. Correlations between VIQ and different types of question comprehension

	VIQ			
	TD	**ASC–ID**	**ASC+ID**	**ID**
Yes/no-questions	.016*	<.001**		
Wh-questions	.015*	.022		
Wh-questions in simple sentences	.039	.032		
Wh-questions in complex sentences				.009*
Local *wh*-questions in complex sentences				
Long-distance *wh*-questions in complex sentences				.009*

Statistically significant *p*-values after Bonferroni's corrections is .016 for the TD and the ASC–ID, 0.50 for the ASC+ID and 0.25 for the ID.

Within the TD and the ASC+ID groups, there was no statistically significant correlation between these variables. However, within the ID group, a Pearson's product-moment correlation was also run to assess the relationship between WM and *wh*-questions. Preliminary analyses showed the relationship to be linear with both variables normally distributed, as assessed by Shapiro-Wilk's test ($p > .05$). There was a statistically significant correlation between these variables within this group, $r(5) = .883$, $p = .008$. The same test was used to stablish the relationship between WM and *wh*-questions in simple sentences. Preliminary analyses showed the relationship to be linear with both variables normally distributed, as assessed by Shapiro-Wilk's test ($p > .05$). There was a statistically significant correlation between these variables within this group, $r(5) = .914$, $p = .004$. No other correlation was found to be significant between WM and the rest of answers to different types of questions within groups as seen in Table 5.

Table 5. Correlations between WM and different types of question comprehension

	WM			
	TD	**ASC–ID**	**ASC+ID**	**ID**
Yes/no-questions	.222			
Wh-questions	.837		.247	.008*
Wh-questions in simple sentences			.225	.004*
Wh-questions in complex sentences			.248	.592
Local *wh*-questions in complex sentences				
Long-distance *wh*-questions in complex sentences				.244

Statistically significant *p*-values after Bonferroni's corrections is .025 for the TD, 0.50 for the ASC–ID, 0.16 for the ASC+ID and 0.12 for the ID.

6.5.3 Phonology

Pearson's product-moment and Spearman's rank-order correlations were run to assess the relationship between intonation and answers to different types of questions within the four different groups. There was only a statically significant correlation within the ASC–ID group. A Pearson's product-moment correlation was run to assess the relationship between intonation and *wh*-questions in simple sentences. Preliminary analyses showed the relationship to be linear with both variables normally distributed, as assessed by Shapiro-Wilk's test ($p > .05$). There was a statistically significant medium positive correlation between these variables within the ASC–ID group, $r(32) = .53$, $p = .001$, with intonation explaining 28% of the variation in comprehension of *wh*-questions in simple sentences. No other correlation showed significant results within groups as seen in Table 6.

Table 6. Correlations between intonation and different types of question comprehension

	Intonation			
	TD	**ASC–ID**	**ASC+ID**	**ID**
Yes/no-questions		.338		.035
Wh-questions				.038
Wh-questions in simple sentences		.001**		.027
Wh-questions in complex sentences	.134		.111	
Local *wh*-questions in complex sentences				
Long-distance *wh*-questions in complex sentences	.099			

Statistically significant *p*-values after Bonferroni's corrections is .025 for the TD and the ASC–ID, 0.50 for the ASC+ID and 0.16 for the ID.

Regarding the relationship between the scores of frequent and non-frequent pseudowords repetition tasks and answers to different types of questions, no statistically significant correlation was found within the four groups as seen in Tables 7 and 8.

Table 7. Correlations between frequent pseudowords repetition and different types of question comprehension

	Frequent Pseudowords Repetition			
	TD	**ASC–ID**	**ASC+ID**	**ID**
Yes/no-questions			.757	.780
Wh-questions	.132		.253	.948
Wh-questions in simple sentences			.200	.890
Wh-questions in complex sentences				.846
Local *wh*-questions in complex sentences				
Long-distance *wh*-questions in complex sentences				

Statistically significant *p*-values after Bonferroni's corrections is .050 for the TD and the ASC–ID, 0.16 for the ASC+ID and 0.25 for the ID.

Table 8. Correlations between non-frequent pseudowords repetition and different types of question comprehension

	Non-frequent Pseudowords Repetition			
	TD	**ASC–ID**	**ASC+ID**	**ID**
Yes/no-questions	.553		.591	.698
Wh-questions	.292		.264	
Wh-questions in simple sentences			.184	
Wh-questions in complex sentences				
Local *wh*-questions in complex sentences				
Long-distance *wh*-questions in complex sentences				

Statistically significant *p*-values after Bonferroni's corrections is .025 for the TD, 0.50 for the ASC–ID and the ID and 0.16 for the ASC+ID.

6.6 Results summary

ASC with or without ID and the TD groups answered *yes/no*-questions significantly more correctly than *wh*-questions. Between groups, ASC–ID participants showed significantly greater difficulties to comprehend *wh*-questions in complex sentences in comparison to the TD group. The ASC+ID group showed the greatest difficulties to answer *wh*- and *yes/no*-questions in comparison to the other groups.

The ASC–ID and the ID groups answered *wh*-questions in simple sentences significantly more correctly than *wh*-questions in complex sentences. Between groups, ASC–ID participants had greater difficulties to answer *wh*-questions in complex sentences in comparison to TD but the ASC–ID group answered significantly correct more *wh*-questions in simple and in complex sentences than the ASC+ID ones. Within groups, only TD participants were able to answer statistically significant much better

local rather than long-distance *wh*-questions in complex sentences. Between groups, the ASC–ID group had statistically significant greater difficulties to answer local *wh*-questions in complex sentences than the TD group. Overall, ASC+ID participants had greater difficulties in comparison to other groups to comprehend all types of questions.

All groups could answer better questions of tasks with visual support apart from the ID group. Between groups, the TD group performed significantly better than the ASC–ID one only in question comprehension of tasks *with* visual support. The ASC–ID group scored significantly better than the ASC+ID group in question comprehension both with and without visual support. The ID group also scored significantly better in question comprehension in both conditions in comparison the ASC+ID group.

CA, VMA and VIQ correlated with some types of question comprehension within the TD and the ASC–ID groups. VIQ also correlated statistically significant with *wh*-questions in complex sentences and long-distance questions within the ID group. WM had only a significant relationship with *wh*-questions and *wh*-questions in simple sentences within the ID group. Finally, intonation only correlated statistically significant with the comprehension of *wh*-questions in simple sentences within the ASC–ID group.

Chapter 7. Discussion

This study was focused on question comprehension in ASC. In more specific terms, this project aimed to explore whether the ability to understand questions in ASC was sensitive to syntactic differences in question type, be they *wh*-questions or *yes/no*-questions. In addition, we assessed complexity effects, that is, we compared *wh*-questions occurring in complex (bi-clausal) and simple sentences (mono-clausal). For the former, we examined locality effects, that is, whether it was consequential that the *wh*-expression belonged interpretively to the main (local) or the embedded (long distance) clause. Other goals of this research were to study the role of visual support and age, cognitive or other linguistic factors in question comprehension.

In the present discussion, we will reflect on how our results square with our initial predictions. Secondly, we will present the limitations of the study and suggest further research. Finally, we will comment on the practical applications of our results.

Results of the present study have confirmed a question comprehension impairment in ASC relative to matched TD and ID comparison groups. Between groups, both ASC–ID and ASC+ID participants of our study had significantly greater difficulties in *wh*-question comprehension than their respective TD and ID control groups. In addition, individuals with ASC+ID showed a significantly lower level of *yes/no*-question comprehension than the ID group. These results indicate a question comprehension impairment across the entire verbal spectrum, specifically in *wh*-questions.

We also have partially confirmed our second prediction which was that question comprehension in all groups would be modulated by the question type. With the exception of the ID group, which did not show any significant difference between these two types

of sentences, all other groups scored higher in *yes/no*-questions than *wh*-questions. This greater difficulty found in *wh*-question comprehension in comparison to *yes/no*-question comprehension is in line with the results found by Curcio and Paccia (1987), Oi (2005, 2008, 2010) and Oi and Tanaka (2011). However, it contradicts those of Huang and Oi (2013) and Moradlou et al. (2020). The former did not find that ASC–ID children answered *yes/no*-questions better than *wh*-questions. However, as was commented in Chapter 2, this lack of difference might be due to the type of *yes/no*-questions used in Taiwanese. In turn, Moradlou et al. (2020) found that *wh*-questions were understood before *yes/no*-questions in TD children, which would suggest that *wh*-questions are easier to comprehend than *yes/no* questions. Nevertheless, it is worth noticing that participants of this study were German (ages 1.2-3.1, mean 1.9) and Chinese children (ages 1.5-2.9, mean 2.0), who may not have had fully developed their question comprehension due to their young age.

Our third prediction was about the syntactic complexity of *wh*-questions. In more specific terms, ASC participants would have fewer correct answers to *wh*-questions in complex sentences than in simple sentences and in long-distance *wh*-questions than in local questions. We also hypothesize that this within-group pattern will be similar in TD and both ID groups.

Regarding the first comparison between *wh*-questions in complex and in simple sentences, findings of this study showed that question comprehension of the ASC–ID group was significantly higher in *wh*-questions in simple sentences in comparison to complex sentences. The ID group showed the same pattern. However, ASC+ID participants did not show any significant differences between question comprehension of these two types of *wh*-questions, probably because there was a floor effect in their *wh*-question comprehension, regardless of whether they were embedded or not. In contrast,

TD participants' *wh*-question comprehension showed a ceiling effect in both simple and complex questions. Thus, their comprehension was not affected by embedding clauses either.

Between-group comparisons also showed that in the ASC–ID group, question comprehension was affected by syntactic complexity in comparison to the TD group because the former group scored significantly lower in *wh*-question comprehension in complex sentences but not in simple ones in comparison to the TD control group. The ASC+ID group's question comprehension was not sensitive to syntactic complexity of *wh*-questions because they had significant greater difficulties in *wh*-questions in both simple and complex sentences in comparison to ASC–ID group and only in *wh*-questions in simple sentences in comparison to the ID group.

Therefore, our within-group prediction was only valid for the ASC–ID group and for the ID group, which we attribute to floor ceiling effects in the other groups. Between groups, only the ASC–ID group validated the aforementioned prediction in the comparison between *wh*-question comprehension in simple and in complex sentences. As far as long-distance *wh*-questions are concerned, the TD group was the only group of participants that showed a significant difficulty to answer long-distance *wh*-questions in complex sentences in comparison to local *wh*-questions in complex sentences. Thus, our prediction about an increased difficulty in the understanding of long-distance *wh*-questions was only confirmed for the TD group. Figure 15 shows all within-group results in terms of significant differences as an effect of an increasing difficulty in question comprehension.

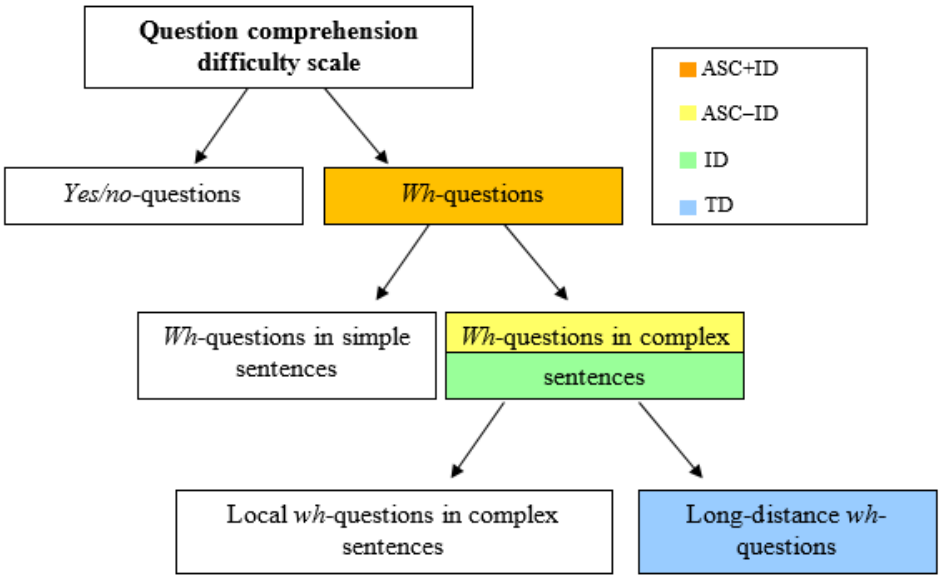


Figure 15. Within-group significant results on the effect of difficulties in question comprehension.

It might be thought that this poorer performance of the ASC–ID group in the comprehension of *wh*-questions in complex sentences may relate to a lexical and not a syntactic complexity effect, due to the use of mental state verbs in most of the complex sentences we used. In line with this, Tager-Flusberg (2000) and Lind and Bowler (2009) found an ASC impairment in the comprehension of complement clauses in declarative sentences with a cognitive main verbs of cognition (e.g. *believe* or *think*) but not in verbs of communication (e.g. *reply* or *say*). However, Durrleman and Franck (2015) found similar performance by children with ASC and TD controls for the understanding of complement sentences, non-verbal ToM and executive functions but their ASC participants were significantly impaired in verbal FB tasks. For both groups, correlations controlling for IQ were found between the verbal FB task and complement sentences of

verbs of communication and cognition, but not with verbs of perception. In our study, three of four of our *wh*-questions in complex sentences contained a verb of cognition (*think*, *believe* and *know*). The fourth was with *do (¿Qué hace el hombre cuando vuelve? (Sp.) / What does the man do when he comes back?*). Like in English, this verb in combination with *qué* (Sp.) (*what*) acts as a pro-verb and entails a more complex response in the sense that a verb heading a nonfinite or finite clause must be provided in the answer.

Another aspect that may imply a greater difficulty of *wh*-questions in complex sentences is that all of them are in tasks with FB content, whereas *wh*-questions in simple sentences are found in tasks with and without FB. It could thus be thought that FB makes *wh*-question comprehension in complex sentences more difficult in ASC. However, a post hoc between-group analysis of comprehension of all questions across both FB tasks did not show any significant differences between the TD and the ASC–ID group.

In addition, we were able to identify that all ASC and TD groups (unlike the ID group) benefited significantly from visual support in question comprehension compared to question comprehension with only auditory input. So, our prediction about the aid of visual support in question comprehension was confirmed by all groups except for the ID group. However, interestingly, the TD group showed better question comprehension than the ASC–ID group only *with* visual support. These results would indicate that visual support in ASC is not enough to overcome language comprehension deficits. As Coderre (2020) noted:

> While visual supports may be beneficial in some situations (e.g., picture-based communication systems such as PECS, […]), educators, investigators, and clinicians must be careful in assuming that simply including pictures in every aspect of intervention or training will make processing easier for individuals with language difficulties. Instead, cognitive deficits in the more

> domain-general aspects of narrative processing may extend beyond differences in modality. (p.247)

Our study also found that the ASC–ID group had significantly better comprehension with visual support rather than the ASC+ID participants, who in turn scored significantly worse than the ID group. The same pattern between these groups was obtained for question comprehension without visual support. Therefore, these group differences related to question comprehension exist irrespective of the modality and cannot be resolved by visual support.

As noted above, without visual support, there were no statistically significant differences in question comprehension between the ASC–ID and the TD groups. We administered two different question comprehension tasks without visual support, one with false beliefs and the other without them. Each of these tasks contained 6 *yes/no*-questions and 6 *wh*-questions of different complexity. Both groups had notable and comparable difficulties answering questions concerning false beliefs (ASC–ID mean = 8.50, TD mean = 8.47) and there was a ceiling effect for questions concerning true belief for both groups (ASC–ID mean = 11.26, TD mean = 12).

We also predicted that some age and cognitive factors might be correlated with question comprehension. Our results show that CA related positively to *yes/no* comprehension in TD, in line with Durrleman et al. (2016). In addition, VMA and VIQ had a positive relation to *yes/no*-question comprehension among both TD and ASC–ID participants. In the TD group, there was also a correlation with these variables and *wh*-question comprehension. The fact that TD's question comprehension is associated with VMA and VIQ regardless of question type may suggest a different linguistic processing pattern between TD and ASC–ID participants in question comprehension. VIQ also had a positive correlation with *wh*-question comprehension in complex sentences in the ASC–

ID group. WM only related positively within the ID group in *wh*-question comprehension (regardless of type) and *wh*-question comprehension in simple sentences but paradoxically not *wh*-questions in complex sentences. No other group had any significant relation between their scores on WM and question comprehension. Overall, these non - significant results suggest that the impairment in question comprehension in ASC cannot be attributed to a WM confound.

Finally, we also predicted that deficits in prosody and phonology might affect the understanding of *yes/no*-questions in the ASC–ID and the ASC+ID groups. However, intonation was only shown to have a positive relation with *wh*-question comprehension in simple questions in this group. No significant correlation was found in any group between intonation and question comprehension in *yes/no*-questions. This was an unexpected result because intonation is crucial to distinguish *yes/no*-questions from declaratives in Spanish. Furthermore, there was no significant relation between frequent and non-frequent pseudowords and question comprehension in any group. Thus, it could be suggested that any difficulty with question comprehension is more specifically linguistic, as opposed to reflecting aspects of the phonological surface of language

Several limitations of this study need to be considered. Due to difficulties in recruiting ID participants, we were not able to match individually the ASC+ID and ID groups. For this reason, we have a smaller number of participants in the ID group than in the ASC+ID group. However, there were no significant differences in VMA, CA, IQ, WM and VMA between these groups. Other limitations are due to the experimental design. In more concrete terms, we did not include *yes/no*-questions in complex sentences as we did with *wh*-questions. Furthermore, all our *wh*-questions in complex sentences contain cognitive verbs, except one. Finally, in our experiment, there were only two

examples each of long-distance *wh*-questions and local *wh*-questions in complex sentences.

Further research could involve a more exhaustive qualitative analysis of the errors observed in the answers of participants as well as an analysis of answers to different *wh*-elements and the influence in comprehension of transitive and intransitive verbs in questions, as Ervin-Tripp (1970) and Tyack and Ingram (1977) had already suggested. In addition, *yes/no*-question comprehension in complex sentences could be explored in the future in order to know whether embedding also hinders *yes/no*-question comprehension, as happens in *wh*-questions. It is also necessary to study question comprehension of *wh*-questions in complex sentences that contain other verbs than cognition verbs and to contrast them with cognition verbs, so as to determine whether the cause of the effect in complexity in ASC is lexical or syntactic.

Although this has been a quantitative study, some answer patterns of the ASC individuals were notable. For example, some participants did not know the answer to a certain question and replied "I don't know". This case was counted as an inappropriate answer. In the case of the *yes/no*-questions, most of the wrong answers consisted in answering *yes* when the correct answer is *no* and vice versa. Furthermore, it could be observed that most of the wrong answers were so in terms of content but correct as for the aboutness, that is a *where* question was always answered with a place specification, a *who* one with a person specification. For example, a wrong answer to *¿Dónde está la canica de Sally al final?* (Sp.) (*Where is Sally's marble at the end?*) could be *en la cesta* (Sp.) (*in the basket*), whereas the correct answer is *en la caja* (Sp.) (*in the box*).

Other wrong answers to *wh*-questions were tangential in the sense of being detached from the story. Thus, in some cases the participants gave generic responses. like

that of *miau*, the Spanish onomatopoeia for a cat's sound, to the question *¿Qué hace el gato?* (Sp.) (*What is the cat doing?*). In other cases, participants instead went to their personal life to answer. For instance, one ASC+ID participant answered to the question *¿Quién pone la canica dentro de la cesta?* (Sp.) (*Who puts the marble inside the basket?*) saying *la yaya José* (Sp.) (*Granny José*).

A third type of detached response we found was *¿Por qué el hombre no sabe dónde están las gafas al final?* (Sp.) (*Why doesn't the man know where the glasses are at the end?*) saying *porque no las encuentra* (Sp.) (*because he doesn't find them*). In this example, it seems that the participant is responding with a metalinguistic inference: anybody who is looking for something does not know where this something is. This pattern of errors suggests that the difficulty that *wh*-question comprehension presents is not related to the scope of the *wh*-word, but to some other factor(s).

Making a step further, it seems right to conclude that in order to explain why *wh*-questions are (to some extent) difficult across the whole autism spectrum, syntactic factors as such seem to be of little help. In this regard, it has to be borne in mind that *wh*-questions have been shown to be differentially difficult with respect to *yes/no*-questions for East-Asian language speaking autistic children, which eliminates the issue of an overt filler-gap structure as an explanatory factor. A more complex sentence initial periphery in *wh*-questions than in declarative sentences has also to be cast aside since in the present study the participants were Spanish speaking, which means that there is no overt formal complication in this part of sentences. Furthermore, all the questions in the sample were with bare *wh*-expressions so that the discourse presuppositions triggered by *wh*-expressions with pied-piping (i.e. discourse-linked *wh*-questions) cannot be either a hurdle to overcome. Finally, the difference between long-distance and local *wh*-questions was not at work in the autistic groups examined. What is then the impediment with *wh*-

questions across the spectrum? Sentential complexity in terms of bi-clausality was indeed a significant factor in the present study. With high likelihood the fact that questions were embedded in a narrative was also a further complication as narratives (even with visual support) have to be hold internally to the mind by means of language itself.

At that point, we are left to speculate about the reason why, apart from the intrasentential complexity and the narrative factor, *wh*-questions are burdensome in ASC in a way that does not compare to *yes/no*-questions. The presence in the former *vs*. the absence in the latter of a *wh*-expression suggests itself as a main independent cause. Moreover, our data invite to counteract the alleged increased difficulty of the discourse-linked *wh*-questions. In a condition like Williams syndrome, where *wh*-questions are also difficult, an intervention which has been shown to be effective (Semel & Rosner, 2003) is the replacement of bare *wh*-expressions with *wh*-expressions with pied-piping (*what* with *what thing*; *who* with *what person*; *where* with *what place*, etc.). To our understanding, this practice coheres with Curcio and Paccia's (1987) interpretation mentioned in Section 2.4. According to it, the greater necessity of an externally imposed structure in the autistic condition might increase the difficulty of *wh*-questions compared to *yes/no*-questions: in the former, the addressee has to internally generate the requested information while, in the latter, the addressee receives a sentence which has to be just truth-valued in a way.

In conclusion, this dissertation sheds light on question comprehension in ASC, a capacity which is crucial for social interaction and unexplored in Spanish. It provides evidence of a question comprehension deficit across the entire verbal spectrum, which is specific to this condition in comparison to TD or ID groups. This linguistic impairment is affected by question type, especially in *wh*-questions. Syntactic complexity affects ASC *wh*-question comprehension when embedding is involved but not in terms of long-

distance *vs.* local relation, which only has an effect in the TD population. Other factors such as phonology and WM came out as not related to question comprehension in ASC. CA has a very residual impact on ASC question comprehension (only in the ASC+ID group). Only VIQ influenced performance in some cases. Finally, visual support also benefits ASC question comprehension but it does not fully compensate for this linguistic deficit.

With this evidence, we would like to contribute to a greater awareness of the linguistic impairment in ASC regarding questions, in particular in *wh*-questions. Any diagnostic assessment, intervention and hospital, school or police questionnaire addressed to this population should consider the aforementioned language difficulties, if their purpose is other than to test their linguistic abilities. In addition, we would like to reaffirm the benefits of visual support in question comprehension not only for individuals with ASC but also with TD in question comprehension, despite of the fact that they cannot cover deficits in question comprehension in ASC.

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Annexes

1. Experimental tasks and scoresheet

Información del participante

1. Nombre del participante:

2. Fecha de nacimiento:

3. Lengua inicial:

4. Lugar de nacimiento:

5. Lugar donde se realiza el test:

6. Fecha:

7. Observaciones:

Pre-tests

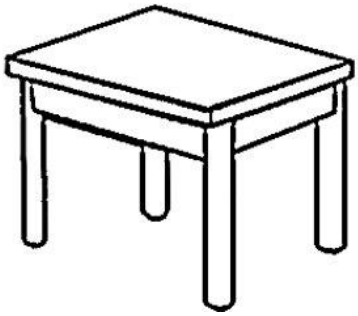
Task 1: Picture Naming Task

Consigna: A continuación, tenemos unos dibujos. ¿Me podrías decir qué son?

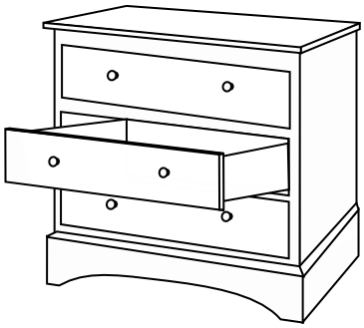
Si el participante no responde, después de unos minutos, se le puede preguntar: ¿Qué és esto?

1.

2.



3.



4.

5.

6.

7.

8.

	Respuesta correcta	**Respuesta incorrecta. ¿Cuál?**
1	gafas	
2	mesa	
3	cajón	
4	hombre, niño…	
5	mujer, abuela…	
6	perro	
7	ladrar, un perro ladrando…	
8	niña, muñeca…	

Task 2.1: Frequent Pseudowords Repetition task

Consigna: Ahora vamos a escuchar unas palabras que no significan nada, pero no te preocupes por eso. Las escucharas dos veces y después tú las repites. Puede ser un poco aburrido porque son bastantes, pero enseguida se termina. Empezamos.

Poner audio 2.1.

2 sílabas	**Respuesta correcta**	**Respuesta incorrecta. ¿Cuál?**
1	ena	
2	cote	
3	esmo	
4	saén	
5	decón	
3 sílabas		
1	conamo	
2	paesma	
3	asope	
4	sitaen	
5	brénodi	
4 sílabas		

1	entosame	
2	deteraco	
3	pacósena	
4	menciabiso	
5	autidenes	
5 sílabas		
1	terablenicia	
2	cosimenlada	
3	indetomapo	
4	analícato	
5	masperamones	

Task 3: Grammatical Perception of Intonation task

Consigna: Vas a escuchar unas frases. Después de cada frase, tendrás que decir si es una pregunta o si no lo es. Por ejemplo, si escuchas "Marta tiene un perro", tendrás que decir que no es una pregunta, pero si escuchas "¿Marta tiene un perro?" entonces tendrás que decir que es una pregunta. ¿Empezamos?

Poner audio 3.

Frase	**Respuesta**	**Error**
1. Habla francés – no pregunta	□ pregunta □ no pregunta	
2. ¿Está en el restaurante? pregunta	□ pregunta □ no pregunta	
3. Bebe tres tazas de café cada día – no pregunta	□ pregunta □ no pregunta	
4. Quiere irse ahora – no pregunta	□ pregunta □ no pregunta	
5. ¿Toca el piano? – pregunta	□ pregunta □ no pregunta	
6. ¿Habla francés? – pregunta	□ pregunta □ no pregunta	
7. Toca el piano – no pregunta	□ pregunta □ no pregunta	
8. ¿Le gusta conducir grandes coches? - pregunta	□ pregunta □ no pregunta	
9. Quiere comprarse una casa cerca de la playa – no pregunta	□ pregunta □ no pregunta	
10. ¿Quiere comprarse una casa cerca de la playa? pregunta	□ pregunta □ no pregunta	
11. ¿Olvidasteis el libro? - pregunta	□ pregunta □ no pregunta	

12. ¿Has vivido en París durante tres meses? - pregunta	□ pregunta □ no pregunta	
13. Está en el restaurante – no pregunta	□ pregunta □ no pregunta	
14. El supermercado cierra los domingos- no pregunta	□ pregunta □ no pregunta	
15. ¿Trabaja diez horas cada día? - pregunta	□ pregunta □ no pregunta	
16. ¿El teléfono funciona? - pregunta	□ pregunta □ no pregunta	
17.Le gusta conducir grandes coches – no pregunta	□ pregunta □ no pregunta	
18. ¿Quiere irse ahora? - pregunta	□ pregunta □ no pregunta	
19. Olvidasteis el libro – no pregunta	□ pregunta □ no pregunta	
20. El teléfono funciona – no pregunta	□ pregunta □ no pregunta	
21. Trabaja diez horas cada día – no pregunta	□ pregunta □ no pregunta	
22. ¿El supermercado cierra los domingos? – pregunta	□ pregunta □ no pregunta	

23. Has vivido en París durante tres meses – no pregunta	□ pregunta □ no pregunta	
24. ¿Bebe tres tazas de café cada día? pregunta	□ pregunta □ no pregunta	

Task 2.2: Non-Frequent Pseudowords Repetition task

Consigna: Ahora volveremos a escuchar unas palabras que no significan nada. Otra vez, las escucharas dos veces y después tú las repites. ¿Empezamos?

Poner audio 2.2.

2 sílabas	**Respuesta correcta**	**Respuesta incorrecta. ¿Cuál?**
1	olu	
2	chegue	
3	osfu	
4	riol	
5	bupil	
3 sílabas		
1	burrefo	
2	geoncu	

3	irrolo	
4	muñeas	
5	plúzogue	
4 sílabas		
1	ustiñole	
2	denomugue	
3	marópeno	
4	tundialaso	
5	augicumal	
5 sílabas		
1	neciglotadia	
2	cosumanfora	
3	anquibesido	
4	onotánego	
5	cusmipalates	

Question-answering tasks

Task 4: Question-answering task with visual support and false beliefs

Consigna: ¿Te gustan los cómics? Te voy a dejar uno. Te lo puedes mirar y cuando lo hayas visto, me lo dices y me cuentas la historia sin mirar el dibujo. Aquí tienes.

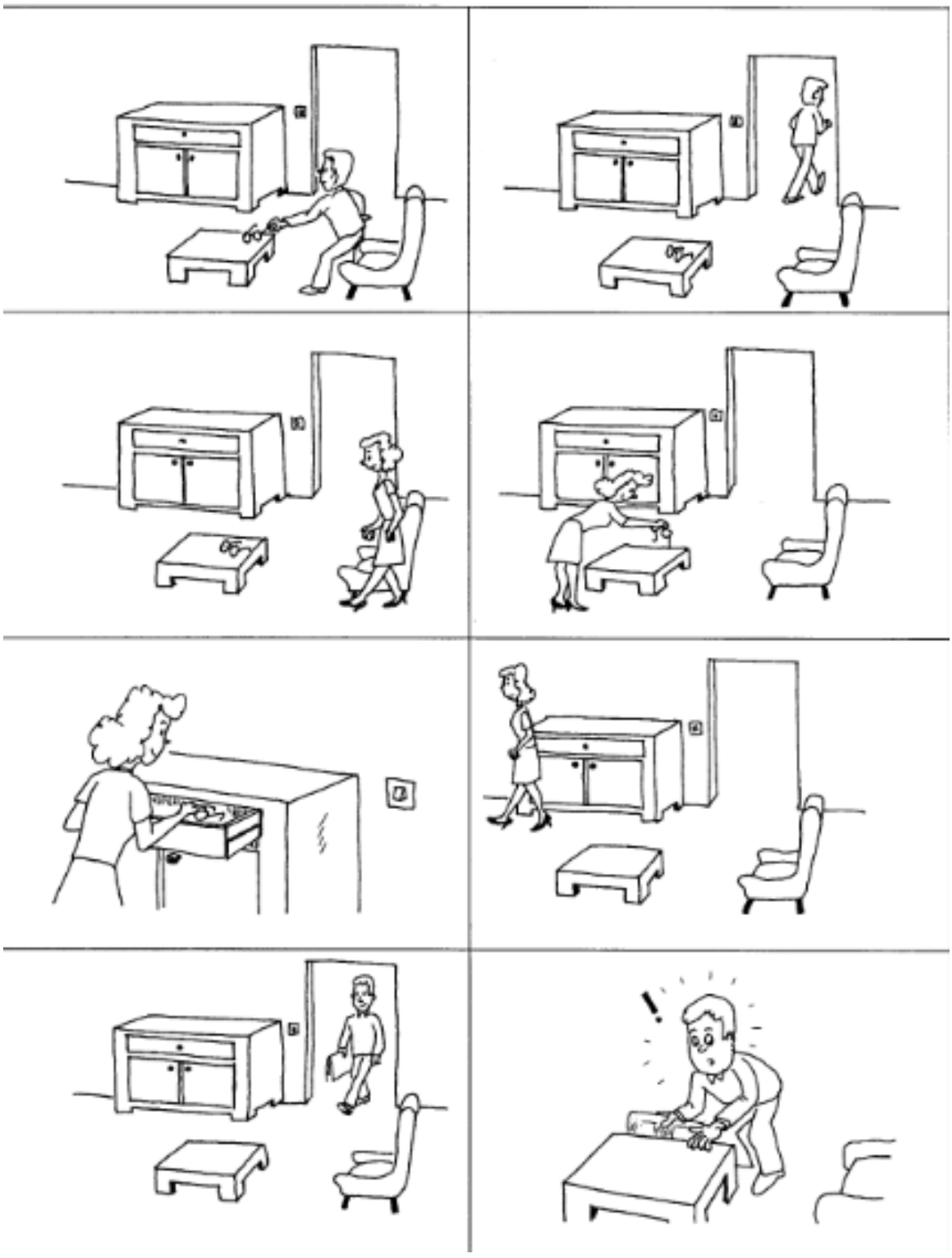


Figure 11. Comic published by Monfort and Monfort (2001).

Si el participante no consigue narrar bien la historia, decir:

"En estos dibujos, se puede ver cómo un hombre pone las gafas encima de la mesa del comedor y se va. Luego la mujer entra, ve las gafas y las pone en el cajón. Cuando regresa el hombre, no encuentra las gafas en la mesa".

Consigna: Muy bien. Ahora vamos hablar de la historia de los dibujos.

Si el participante no responde a alguna pregunta, volver a preguntarle.

1. ¿El hombre pone las gafas encima de la silla? (*Yes/no-question*)

2. ¿Quién pone las gafas encima de la mesa? (*Wh*-question in a simple sentence)

3. ¿Qué hace la mujer? (*Wh*-question in a simple sentence)

4. ¿La mujer cambia las gafas de sitio? (*Yes/no-question*)

5. ¿La mujer coloca las gafas dentro del cajón? (*Yes/no-question*)

6. ¿La mujer pone las gafas encima de la silla? (*Yes/no-question*)

7. ¿Qué hace el hombre cuando vuelve? (*Wh*-question in a complex sentence. In more details, local *wh*-question in a complex sentence)

8. ¿Dónde cree el hombre que están las gafas? (*Wh*-question in a complex sentence. In more details, long-distance *wh*-question)

9. ¿El hombre encuentra las gafas después? (*Yes/no-question*)

10. ¿El hombre tiene las gafas al final? (*Yes/no-question*)

11. ¿Dónde están las gafas al final? (*Wh*-question in a simple sentence)

12. ¿Por qué el hombre no sabe dónde están las gafas al final? (*Wh*-question in a complex sentence. In more details, local *wh*-question in a complex sentence)

Frase	**Respuesta correcta**	**Respuesta incorrecta ¿Cuál?**
1	No	
2	El hombre	
3	Poner las gafas en el cajón	
4	Sí	
5	Sí	
6	No	
7	No encuentra/ busca las gafas	
8	En la mesa	
9	No	
10	No	
11	En el cajón	
12	Porque la mujer las ha cambiado de sitio	

Task 5: Question-answering task with visual support and without false beliefs

Consigna: Muy bien ahora te voy a dejar otro dibujo y si te parece bien, vamos a hacer lo mismo: Te lo puedes mirar y cuando lo hayas visto, me lo dices y me cuentas la historia sin mirar el dibujo. Aquí tienes (see Figure 12).

Si el participante no consigue narrar bien la historia, decir:

“En estos dibujos, se puede ver cómo un hombre pasea con su perro en el parque. De golpe, el perro ve a un gato y empieza a perseguirlo tirando del hombre. El gato sube a un árbol mientras el perro lo persigue y el hombre va detrás del perro. Al final, es el hombre quien acaba atado al árbol”.

Figure 12. Comic published by Whelon (2011).

Consigna: Muy bien. Ahora vamos hablar de la historia de los dibujos.

Si el participante no responde a alguna pregunta, volver a repetirla.

1. ¿El hombre tiene un perro? (*Yes/no-question*)

2. ¿El hombre pasea un perro? (*Yes/no-question*)

3. ¿Qué ve el perro? (*Wh*-question in a simple sentence)

4. ¿Quién persigue al gato? (*Wh*-question in a simple sentence)

5. ¿Qué hace el gato? (*Wh*-question in a simple sentence)

6. ¿El gato persigue al perro? (*Yes/no-question*)

7. ¿El gato huye del perro? (*Yes/no-question*)

8. ¿Quién lleva al perro? (*Wh*-question in a simple sentence)

9. ¿El perro quiere perseguir al gato? (*Yes/no-question*)

10. ¿Dónde se queda atado el hombre? (*Wh*-question in a simple sentence)

11. ¿Por qué se queda atado el hombre? (*Wh*-question in a simple sentence)

12. ¿El hombre quiere quedarse atado a un árbol? (*Yes/no-question*)

Frase	**Respuesta correcta**	**Respuesta incorrecta ¿Cuál?**
1	Sí	
2	Sí	
3	Un gato	

4	El perro	
5	Huir/ subir a un árbol	
6	No	
7	Sí	
8	El hombre	
9	Sí	
10	A un árbol	
11	Porque se hace un lio con el gato y el perro	
12	No	

Task 6: Question-answering task without visual support and with false beliefs

Consigna: Ahora vamos a oír una historia. La escuchamos con atención y luego me dices lo que piensas de ella.

Poner audio 6.1.

Consigna: Muy bien. Ahora vamos hablar de la historia.

Si el participante no responde a alguna pregunta, volver a repetirla.

1. ¿Sally tiene una canica? (*Yes/no-question*)

2. ¿Quién pone la canica dentro de la cesta? (*Wh*-question in a simple sentence)

3. ¿Qué hace Anne? (*Wh*-question in a simple sentence)

4. ¿Anne tiene una pelota? (*Yes/no-question*)

5. ¿Anne cambia la canica de sitio? (*Yes/no-question*)

6. ¿Anne pone la canica dentro de la cesta? (*Yes/no-question*)

7. ¿Anne coloca la canica dentro de la caja? (*Yes/no-question*)

8. ¿Qué pone Anne en la caja? (*Wh*-question in a simple sentence)

9. ¿Sally ve a Anne cogiendo la canica? (*Yes/no-question*)

10. ¿Dónde está la canica de Sally al final? (*Wh*-question in a simple sentence)

11. ¿Dónde piensa Sally que está la canica? (*Wh*-question in a complex sentence. In more details, long-distance *wh*-question)

12. ¿Dónde va a buscar Sally la canica? (Wh- question in a simple sentence)

Frase	**Respuesta correcta**	**Respuesta incorrecta ¿Cuál?**
1	Sí	
2	Sally	
3	La pone dentro de la caja	
4	No	
5	Sí	
6	No	

7	Sí	
8	La canica	
9	No	
10	En la caja	
11	En la cesta	
12	En la cesta	

Task 7: Question-answering task without visual support and without false beliefs

Consigna: Ahora vamos a oír otra historia. La escuchamos con atención y luego me dices lo que piensas de ella.

Poner audio 7.1.

Consigna: Muy bien. Ahora vamos hablar de la historia.

Si el participante no responde a alguna pregunta, volver a repetirla.

1. ¿Dónde ocurre esta situación? (*Wh*-question in a simple sentence)

2. ¿Quién quiere tocar el perro? (*Wh*-question in a simple sentence)

3. ¿La niña quiere tocar el perro? (*Yes/no-question*)

4. ¿Qué dice la mamá? (*Wh*-question in a simple sentence)

5. ¿El perro es peligroso? (*Yes/no-question*)

6. ¿El perro ladra? (*Yes/no-question*)

7. ¿El perro tiene dueño? (*Yes/no-question*)

8. ¿Qué dice el hombre? (*Wh*-question in a simple sentence)

9. ¿Cómo se comporta el perro? (*Wh*-question in a simple sentence)

10. ¿La mamá toca al perro? (*Yes/no-question*)

11. ¿Finalmente, la niña toca al perro? (*Yes/no-question*)

12. ¿Cómo acaba la historia? (*Wh*-question in a simple sentence)

Frase	**Respuesta correcta**	**Respuesta incorrecta ¿Cuál?**
1	En un parque	
2	La niña	
3	Sí	
4	Que el perro ladra	
5	No	
6	No	
7	Si	
8	Que el perro no ladra	
9	Bien	
10	No	

11	Si	
12	La nina toca el perro	