disabilities

MDPI

Article

When Language Is Not Enough: How to Explain ToM Abilities of Individuals with Williams Syndrome and Down Syndrome

Claire Touchet [1], Régis Pochon [2] and Laure Ibernon [1,*]

[1] Research Center in Psychology: Cognition, Psyche and Organizations (CRP-CPO), University of Picardie Jules Verne (UPJV), 80025 Amiens, France; claire.touchet@me.com
[2] Cognition, Health and Society Laboratory, University of Reims Champagne-Ardenne, 51097 Reims, France; regis.pochon@univ-reims.fr
* Correspondence: laure.ibernon@u-picardie.fr

Abstract: This study examines the link between language abilities and Theory of Mind (ToM) development in individuals with Williams Syndrome (WS) and Down Syndrome (DS). We compared the results of 16 participants with WS, aged 6.3 to 27.2 years (Mean = 15.9 years, *SD* = 6.8 years), to those of 16 participants with DS, aged 10.7 to 23.9 years (Mean = 16.8 years, *SD* = 3.6 years). Using the French version of the ToM test-Revised (ToM test-R), we assessed three levels of ToM development: prerequisites, first-order beliefs, and second-order beliefs. Language abilities were evaluated using the Isadyle French language assessment battery, focusing on word comprehension, word production, syntax comprehension and production, and emotional lexicon. The results showed that the WS group performed significantly better in overall ToM skills in the ToM test-R compared to the DS group. Moreover, language skills were significantly associated with ToM development in the WS group, but not in the DS group. These findings underscore the importance of language development, particularly syntax and emotional understanding, in ToM acquisition. Through the application of a cross-syndrome approach, this study provides insights into how each syndrome impacts ToM development and the role of language in this process.

Keywords: Williams syndrome; Down syndrome; theory of mind; language development; emotion lexicon

check for updates

Academic Editor: Reinie Cordier

Received: 29 October 2024
Revised: 11 December 2024
Accepted: 8 January 2025
Published: 15 January 2025

Citation: Touchet, C.; Pochon, R.; Ibernon, L. When Language Is Not Enough: How to Explain ToM Abilities of Individuals with Williams Syndrome and Down Syndrome. *Disabilities* **2025**, *5*, 4. https://doi.org/10.3390/disabilities5010004

Copyright: © 2025 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (https://creativecommons.org/licenses/by/4.0/).

1. Introduction

The intricate relationship between language development and Theory of Mind (ToM) has been a subject of significant interest in developmental psychology and cognitive neuroscience. This relationship becomes particularly intriguing when examined in the context of neurodevelopmental disorders, such as Williams syndrome (WS) and Down syndrome (DS). These genetic conditions present unique cognitive profiles that offer valuable insights into the complex interplay between language abilities and social cognition.

This research aims to explore the current understanding of how language and theory of mind are interconnected in individuals with WS and DS. By examining these two distinct neurodevelopmental disorders, we can gain a deeper appreciation of the nuanced relationship between linguistic competence and social–cognitive abilities, as well as the potential implications for intervention strategies. ToM refers to the ability to attribute mental states—such as beliefs, desires, intentions, and emotions—to oneself and others, and to understand that these mental states can differ from one's own and from reality [1]. This cognitive skill is crucial for social interaction, as it allows individuals to predict and explain others' behavior based on their inferred mental states. The development of ToM

follows a predictable trajectory in typically developing children, with three key stages: understanding different desires around age 2, understanding first-order false beliefs around ages 4–5, and understanding second-order false beliefs around ages 6–7 (for a recent review, see [2]). One of the most widely used assessments of ToM is the false belief task, which tests a child's ability to understand that others can hold beliefs that are different from reality and from the child's own beliefs [3]. The development of ToM is underpinned by several cognitive and affective prerequisites, with emotional development and language abilities playing crucial roles (for a review, see [4]). Emotional understanding, including the ability to recognize and differentiate between various emotional states, forms a foundation for more complex social–cognitive skills. This emotional competence allows individuals to interpret social cues and infer others' mental states based on affective information. Language plays a multifaceted role in ToM development. It provides a medium for learning about mental states through conversation and storytelling, offers syntactic structures (such as complement clauses) that may scaffold mental state representations, and serves as a tool for reflecting on and expressing understanding of others' thoughts and beliefs [5,6].

The relationship between language and ToM has been a subject of extensive research and debate. Some researchers argue that language plays a crucial role in the development of ToM, while others suggest that ToM can develop independently of language skills. De Villiers (2007) proposed that the acquisition of complex syntactic structures, particularly those involving complement clauses, is necessary for the development of false belief understanding [5]. A meta-analysis by Milligan et al. (2007) found a significant relationship between language ability and false belief understanding, even when controlling for age. This relationship was found to be stronger for general language ability and semantic knowledge than for syntactic knowledge, suggesting that multiple aspects of language contribute to ToM development [6]. The interplay between language and ToM is complex and likely bidirectional, with advancements in each domain potentially facilitating growth in the other. Understanding these foundational skills is crucial when examining ToM in neurodevelopmental disorders like WS and DS, as deficits or atypicalities in any of these areas may contribute to the observed patterns of ToM abilities in these populations.

WS is a rare neurodevelopmental disorder caused by microdeletion on chromosome 7q11.23 with mild to moderate Intelligence Quotient (IQ) [7]. It is characterized by a unique cognitive profile that includes relative strengths in verbal abilities and facial recognition, alongside significant weaknesses in visuospatial construction and number skills [8]. Individuals with WS often display a highly social personality and an unusual fascination with faces, leading to what has been termed "hypersociability" [9]. Language development in WS has been a subject of considerable interest due to its apparent dissociation from other cognitive abilities. While early reports suggested that language might be "spared" in WS, more recent research has revealed a more complex picture. Brock (2007) provided a critical review of language abilities in WS, highlighting that while some aspects of language (such as vocabulary) may be relative strengths, other areas (such as pragmatics and complex syntax) are often impaired [10]. Mervis and Pitts (2015) found that individuals with WS typically show stronger receptive vocabulary skills compared than their overall cognitive abilities. However, they also noted significant variability in language skills within the WS population [11]. The investigation of ToM abilities in WS has yielded mixed results, reflecting the complex nature of social cognition in this population. Early studies, such as that by Karmiloff-Smith et al. (1995), suggested that individuals with WS might have intact ToM abilities [12]. However, subsequent research has revealed a more nuanced picture. Tager-Flusberg and Sullivan (2000) proposed a componential view of ToM, distinguishing between social–perceptual and social–cognitive components. They suggested that individuals with WS might show relative strengths in social–perceptual aspects of

ToM (such as emotion recognition) but weaknesses in more cognitive aspects (such as false belief understanding) [13]. Several studies have found that individuals with WS often struggle with standard false belief tasks. Porter et al. (2008) used a non-verbal ToM task and found that participants with WS performed significantly worse than both chronological age-matched and mental age-matched control groups [14]. Similarly, Van Herwegen et al. (2013) found that children with WS performed poorly in both verbal and low-verbal false belief tasks, suggesting that their ToM difficulties cannot be solely attributed to language impairments [15].

Down syndrome (DS), caused by all or part of an extra chromosome 21, is the most common genetic cause of intellectual disability, with an incidence of around 1 in 700 to 1 in 1000 live births. DS is typically associated with mild to severe intellectual disability. It is characterized by a profile of relative strengths in visuospatial memory and deficits in the processing of verbal information (see [16]). The social abilities of people with DS appear to be a relative strength, and they are often stereotyped as being warm and sociable [17]. Language is among the most impaired domains of functioning in DS [18] with a profile of stronger receptive language skills and weaker expressive language skills (see [16]). More precisely, people with DS have relative strengths in lexical comprehension and deficits in lexical and sentence production [19]. The receptive lexicon of adolescents with DS would be at the same level as that of typically developing (TD), non-verbal developmental age-matched children [20], while deficits have been found by Witecy and Penke (2017) in the receptive syntactic abilities in adults with DS [21]. However, it should be emphasized that language skills vary highly on an individual level in DS [22]. For Cebula et al. (2010), the examination of the literature shows that children with DS may encounter difficulties in ToM acquisition, but to a much lesser extent than children with Autism Spectrum Disorder (ASD) [23]. However, few studies have investigated the ToM abilities in DS so far. Recently, using the Sally–Anne task, Neitzel and Penke (2021) [24] studied the relations between false belief understanding and syntactic abilities in children and adolescents with DS. A significant proportion of the participants (15 of 24) failed to complete the Sally–Anne task, a result in line with most of the previous studies. Regarding the relationship between success in the false belief task and syntactic level, the results did not show any relation, but according to the authors, this could be attributable to a lack of statistical power [24]. Thus, the question on the role of syntactic abilities in false belief understanding remains open in DS.

The contrasting profiles of WS and DS provide a unique opportunity to explore the relationship between language and ToM. Furthermore, in previous studies, WS participants consistently performed better than DS participants. While individuals with WS often show relative strengths in some aspects of language (particularly vocabulary) alongside significant social–cognitive difficulties, those with DS typically display more severe language impairments, but potentially better-preserved ToM abilities relative to their overall cognitive level [16]. Both WS and DS groups have shown relative strengths in emotion recognition, an important precursor to more advanced ToM skills. Pochon et al. (2017) found that adolescents with DS performed better in a non-verbal emotion recognition task than in a verbal task, particularly for happiness and sadness [25]. Similarly, Ibernon et al. (2018) demonstrated that individuals with WS perform as well as mental age-matched, typically developing participants in recognizing emotions in dynamic facial expressions [26]. These findings suggest that the social–perceptual component of ToM, which involves the ability to read emotional cues from faces and voices, might be relatively preserved in both syndromes, despite their differing language profiles. This highlights the potential dissociation between certain aspects of social cognition and overall language ability. The relationship between language and more advanced ToM skills, such as false belief under-

standing, appears to be more complex. In WS, despite relative strengths in some language domains, performance in false belief tasks is often poor. Campos et al. (2017) found that children with WS struggled with standard false belief tasks, but performed better when the tasks were modified to include more salient emotional content [27]. This suggests that their social–perceptual strengths might partially compensate for difficulties in more cognitive aspects of ToM.

In DS, false belief understanding appears to be delayed, but potentially less impaired than would be expected given language difficulties. In a preliminary study, Touchet et al. (2016) compared ToM abilities in six individuals with WS and DS, and they found that the DS participants outperformed the WS participants in false belief tasks, despite having lower language scores [28]. These findings challenge simplistic notions of a direct relationship between language ability and ToM development.

Research using non-verbal ToM tasks has provided further insights into the language–ToM relationship in WS and DS. Hsu and Rao (2023) used computerized false belief tasks with individuals with WS and found that performance improved when linguistic demands were reduced [29]. This suggests that at least some of the ToM difficulties observed in WS might be related to the verbal nature of many standard ToM tasks. For individuals with DS, non-verbal ToM tasks have also revealed interesting patterns. Pochon et al. (2022) found that adolescents with DS performed better on emotion recognition tasks when they did not require the use of emotional vocabulary [30]. This highlights the importance of considering task demands when assessing ToM abilities in people with low language levels [31].

The examination of language and ToM in WS and DS reveals a complex and nuanced relationship between these two domains. While both conditions are associated with intellectual disability and atypical cognitive profiles, they present distinct patterns of strengths and weaknesses in language and social cognition. The relative strength in vocabulary and some aspects of social perception in WS, contrasted with their difficulties in more cognitive aspects of ToM, suggests that language ability alone is not sufficient for the development of advanced ToM skills. Conversely, the better-than-expected ToM performance in DS, alongside mild to severe intellectual disability and despite significant language impairments, indicates that some aspects of social cognition can develop even in the face of language delays. These findings highlight the need for a multifaceted approach to understanding the relationship between language and ToM.

This study examines the link between language abilities and theory of mind (ToM) development in French children with WS and DS. We adopt a cross-syndrome approach to highlight how each syndrome impacts ToM development and the role of language abilities in this process.

The relationship between language and ToM has been a subject of extensive research and debate in developmental psychology. While some researchers posit the crucial role of language in ToM development [5,6], others suggest that ToM can develop independently of language skills [32]. Our study contributes to this debate by examining this relationship in two neurodevelopmental disorders with distinct language profiles.

The novelty of our approach lies in its comprehensive assessment of language abilities, including morphosyntactic aspects and their relation to different levels of ToM development. While previous studies have often focused on general language abilities or specific aspects such as complement syntax (de Villiers, 2007) [5], our study provides a more nuanced understanding by separately examining word comprehension and production, syntax comprehension and production, and emotional lexicon. This approach allows us to disentangle the contributions of different language components to ToM development in WS and DS.

2. Materials and Methods

2.1. Participants

A total of 16 French-speaking participants with WS aged from 127 to 285 months (8 boys, 8 girls) and 16 French-speaking participants with DS aged from 75 to 326 months old (8 boys, 8 girls) participated in this study. The fluorescence in situ hybridization (FISH) technique revealed that all participants in the WS group were positive for 7q11.23 microdeletion. Participants in the DS group had a diagnosis of trisomy 21 confirmed by the medical teams at the institutions where they were being followed up. Participants with sensory deficits, major attention disorders, or ASD were not included in this experiment. The two groups were matched for non-verbal reasoning level using the raw score on the Raven's Colored Progressive Matrices (RCPM) [33], so that the two groups were at similar levels (WS: 18.2; DS: 17.2; $t(30) = -0.46$, $p = 0.649$).

2.2. Material and Procedure

2.2.1. Language Ability Assessment (Independent Variables)

Language abilities were assessed with several subtests taken from the Isadyle French language assessment battery [34].

- Word comprehension and production

In the Isadyle language battery, passive vocabulary knowledge assessment consisted of 14 lexically frequent and concrete nouns and 14 lexically infrequent nouns. Participants were each shown sets of four pictures and had to point to the correct picture, in response to an instruction like "Look at these pictures. I'll tell you a word and you'll show the picture where we see this word". A score of 1 was given when the correct picture was shown, and a score of 0 was given for an incorrect choice. The number of pictures correctly shown was determined for the total score in word comprehension (maximum = 28). Active vocabulary knowledge assessment consisted of 20 lexically frequent nouns and 15 lexically infrequent nouns. For each item, participants were shown a picture and were asked to name it. For this picture-naming subtest, a score of 1 was given when the correct lexical target was produced, and a score of 0 was given for an incorrect response or no response. The number of pictures correctly named was determined for the total score in word production (maximum = 35).

- Syntax comprehension and production

Three different subtests of the Isadyle language battery were used to assess syntax comprehension and syntax production: simple sentences (9 points), passive sentences (6 points), and temporal inflections (6 points). Playmobil® figures were used for these subtests. For syntax comprehension, the participant was told to manipulate the figures in correspondence with a sentence (simple or passive) stated by the examiner. Pictures were also used to assess temporal inflections; the participant had to show the picture corresponding to the temporal inflection stated by the examiner. For syntax production, the examiner played a scene with the figures and the participant was required to describe this scene with a simple sentence or a passive sentence. Sets of three pictures were used to assess temporal inflections: each picture showed the same action at three different moments (before, during, and after) and the participant had to describe one of these three pictures. The total score was calculated as the sum of these three subtests in comprehension (21 points) as well as in production (21 points).

- Emotional lexicon

The task administered was based on the non-verbal task presented in the previous studies by the authors [30]; thus, only the main characteristics of the task will be presented here. The emotion recognition task presented six basic emotions (happiness, sadness, anger,

disgust, surprise, and fear) through video sequences, with each emotion appearing as a target three times. Two professional actors (one male, one female) were filmed from the shoulders up expressing these emotions, each performing 9 sequences. The actors underwent specific training, and multiple takes were recorded to ensure their quality. The final sequences achieved 95% recognition accuracy when validated with 20 adults aged 20–40 years. During recording, actors alternated between three sentences: two French phrases ("Léa est venue en avion", "La bouteille est sur la table") and one nonsense phrase ("Cognogo tiketou"), each used six times. Videos were presented without sound to focus the assessment on facial expression recognition. Participants were instructed to identify specific emotions (e.g., "Show me where the lady is happy" or "Show me where the man is surprised") by pointing to the screen. The total possible score was 18, based on six emotions presented three times each.

2.2.2. Theory of Mind Assessment (Dependent Variables)

The French version of the theory of mind test-Revised (ToM test-R) [35] is a standardized instrument that measures the construct of theory of mind at three levels of development. For the first level, prerequisites of ToM as a pretense, differentiating between physical, mental, and emotion recognition, are assessed. The second level, with the first manifestations of a real ToM, examines the first-order beliefs and the false beliefs, whereas the highest level of ToM aims for the second-order beliefs. Initially designed for children with Autistic Spectrum Disorders, this instrument can be used with neurotypical children between the ages of 4 and 12 and persons with developmental delays. This test is a structured interview consisting of 14 tests items. These 14 items were administered through 36 questions, with 12 questions per level. Correct answers were coded as 1 and incorrect answers as 0, leading to a maximum of 36 points for the full test and a maximum of 12 points per level.

Participants were tested in a quiet, familiar room at their health care institution or school, or at home. Depending on participants' fatigue and motivation, three or four sessions were necessary to administer all the tests.

3. Results

Preliminary analyses revealed moderate violations of distribution normality in the DS group for the ToM test results and in the WS group for word comprehension and syntax comprehension, due to ceiling effects. While non-parametric alternatives were considered, they failed to capture developmental patterns effectively. Following Thomas et al. (2009) [36], parametric analyses were maintained, as they are relatively robust in the face of moderate normality violations when examining developmental trajectories. For regression analyses, extreme observations were excluded, and homoscedasticity and error independence were verified.

3.1. Results of the ToM Test-R: Comparative Study

A 2 × 3 (Group, Test) mixed-design Analysis Of Variance (ANOVA) was used to compare the scores obtained by participants in the ToM test-R (Table 1). The levels of ToM acquisition (prerequisites of ToM, first manifestations of a real ToM, highest level of ToM) were treated as within participants factors and named Prerequisites, First order, and Second order. Group (WS, DS) was a between-participants factor (Figure 1). This analysis was followed by Tukey's post hoc test with Bonferroni correction for multiple comparisons.

There was a significant main effect of Group ($F(1,30) = 14.78$, $p < 0.001$, $\eta^2 = 0.098$) reflecting better overall results in the WS group than in the DS group in the ToM test-R. A significant main effect of Test was found ($F(2,60) = 113.338$, $p < 0.001$, $\eta^2 = 0.554$)

showing that the three levels of the test differentiated themselves in terms of difficulty. The Group × Test interaction effect was not significant ($F(2,60) = 0.662$, $p = 0.520$, $\eta^2 = 0.003$).

Table 1. Mean scores for participants with WS and DS in the ToM test-R.

Variables	Group					
	Williams Syndrome			Down Syndrome		
	Mean	*SD*	Shapiro–Wilk *W*	Mean	*SD*	Shapiro–Wilk *W*
Prerequisites of ToM	9.50	1.93	0.93	7.88	2.03	0.84 **
First manifestations of a real ToM	5.13	2.53	0.96	2.56	1.50	0.80 **
Highest level of ToM	4.06	2.11	0.92	1.94	2.02	0.86 *

Note. *SD*: Standard Deviation, $N = 16$ in each group. * $p < 0.05$. ** $p < 0.01$.

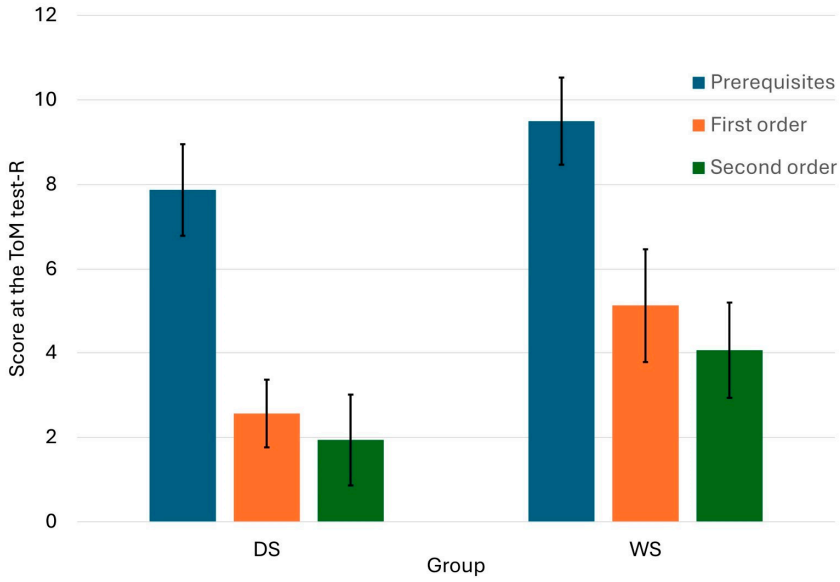

Figure 1. Mean scores for participants with WS and DS at each level of the ToM test-R.

Post hoc intra-group comparisons showed higher results for prerequisites compared to first order (WS: +4.675, $p < 0.001$; DS: +5.312, $p < 0.001$) and compared to second order (WS: +5.437, $p < 0.001$; DS: +5.937, $p < 0.001$). First order versus second order comparison was not significant for either the WS group (+1.062, $p = 0.479$) or DS group (+0.625, $p = 0.893$). Post hoc between-group comparisons revealed a better result in the WS group for first order (+2.562, $p = 0.017$), but no difference for prerequisites ($p = 0.218$) and second order ($p = 0.067$).

3.2. Language Development and Success in the ToM Test-R

We explored the developmental characteristics associated with the three levels of ToM acquisition (prerequisites of ToM, first manifestations of a real ToM, highest level of ToM) using cross-sectional developmental trajectories [36]. The trajectories of ToM acquisition were plotted against each independent variable (word comprehension, word production, syntax comprehension, syntax production, and emotional lexicon, see Table 2). For each model, the influence of outliers on the regression line was checked, the goodness-of-fit of different linear and non-linear functions was compared, and the linear method was retained for each trajectory. The models with and without outliers were always plotted, but the outliers were excluded from the main results only when the model was significant. In this case, the standardized coefficients, with and without outliers, are presented to show their influence.

Table 2. Mean scores for participants with WS and DS in language abilities assessment.

Variables	Group						*t* Value
	Williams Syndrome			Down Syndrome			
	Mean	*SD*	Shapiro–Wilk *W*	Mean	*SD*	Shapiro–Wilk *W*	
Word comprehension	26.13	2.03	0.85 *	25.00	2.34	0.92	−1.45
Word production	23.88	3.70	0.97	23.31	3.46	0.97	−0.45
Syntax comprehension	17.25	1.98	0.88 *	14.00	2.78	0.96	−3.81 ***
Syntax production	12.06	3.09	0.95	10.69	4.01	0.93	−1.09
Emotional lexicon	15.75	1.69	0.84 **	13.56	2.37	0.95	−3.01 **

Note. $N = 16$ in each group. * $p < 0.05$. ** $p < 0.01$. *** $p < 0.001$.

3.2.1. Word Comprehension

For prerequisites of ToM, the model including word comprehension was not significant for either group (WS: $F(1,14) = 0.06$, $p = 0.802$, $R^2 = 0.005$; DS: $F(1, 14) = 0.14$, $p = 0.717$, $R^2 = 0.010$). The model examining first manifestations of a real ToM relative to word comprehension was not significant (WS: $F(1,14) = 0.07$, $p = 0.802$, $R^2 = 0.005$; DS: $F(1,14) = 1.42$, $p = 0.253$, $R^2 = 0.092$). The model examining highest level of ToM relative to word comprehension also was not significant for either group (WS: $F(1,14) = 0.27$, $p = 0.610$, $R^2 = 0.019$; DS: $F(1,14) = 0.35$, $p = 0.565$, $R^2 = 0.024$).

3.2.2. Word Production

The model examining prerequisites of ToM relative to word production was not significant for either group (WS: $F(1,14) = 0.41$, $p = 0.535$, $R^2 = 0.028$; DS: $F(1,14) = 1.30$, $p = 0.274$, $R^2 = 0.085$). For first manifestations of a real ToM, the model including word production was not significant for either group (WS: $F(1,14) = 0.09$, $p = 0.768$, $R^2 = 0.006$; DS: $F(1,14) = 4.01$, $p = 0.065$, $R^2 = 0.223$). The model examining highest level of ToM relative to word production also was not significant (WS: $F(1,14) = 0.03$, $p = 0.872$, $R^2 = 0.002$; DS: $F(1,14) < 0.01$, $p = 0.953$, $R^2 < 0.001$).

3.2.3. Syntax Comprehension

The model examining prerequisites of ToM relative to syntax comprehension was significant in the WS group, $F(1,14) = 5.24$, $p = 0.038$, $R^2 = 0.272$, demonstrating a linear increase in success at the first level of ToM acquisition with increasing syntax comprehension (Figure 2). For the DS group, the model was not significant, $F(1,14) = 0.02$, $p = 0.896$, $R^2 = 0.001$. The model examining first manifestations of a real ToM relative to syntax comprehension was not significant for either group (WS: $F(1,14) = 0.07$, $p = 0.802$, $R^2 = 0.005$; DS: $F(1,14) = 1.42$, $p = 0.253$, $R^2 = 0.092$). The model examining highest level of ToM relative to syntax comprehension also was not significant (WS: $F(1,14) = 0.27$, $p = 0.610$, $R^2 = 0.019$; DS: $F(1,14) = 0.35$, $p = 0.565$, $R^2 = 0.024$).

3.2.4. Syntax Production

For prerequisites of ToM, the model including syntax production was not significant for either group (WS: $F(1,14) = 1.98$, $p = 0.183$, $R^2 = 0.132$; DS: $F(1,14) = 0.30$, $p = 0.594$, $R^2 = 0.021$). The model examining first manifestations of a real ToM relative to syntax production was significant in the WS group (Figure 3), $F(1,13) = 7.08$, $p = 0.015$, $R^2 = 0.375$, showing a linear increase in success at the second level of ToM acquisition with increasing syntax production ($\beta = 0.61$). One bivariate outlier was excluded from the model presented ($\beta = 0.32$ when the outlier was included). For the DS group, the model was not significant, ($F(1,14) = 1.14$, $p = 0.304$, $R^2 = 0.075$). The model examining highest level of ToM relative to

syntax production also was not significant (WS: $F(1,14) = 1.24$, $p = 0.284$, $R^2 = 0.082$; DS: $F(1,14) = 0.12$, $p = 0.731$, $R^2 = 0.009$).

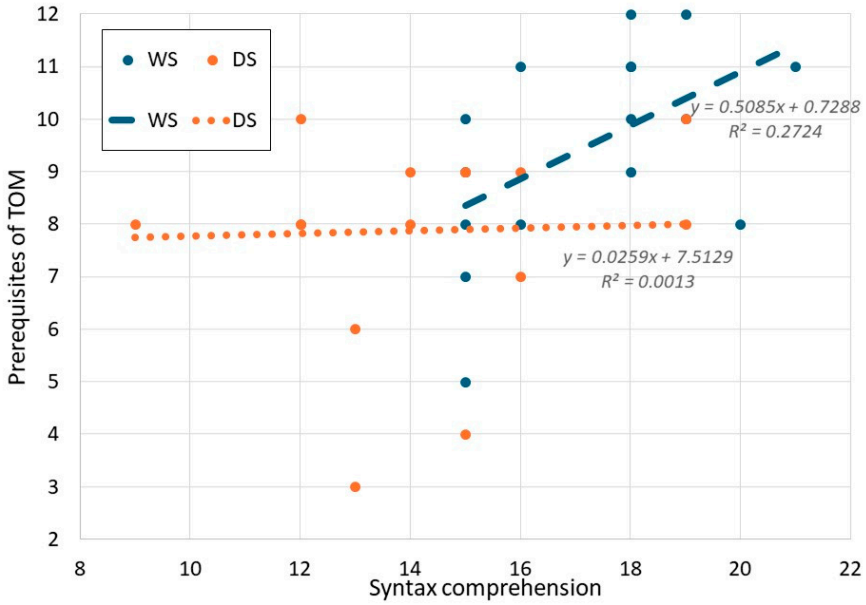

Figure 2. Cross-sectional trajectories of prerequisites of ToM scores for each group plotted against syntax comprehension scores.

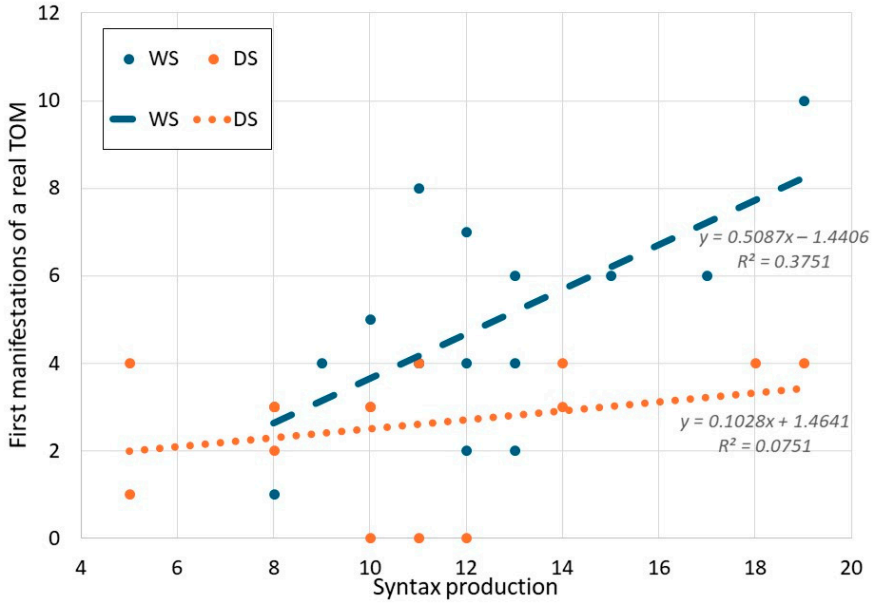

Figure 3. Cross-sectional trajectories of first manifestations of a real ToM scores for each group plotted against syntax production scores.

3.2.5. Emotional Lexicon

The model examining prerequisites of ToM relative to emotional lexicon was significant in WS group, $F(1,14) = 6.08$, $p = 0.027$, $R^2 = 0.303$, demonstrating a linear increase in success at the first level of ToM acquisition with increasing emotional lexicon (Figure 4). For the DS group, the model was not significant, $F(1,14) = 0.48$, $p = 0.499$, $R^2 = 0.033$. The model examining first manifestations of a real ToM relative to emotional lexicon was not significant for either group, but with a near-significant effect for DS (WS: $F(1,14) = 0.10$, $p = 0.752$, $R^2 = 0.007$; DS: $F(1,14) = 4.33$, $p = 0.056$, $R^2 = 0.236$). The model examining highest level of

ToM relative to emotional lexicon also was not significant (WS: $F(1,14) = 0.91$, $p = 0.356$, $R^2 = 0.061$; DS: $F(1,14) = 1.16$, $p = 0.302$, $R^2 = 0.082$).

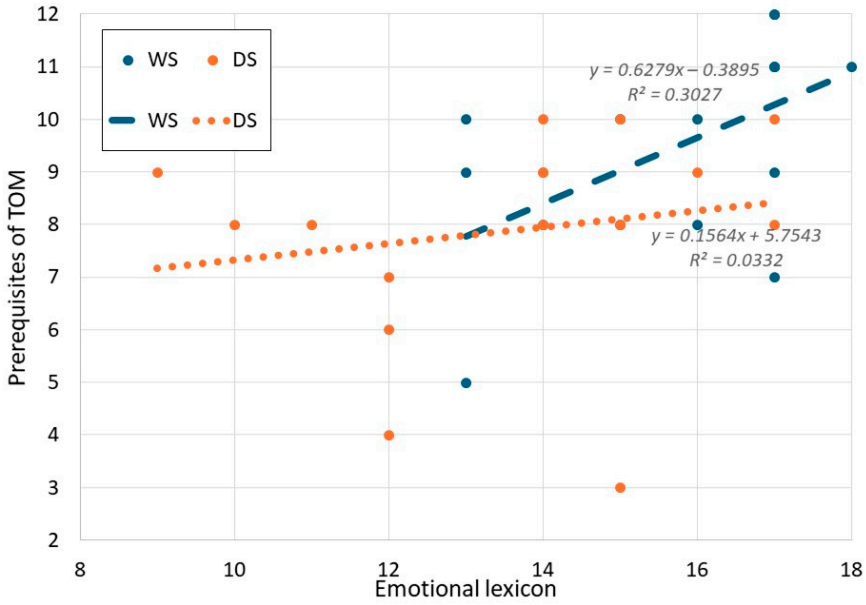

Figure 4. Cross-sectional trajectories of prerequisites of ToM scores for each group plotted against emotional lexicon scores.

4. Discussion

This study investigates the complex relationship between language abilities and ToM development in children and adolescents with WS and DS. Our findings provide novel insights into the intricate interplay between language and social cognition in these two neurodevelopmental syndromes, contributing significantly to the ongoing debate regarding the role of language in ToM development.

Our results demonstrate that the WS group performed significantly better overall in the ToM test-R compared to the DS group, particularly in first-order beliefs. These findings challenge the traditional view presented by Porter et al. (2008) [14] regarding severe social–cognitive impairments in WS, and suggest a more complex picture of ToM abilities in this population. The superior performance of the WS group aligns with early studies by Karmiloff-Smith et al. (1995) [12], highlighting the relative strength of WS individuals in social cognition, while also supporting more recent research by Campos et al. (2017) [27], indicating the nuanced profile of ToM abilities in WS.

Our analyses revealed significant associations between specific language abilities and ToM development in the WS group. This finding is consistent with de Villiers' (2007) hypothesis [5] on the crucial role of language in ToM development, particularly regarding the importance of complement syntax for false belief understanding. The relationship we found between syntax comprehension and ToM prerequisites, and between syntax production and first manifestations of ToM, provides strong empirical support for Milligan et al.'s (2007) meta-analytic findings [6] on the significant relationship between language ability and false belief understanding. Notably, our findings regarding word production and comprehension were not significant, suggesting that lexical abilities alone may not be sufficient for ToM development. This selective pattern of associations highlights the specific importance of syntactic abilities in ToM development.

The specific association between syntax and ToM in our WS group is particularly noteworthy in light of Brock's (2007) critical review of language abilities in WS [10]. While Brock highlighted that some aspects of language may be relative strengths in WS, our

findings suggest that these linguistic skills actively contribute to ToM development. This observation expands upon Mervis and Pitts's (2015) observations about the variability of language skills within the WS population [11]. The strong association between syntactic abilities and ToM in our WS group suggests that this variability in language skills might help explain individual differences in social–cognitive development within the WS population.

The relationship between emotional lexicon and ToM prerequisites in our WS group can be interpreted through the lens of Tager-Flusberg and Sullivan's (2000) componential view of ToM [13]. Their distinction between social–perceptual and social–cognitive components provides a framework for understanding why WS individuals might show strengths in emotion-related aspects of ToM, while struggling with more cognitive components. This pattern further supports Jones et al.'s (2000) observations about hypersociability in WS [9], suggesting that enhanced social interest might facilitate the development of emotional understanding.

A central finding of our study is the dissociation between language and ToM abilities in the DS group, which contrasts sharply with the pattern observed in WS. We did not find significant associations between language measures and ToM performance in the DS group, except for a near-significant trend between emotional lexicon and first manifestations of ToM. This result warrants examination in light of Chapman's (1997) characterization of language development in DS [19], which emphasizes significant impairments across multiple linguistic domains. This dissociation becomes particularly striking when considered alongside Abbeduto et al.'s (2001) characterization of the linguistic and cognitive profile of DS [18]. Despite documented challenges with language, particularly in syntax and production, our DS participants showed evidence of ToM development that was not strongly tied to their language abilities. The absence of strong language—ToM correlations in our DS group presents a challenge to the universality of de Villiers's (2007) language-first hypothesis on ToM development [5]. Instead, our findings align more closely with Cebula et al.'s (2010) suggestion [23] that children with DS may encounter difficulties in ToM acquisition, but to a much lesser extent than with other neurodevelopmental conditions. This raises the possibility that individuals with DS might develop ToM through alternative pathways that are less dependent on language, perhaps relying more on social experience and non-verbal cognitive abilities.

The apparent dissociation between language abilities and ToM performance in the DS group is particularly intriguing, especially given that groups were matched on non-verbal reasoning using RCPM. While individuals with DS typically show significant difficulties with advanced syntax, this pattern suggests distinct developmental pathways in how language and ToM abilities interact in each syndrome beyond language competencies alone. This finding reflects syndrome-specific characteristics rather than general cognitive level. Indeed, individuals with DS typically show significant difficulties with advanced syntax, which is crucial for success in traditional false belief tasks. Therefore, their performance in such tasks may underestimate their actual ToM capabilities, suggesting a need to develop assessment methods less dependent on linguistic expression.

Regarding emotional understanding in both groups, our findings can be understood within the framework provided by Moore (2001) [31] regarding emotion recognition in people with intellectual disabilities. The significant relationship between emotional lexicon and ToM prerequisites in the WS group corroborates Ibernon et al.'s (2018) demonstration [26] that individuals with WS perform well in recognizing emotions in dynamic facial expressions. Similarly, our results complement Pochon et al.'s (2017, 2022) findings about emotion recognition in DS [25,30], particularly their observation that performance improves when linguistic demands are reduced.

These results advance our theoretical understanding in several ways. They support the specificity view of ToM development proposed by Scholl and Leslie (1999) [37], while demonstrating that the relationship between language and ToM varies across neurodevelopmental disorders. The distinct patterns observed in each syndrome emphasize the need for differentiated theoretical models of social cognitive development.

Our findings have direct implications for clinical practice. For individuals with WS, interventions targeting syntactic skills and emotional vocabulary would be most effective for enhancing ToM development. For individuals with DS, an approach emphasizing non-verbal aspects of social cognition alongside language development would be more appropriate. These syndrome-specific intervention strategies reflect the unique cognitive profiles of different neurodevelopmental disorders.

While our study provides valuable insights, it has certain limitations. The cross-sectional design and relatively small sample size limit our ability to draw causal conclusions and generalize findings. While this sample size led to some violations of statistical assumptions, particularly in the DS group, we followed the recommendations for rare syndrome research [36] to maintain the most informative analytical approach. Additionally, our study focused on specific aspects of language and ToM, and future research would benefit from including measures on pragmatic language abilities and more naturalistic assessments of social cognition. Future research should implement the following criteria: (1) employ longitudinal designs to track the developmental trajectories of language and ToM in WS and DS, (2) investigate the role of non-verbal cognitive abilities and environmental factors in ToM development across different syndromes, (3) examine how different aspects of language (vocabulary, syntax, and pragmatics) interact with various components of ToM (emotional understanding and false beliefs, etc.) during development in larger samples, and (4) investigate potential compensatory mechanisms that might support ToM development in cases where typical language-based pathways are impaired.

5. Conclusions

Our study marks a significant advancement in understanding the complex relationship between language and ToM in neurodevelopmental disorders. By demonstrating syndrome-specific patterns of association between morphosyntactic abilities and ToM, we challenge existing theories and pave the way for more nuanced, disorder-specific models of social–cognitive development. These findings not only contribute to theoretical debates, but also have important implications for clinical practice, highlighting the need for tailored interventions that consider the unique cognitive profiles of individuals with WS and DS.

These results extend the research tradition on genetic syndrome specificity initiated in the 1990s, which demonstrated that each syndrome presents a unique pattern of cognitive strengths and weaknesses [7,19]. The dissociation observed between language abilities and ToM in participants with Down syndrome raises a fundamental theoretical question: do limitations in ToM tasks reflect a genuine difficulty in understanding mental states or simply a difficulty in expressing this understanding due to morphosyntactic limitations?

Author Contributions: Conceptualization, R.P. and L.I.; formal analysis, C.T. and R.P.; funding acquisition, L.I.; investigation, C.T.; methodology, C.T.; project administration, L.I.; supervision, R.P. and L.I.; writing—original draft, C.T., R.P. and L.I.; writing—review and editing, R.P. and L.I. All authors have read and agreed to the published version of the manuscript.

Funding: This research was supported by the French National Research Agency—grant number: Projet-ANR-20-CE28-0013.

Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki and with the recommendations of French law. Ethical approval was obtained according to the national and institutional guidelines, the CPP (Comité de Protection des Personnes) of CHU Amiens-Picardie, France (Protocol code: 2022-A00341-42, date of approval: 22 March 2022) for the project: ANR-20-CE28-0013. Because most of the assessment meetings took place at educational institutions, the medical, social, and academic authorities were also informed and approved of the study setting.

Informed Consent Statement: Written informed consent has been obtained from the participants to publish this paper. None of the participants, their parents, and/or legal guardians objected that their data would be used for research. Each was informed of the objectives of the study, the nature of the tasks that would be administered, and the fact that they could withdraw the use of their data at any time.

Data Availability Statement: The data presented in this study are available on request from the corresponding author due to privacy protection considerations for participants with neurodevelopmental conditions.

Acknowledgments: Our thanks go to the children and their families who participated in the study. We would like to thank Trisomie 21 Marne and Trisomie 21 Ardennes, the Fédération Williams France and "autour des Williams" for facilitating the administration of our protocol to participants with DS and WS. During the preparation of this manuscript, the authors used Claude 3.5 Sonnet (Anthropic, October 2024 release) solely as a technical aid for English language refinement, formatting verification, and bibliographic reference checking. The authors have reviewed and validated all suggestions and take full responsibility for the content of this publication. For graphical abstract, base images were generated with DALL-E3 and edited with MS Paint to show typical facial features of DS and WS. We would like to thank Nicolas Ribeiro, Research Engineer, for his technical assistance in image generation.

Conflicts of Interest: The authors declare no conflicts of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript; or in the decision to publish the results.

References

1. Premack, D.; Woodruff, G. Does the Chimpanzee Have a Theory of Mind? *Behav. Brain Sci.* **1978**, *1*, 515–526. [CrossRef]
2. Wellman, H.M. Theory of Mind: The State of the Art. *Eur. J. Dev. Psychol.* **2018**, *15*, 728–755. [CrossRef]
3. Baron-Cohen, S.; Leslie, A.M.; Frith, U. Does the Autistic Child Have a "Theory of Mind"? *Cognition* **1985**, *21*, 37–46. [CrossRef] [PubMed]
4. Nader-Grosbois, N.; Simon, P.; Jacobs, E.; Houssa, M. Psychometric Properties of the Theory of Mind Task Battery (French Version) in Neurotypical Children and Intellectually Disabled Children. *Children* **2024**, *11*, 79. [CrossRef]
5. de Villiers, J. The Interface of Language and Theory of Mind. *Lingua* **2007**, *117*, 1858–1878. [CrossRef]
6. Milligan, K.; Astington, J.W.; Dack, L.A. Language and Theory of Mind: Meta-Analysis of the Relation Between Language Ability and False-belief Understanding. *Child Dev.* **2007**, *78*, 622–646. [CrossRef]
7. Bellugi, U.; Wang, P.P.; Jernigan, T.L. Williams Syndrome: An Unusual Neuropsychological Profile. In *Atypical Cognitive Deficits in Developmental Disorders: Implications for Brain Function*; Lawrence Erlbaum Associates, Inc.: Hillsdale, NJ, USA, 1994; pp. 23–56. ISBN 978-0-8058-1180-3.
8. Mervis, C.B.; John, A.E. Cognitive and Behavioral Characteristics of Children with Williams Syndrome: Implications for Intervention Approaches. *Am. J. Med. Genet. C Semin. Med. Genet.* **2010**, *154C*, 229–248. [CrossRef]
9. Jones, W.; Bellugi, U.; Lai, Z.; Chiles, M.; Reilly, J.; Lincoln, A.; Adolphs, R., II. Hypersociability in Williams Syndrome. *J. Cogn. Neurosci.* **2000**, *12*, 30–46. [CrossRef]
10. Brock, J. Language Abilities in Williams Syndrome: A Critical Review. *Dev. Psychopathol.* **2007**, *19*, 97–127. [CrossRef]
11. Mervis, C.B.; Pitts, C.H. Children with Williams Syndrome: Developmental Trajectories for Intellectual Abilities, Vocabulary Abilities, and Adaptive Behavior. *Am. J. Med. Genet. C Semin. Med. Genet.* **2015**, *169*, 158–171. [CrossRef]
12. Karmiloff-Smith, A.; Klima, E.; Bellugi, U.; Grant, J.; Baron-Cohen, S. Is There a Social Module? Language, Face Processing, and Theory of Mind in Individuals with Williams Syndrome. *J. Cogn. Neurosci.* **1995**, *7*, 196–208. [CrossRef] [PubMed]

13. Tager-Flusberg, H.; Sullivan, K. A Componential View of Theory of Mind: Evidence from Williams Syndrome. *Cognition* **2000**, *76*, 59–90. [CrossRef] [PubMed]
14. Porter, M.A.; Coltheart, M.; Langdon, R. Theory of Mind in Williams Syndrome Assessed Using a Nonverbal Task. *J. Autism Dev. Disord.* **2008**, *38*, 806–814. [CrossRef] [PubMed]
15. Van Herwegen, J.; Dimitriou, D.; Rundblad, G. Performance on Verbal and Low-Verbal False Belief Tasks: Evidence from Children with Williams Syndrome. *J. Commun. Disord.* **2013**, *46*, 440–448. [CrossRef]
16. Fidler, D.J.; Nadel, L. Education and Children with Down Syndrome: Neuroscience, Development, and Intervention. *Ment. Retard. Dev. Disabil. Res. Rev.* **2007**, *13*, 262–271. [CrossRef]
17. Wishart, J.G.; Johnston, F.H. The Effects of Experience on Attribution of a Stereotyped Personality to Children with Down's Syndrome. *J. Intellect. Disabil. Res.* **1990**, *34*, 409–420. [CrossRef]
18. Abbeduto, L.; Pavetto, M.; Kesin, E.; Weissman, M.; Karadottir, S.; O'Brien, A.; Cawthon, S. The Linguistic and Cognitive Profile of Down Syndrome: Evidence from a Comparison with Fragile X Syndrome. *Syndr. Res. Pract.* **2001**, *7*, 9–15. [CrossRef]
19. Chapman, R.S. Language Development in Children and Adolescents with Down Syndrome. *Ment. Retard. Dev. Disabil. Res. Rev.* **1997**, *3*, 307–312. [CrossRef]
20. Loveall, S.J.; Conners, F.A.; Tungate, A.S.; Hahn, L.J.; Osso, T.D. A Cross-Sectional Analysis of Executive Function in Down Syndrome from 2 to 35 Years. *J. Intellect. Disabil. Res.* **2017**, *61*, 877–887. [CrossRef]
21. Witecy, B.; Penke, M. Language Comprehension in Children, Adolescents, and Adults with Down Syndrome. *Res. Dev. Disabil.* **2017**, *62*, 184–196. [CrossRef]
22. Karmiloff-Smith, A.; Al-Janabi, T.; D'Souza, H.; Groet, J.; Massand, E.; Mok, K.; Startin, C.; Fisher, E.; Hardy, J.; Nizetic, D.; et al. The Importance of Understanding Individual Differences in Down Syndrome. *F1000Research* **2016**, *5*, 389. [CrossRef] [PubMed]
23. Cebula, K.R.; Moore, D.G.; Wishart, J.G. Social Cognition in Children with Down's Syndrome: Challenges to Research and Theory Building. *J. Intellect. Disabil. Res.* **2010**, *54*, 113–134. [CrossRef] [PubMed]
24. Neitzel, I.; Penke, M. Theory of Mind in Children and Adolescents with Down Syndrome. *Res. Dev. Disabil.* **2021**, *113*, 103945. [CrossRef] [PubMed]
25. Pochon, R.; Touchet, C.; Ibernon, L. Emotion Recognition in Adolescents with Down Syndrome: A Nonverbal Approach. *Brain Sci.* **2017**, *7*, 55. [CrossRef]
26. Ibernon, L.; Touchet, C.; Pochon, R. Emotion Recognition as a Real Strength in Williams Syndrome: Evidence from a Dynamic Non-Verbal Task. *Front. Psychol.* **2018**, *9*, 463. [CrossRef]
27. Campos, R.; Martínez-Castilla, P.; Sotillo, M. False Belief Attribution in Children with Williams Syndrome: The Answer Is in the Emotion. *J. Intellect. Disabil. Res.* **2017**, *61*, 1003–1010. [CrossRef]
28. Touchet, C.; Pochon, R.; Vandromme, L.; Ibernon, L. Langage et théorie de l'esprit: Étude exploratoire auprès d'individus présentant une trisomie 21 ou un syndrome de Williams. *Carrefours Léduc.* **2016**, *42*, 171–186. [CrossRef]
29. Hsu, C.-F.; Rao, S.-Y. Computerized False Belief Tasks Impact Mentalizing Ability in People with Williams Syndrome. *Brain Sci.* **2023**, *13*, 722. [CrossRef]
30. Pochon, R.; Touchet, C.; Ibernon, L. Recognition of Basic Emotions with and without the Use of Emotional Vocabulary by Adolescents with Down Syndrome. *Behav. Sci.* **2022**, *12*, 167. [CrossRef]
31. Moore, D.G. Reassessing Emotion Recognition Performance in People with Mental Retardation: A Review. *Am. J. Ment. Retard.* **2001**, *106*, 481. [CrossRef]
32. Bloom, P.; German, T.P. Two Reasons to Abandon the False Belief Task as a Test of Theory of Mind. *Cognition* **2000**, *77*, B25–B31. [CrossRef] [PubMed]
33. Raven, J. Raven Progressive Matrices. In *Handbook of Nonverbal Assessment*; McCallum, R.S., Ed.; Springer: Boston, MA, USA, 2003; pp. 223–237. ISBN 978-1-4613-4945-7.
34. Piérart, B.; Comblain, A.; Grégoire, J.; Mousty, P. *Batterie Isadyle*; Tests & matériels en orthophonie; Solal: Marseille, France, 2010; ISBN 978-2-35327-086-6.
35. Steerneman, P.; Meesters, C. *ToM test-R: Handleiding*; Garant: Antwerpen, Belgium, 2009; ISBN 978-90-441-2537-5.
36. Thomas, M.S.C.; Annaz, D.; Ansari, D.; Scerif, G.; Jarrold, C.; Karmiloff-Smith, A. Using Developmental Trajectories to Understand Developmental Disorders. *J. Speech Lang. Hear. Res.* **2009**, *52*, 336–358. [CrossRef] [PubMed]
37. Scholl, B.J.; Leslie, A.M. Modularity, Development and "Theory of Mind". *Mind Lang.* **1999**, *14*, 131–153. [CrossRef]

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.