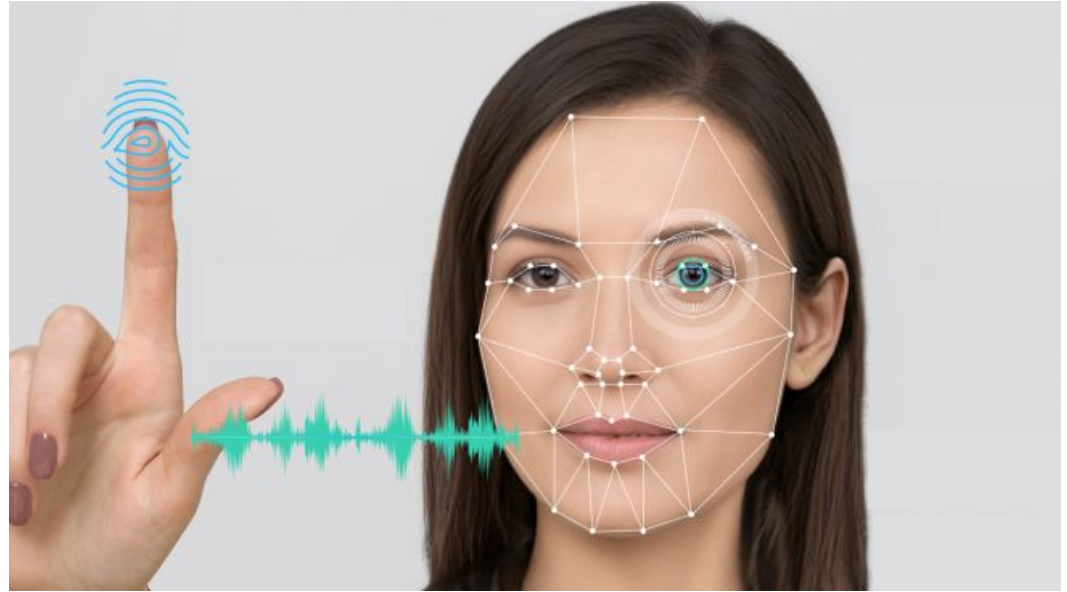
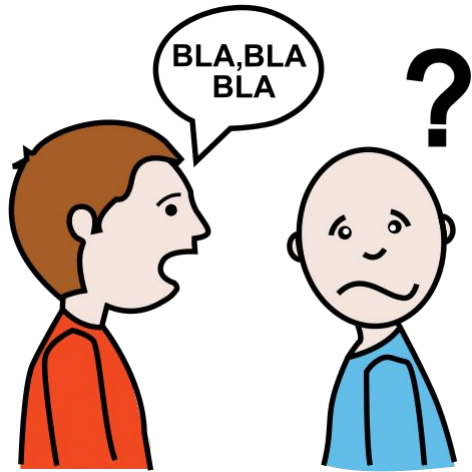


Prosody and gestures in neurodevelopmental disorders

How they facilitate pragmatic comprehension



Developmental Language Disorder (DLD)

Persistent oral language deficits not attributable to biomedical causes (Bishop et al., 2017). It affects production and comprehension.

- Structural language components impaired & phonological skills often affected
- Processing deficits (working memory, executive functions)
- Difficulties with pragmatic inferences (Katsos et al., 2011) and socio-emotional risks
- Prevalence: 7%

<https://youtu.be/KrOISXtCgVA>
(DLDandMe.org)

Autism Spectrum Disorder (ASD)

Difficulties with communication and interaction with other people, accompanied by restricted interests and repetitive behavior (DSM-5).

- Affections at the pragmatic level of language and with socio-cognitive skills
- Linguistic skills may or may not be impaired
- Deficits in integrating multisensory input
- Prevalence: 2-3%

Difficulties in comprehending pragmatic intent

Expressing pragmatic intent in oral language

Propositional content

(Indirect Request) Could you open the window?

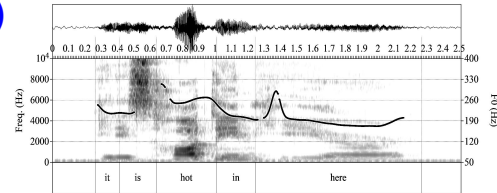
Expressing pragmatic intent in oral language

Propositional content

(Indirect Request) Could you open the window?

Spoken prosody (intonation, rhythm and voice)

(IR) It is hot in here



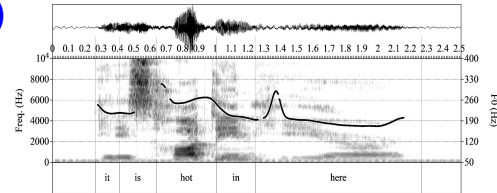
Expressing pragmatic intent in oral language

Propositional content

(Indirect Request) Could you open the window?

Spoken prosody (intonation, rhythm and voice)

(IR) It is hot in here



Bodily signals (hand and head gestures, facial expressions, body posture)

(IR) It is hot in here



Expressing pragmatic intent in oral language

Propositional content

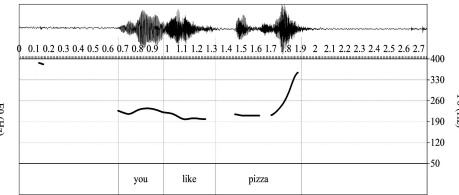
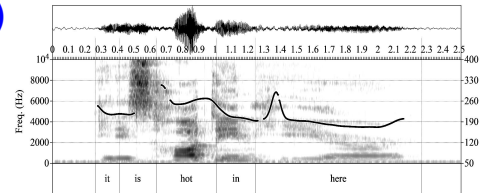
(Indirect Request) Could you open the window?

(Interrogative) Do you like pizza?

Spoken prosody (intonation, rhythm and voice)

(IR) It is hot in here

(IT) You like pizza



Bodily signals (hand and head gestures, facial expressions, body posture)

(IR) It is hot in here



(IT) You like pizza



Prosody and body signals in pragmatic comprehension

- Multisensory facilitation in speech processing (Dohen et al., 2004; Holler et al., 2018)
- Trade-off effects between the two modalities (Borràs et al., 2019; Cruz et al., 2017; Prieto et al., 2015)

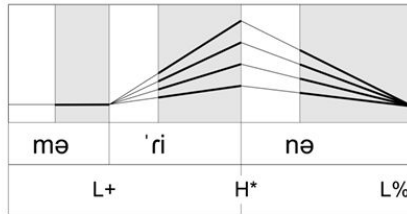
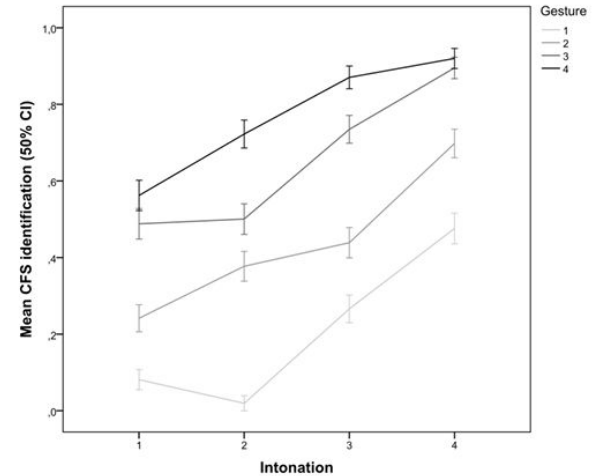
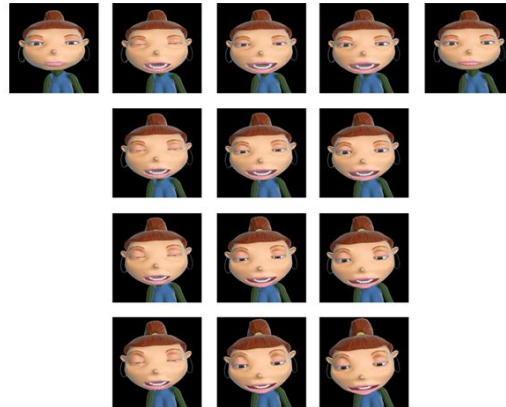


Figure 1. Schematic diagram showing pitch manipulation.



Prosody and body signals in pragmatic comprehension

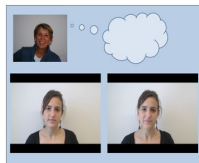
- Prosodic and visual prominences highlight elements in the discourse and **facilitate the children's processing** of these elements (Igalada et al., 2017; Ito, 2014), and are especially useful in challenging situations.
- The children's use of prosodic and visual cues **precede and entrain** the emergence of other linguistic means to signal meaning (e.g. Esteve-Gibert et al., 2020)
- The presence of prosodic and visual cues help children with **typical language development** accessing **pragmatic meaning** (e.g. Armstrong et al., 2018; Glenwright et al., 2014; Hübscher et al., 2017; Krahmer & Swerts, 2005)

Barbara is in a train with two twin friends. She is thinking about her favourite vegetable. It's a tomatoe!"



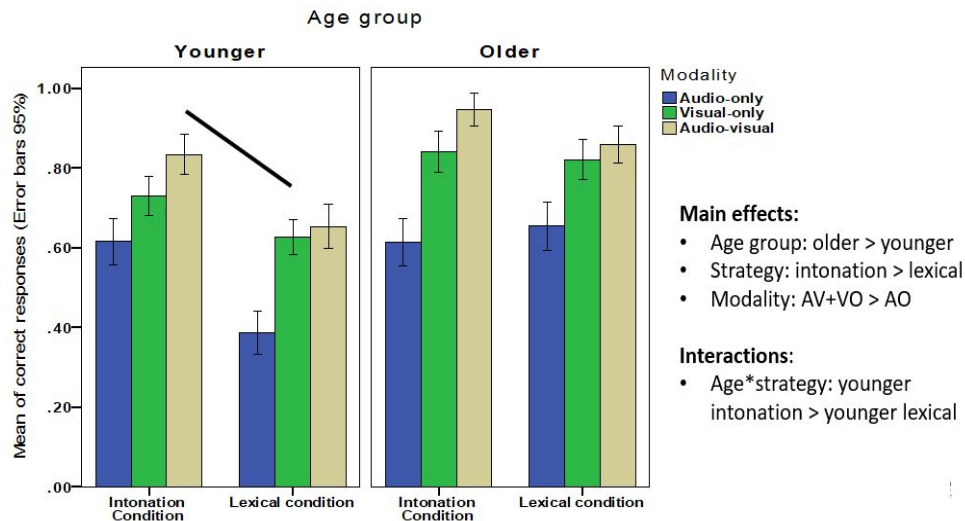
Barbara is now asking her twin friends if they know which is her favourite vegetable. One is certain and one is uncertain about the answer. Point at the uncertain one

>



	Audio-only	Video-only	Audio-visual
Intonation strategy	A tomatoe		
	A tomatoe?		
Lexical strategy	I'm sure it's a tomatoe		sure
	Maybe it's a tomatoe		maybe

Hübscher et al. (2017)



Prosody and body signals in NDD

DLD (structural language and processing deficits)

Practitioners and educators are advised to use emphatic prosodic cues and body movements to ease children's language comprehension.

Not clear scientific evidence of whether the presence of prosody and gestures helps or hinders language comprehension.

- **Prosody:** Intact low-level perception of intonation contours, intact imitation abilities, but impaired comprehension of prosodic chunks and of contrastive focus (Marshall et al., 2009)
- **Gestures:** More hand gestures in production (e.g. Wray et al., 2016), but contradictory findings in comprehension:
 - Iconic gestures boost the processing of contextual information ("Freddie helped his dad paint the bedroom. Freddie had to put on his old clothes") required to comprehend questions ("Why did Freddie have to put on his old clothes?") (Kirk et al., 2011)
 - Worse comprehension of the semantic information conveyed by iconic gestures (Botting et al., 2010)

Prosody and body signals in NDD

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Practitioners and educators are advised to use emphatic prosodic cues and body movements to ease children's language comprehension.

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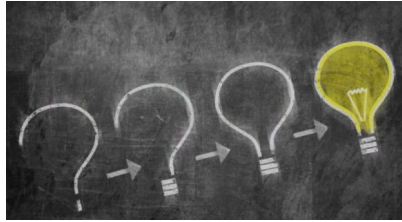
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ASD (socio-communicative deficits)

Practitioners, educators and families use visual signs to facilitate communication (e.g. pictograms).

Mixed evidence on whether children with ASD appropriately process prosodic and gesture cues to pragmatic meanings.

- **Prosody:** it depends on children's age, experimental task, and specific pragmatic function analysed (see review by Grice et al., 2023), but more studies seem to point at a deficit in using prosody to comprehend intentions (Zhou et al., 2020)
- **Gestures:**
 - The combination of speech and gesture to express *semantic* meaning hinders adults' comprehension (Silverman et al., 2010), and they have difficulties in decoding facial expressions (e.g. Ashwin et al., 2006).
 - But, *parents* use more gestures and scaffolding when talking to children with autism (Yoshida et al., 2019)



Mari
Aguilera



Nadia
Ahufinger

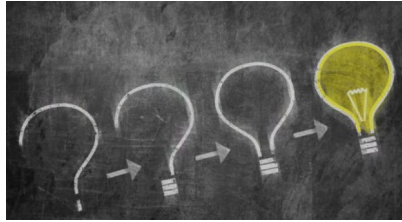


Albert
Giberga



Alfonso
Igualada

Prosodic and body signals as facilitators of the children's comprehension and processing of pragmatic meanings



Mari
Aguilera



Nadia
Ahufinger



Albert
Giberga

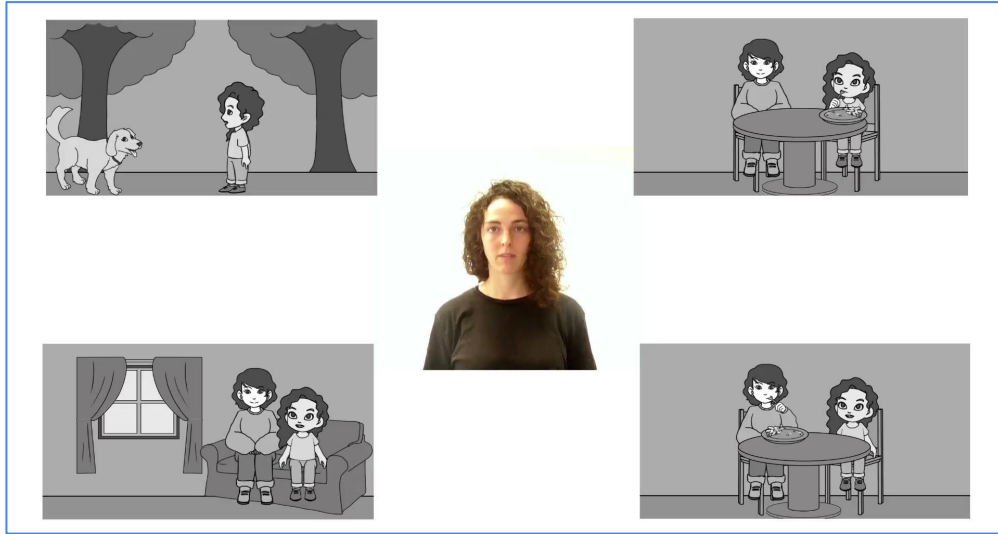


Alfonso
Igualada

Prosodic and body signals as facilitators of the children's comprehension and processing of pragmatic meanings

- Do children rely on prosodic and body signals more when the pragmatic meaning is more cognitively complex?
- Do children with neurodevelopmental disorders (DLD and ASD) benefit equally from prosodic and body signals than children with TD?
- Are prosodic and body signals used differently depending on the nature of the developmental disorder (language impairment in DLD vs socio-communicative impairment in ASD)

Visual-world eye-tracking tasks with picture selection



Adaptation of the visual-world paradigm,
following Silverman et al (2010) and Morett
et al (2021)

Two pragmatic meanings:

- Interrogativity (1st exp. block)
- Indirect requests (2nd exp. block)

Three experimental conditions:

- prosodic signals
- prosodic+bodily signals
- baseline (no signals)



Block 1 (interrogativity)

Mare, el menjar està bo?

Mum, food is good?



Mare, el menjar està bo?
Mum, food is good?

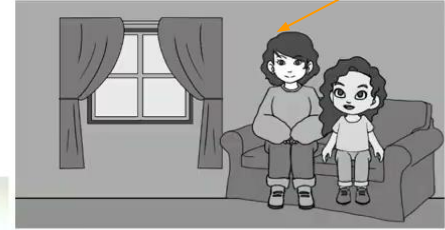
irrelevant
distractor

relevant
distractor

Prosodic
cues to IT

target

competitor



Mare, el menjar està bo?
Mum, food is good?

irrelevant
distractor

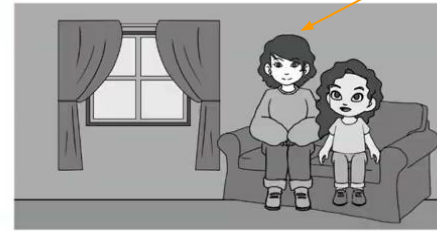
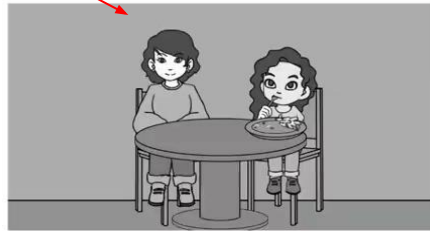
target

Multimodal
cues to IT



competitor

relevant
distractor



Mare, el menjar està bo?
Mum, food is good?

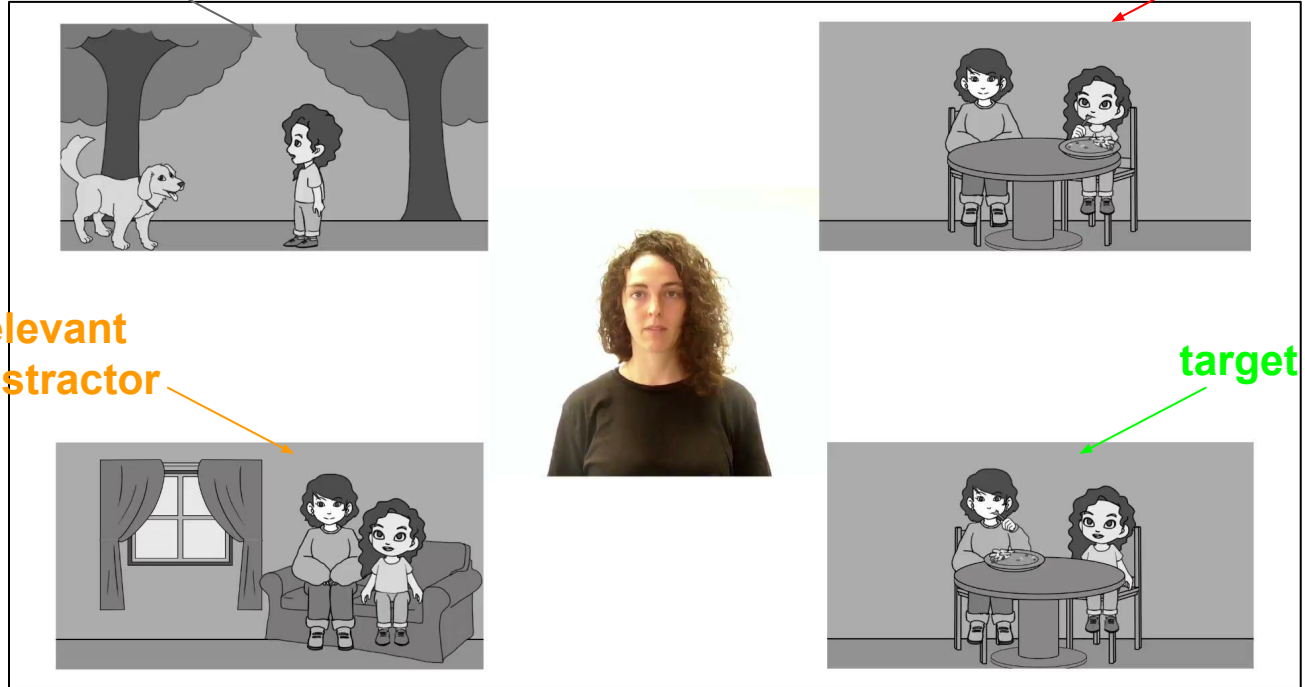
irrelevant
distractor

competitor

Baseline
(no cues to IT)

relevant
distractor

target



Block 2 (indirect requests)

Joan, la gerra està buida
John, the jar is empty



Joan, la gerra està buida
John, the jar is empty

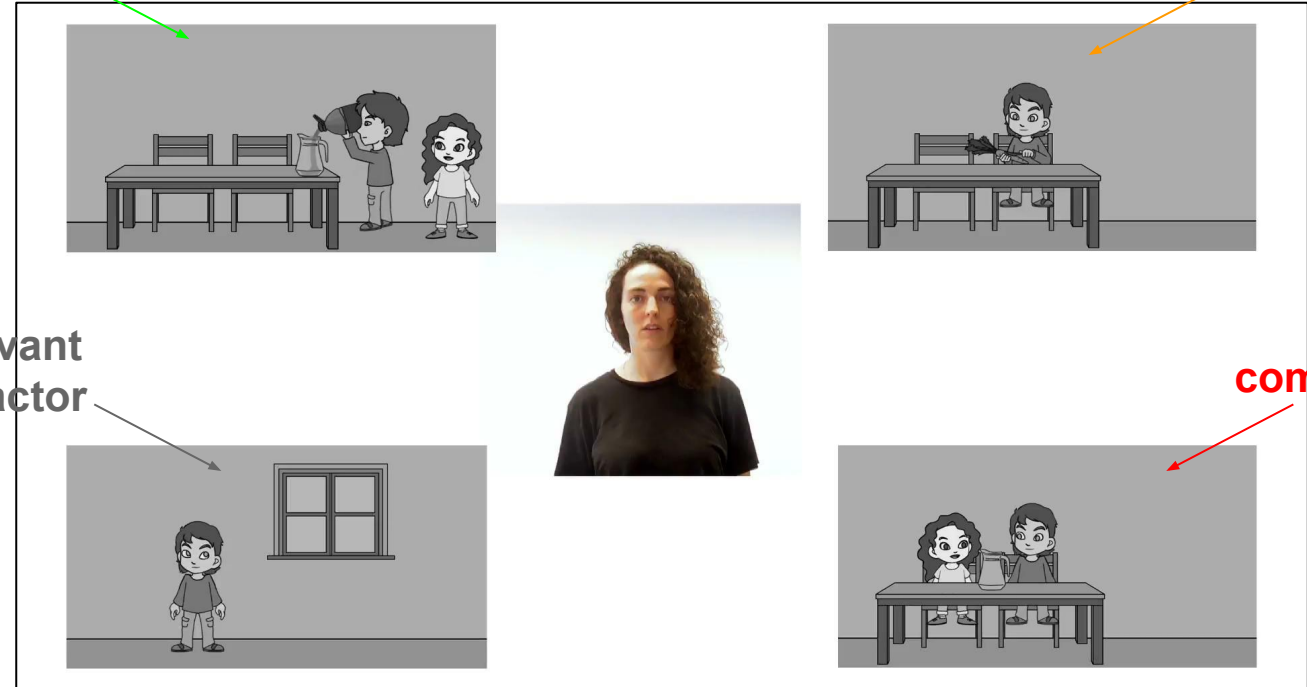
target

relevant
distractor

Prosodic
cues to IR

irrelevant
distractor

competitor



Joan, la gerra està buida
John, the jar is empty

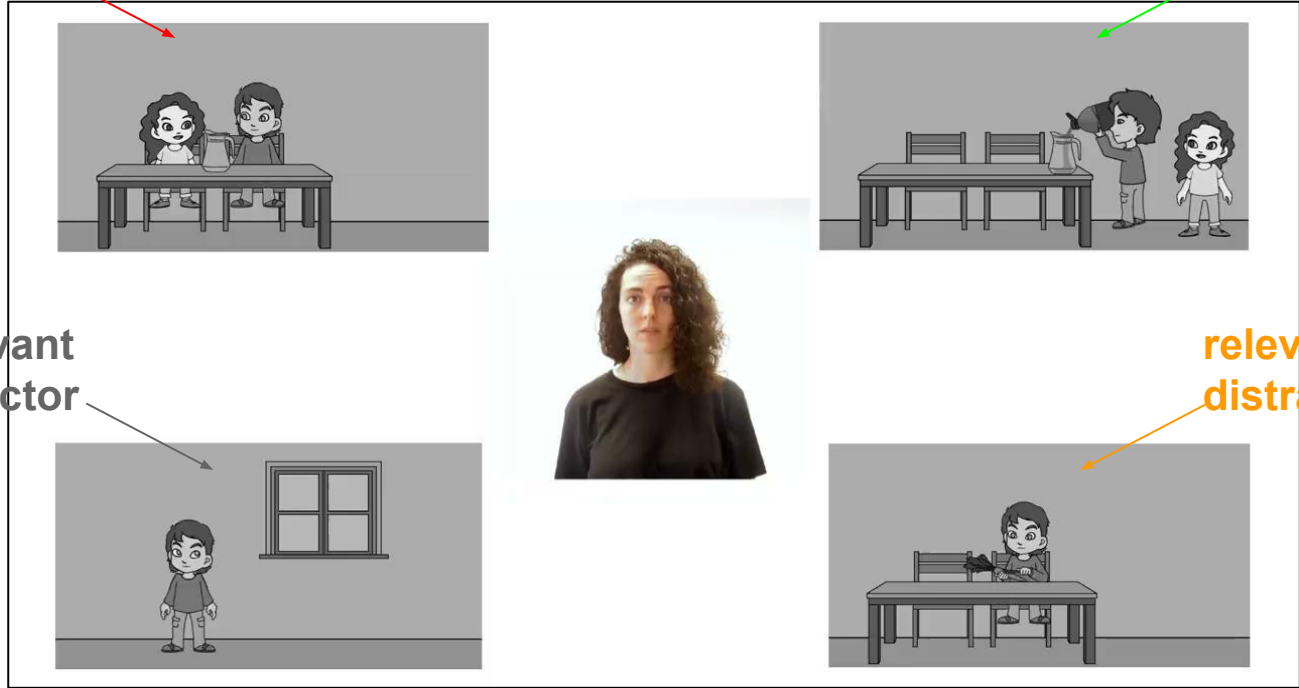
competitor

target

Multimodal
cues to IR

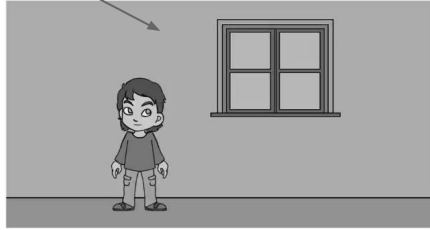
irrelevant
distractor

relevant
distractor

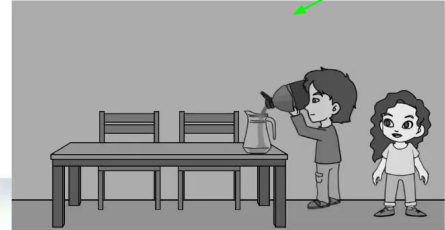


Joan, la gerra està buida
John, the jar is empty

irrelevant
distractor



target

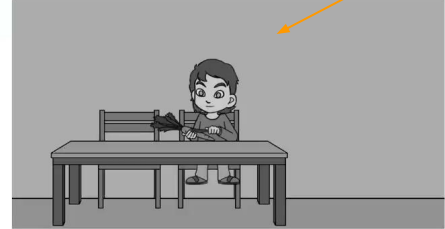


Baseline
(no cues to IR)

competitor



relevant
distractor

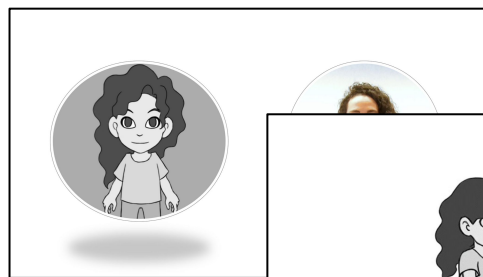


Preparing the stimuli

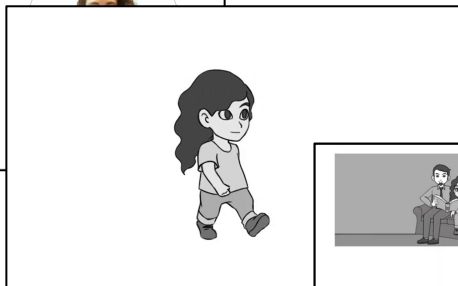
- Cues to interrogativity:
 - Previous literature (Borràs-Comes et al 2014; Prieto et al 2015; Torreira & Valtersson, 2015)
- Cues to indirect requesting:
 - Previous literature for prosody (Prieto et al 2015)
 - Elicitation task (DCT) for gestures



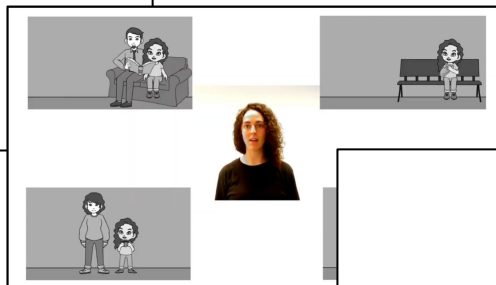
Procedure: the story



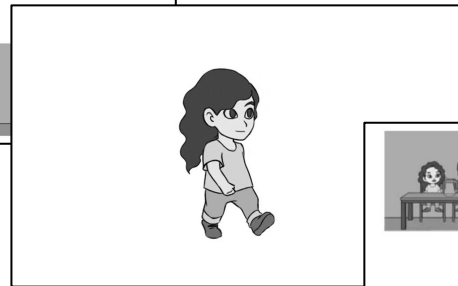
Presenting the main character



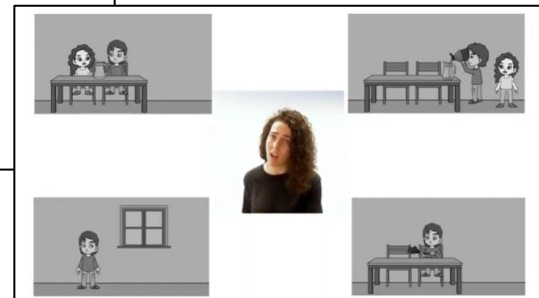
Sentence context



Familiarization trials



Sentence context

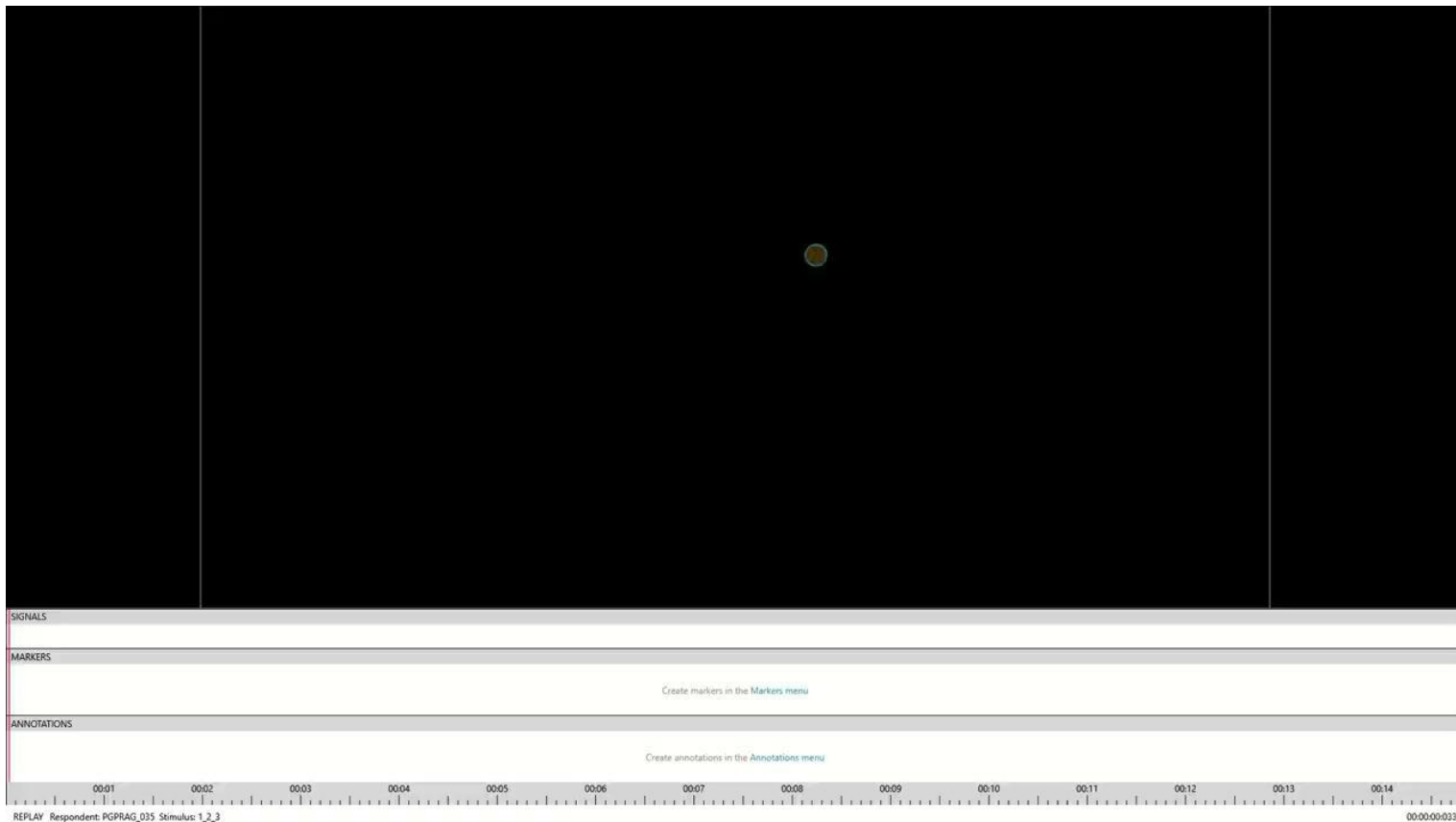


Test trials

Sentence context: Martina and her cousin John sit together at the table. Martina is thirsty. She does not know where the water is but she sees the jar on the table. Then Martina says...

Test sentence: John, the jar is empty

IR - baseline



Results from children with DLD (vs TD children)

79 Catalan-speaking children

39 children with DLD (19 girls) and 40 TD children (20 girls)

Age range: 5-10 (mean age 7.3); no ages differences between groups

Inclusion criteria

DLD group

- Language assessment through CELF-5: score in core language <1 SD
- Parental and/or school concerns about their language development
- Cognitive assessment through K-BIT: score in non-verbal subtest ≥ 70
- Dominant in Catalan language (as reported by family and school)

TD group

- Language assessment through CELF-5: score in core language > 1 SD
- No parental and/or school concerns about their language development
- Cognitive assessment through K-BIT: score in non-verbal subtest ≥ 70
- Dominant in Catalan language (as reported by family and school)

Picture selection

Interrogativity

Condition ($\chi^2 = 32.50$; $p < 0.01$)
Multimodal & Prosody > Baseline

3-way interaction Condition * Age * LingGroup:
Younger children with DLD benefit less
from prosody ($\beta = 1.78$, $SE = 0.70$, $z = 2.54$) and multimodality ($\beta = 1.68$, $SE = 0.74$, $z = 2.26$), while older children with DLD and TD perform equally well



Picture selection

Indirect requests

Condition ($\chi^2 = 12.383$, $p < 0.01$)

Multimodal > Baseline ($\beta=1.78$,
SE=0.74, $z=2.40$)

2-way interaction Condition * Age

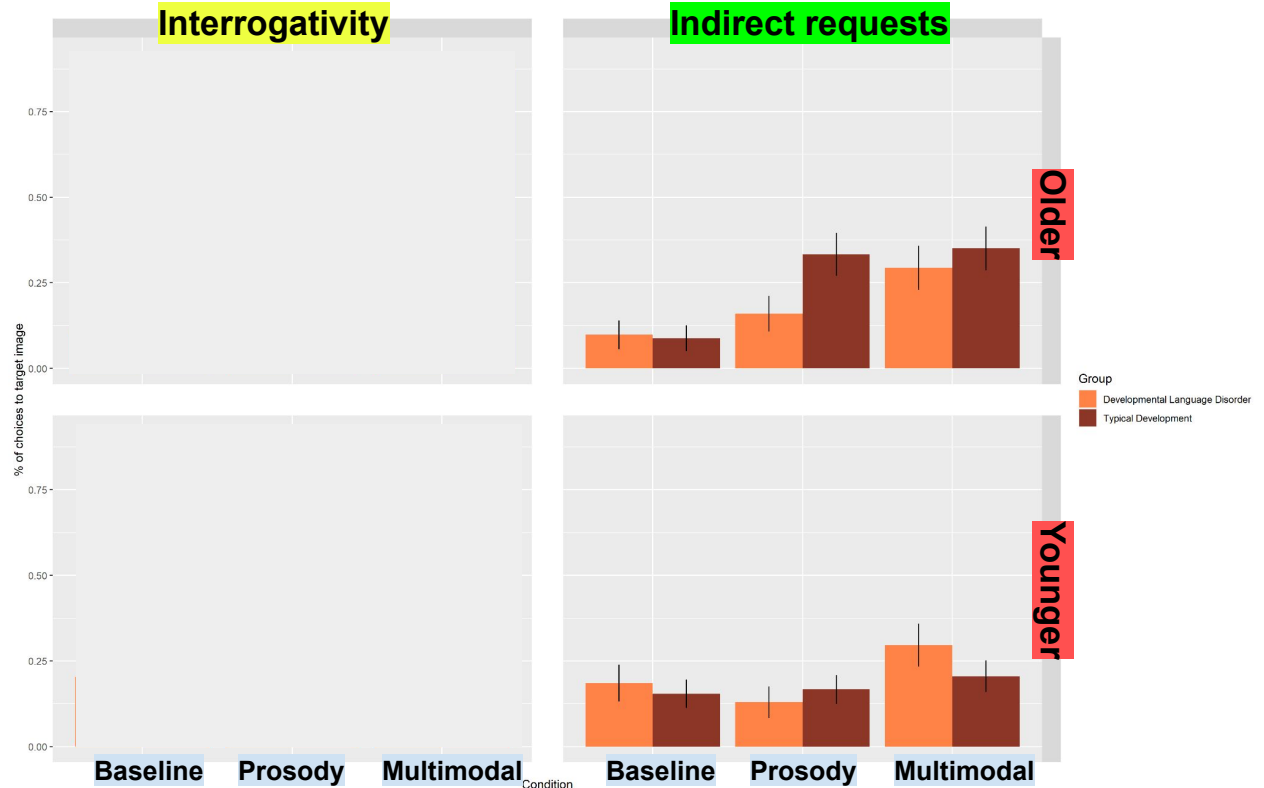
Older children benefit more from multimodality ($\beta=3.0667$, SE=0.9631,
 $z=3.184$)

2-way interaction Condition * LingGroup

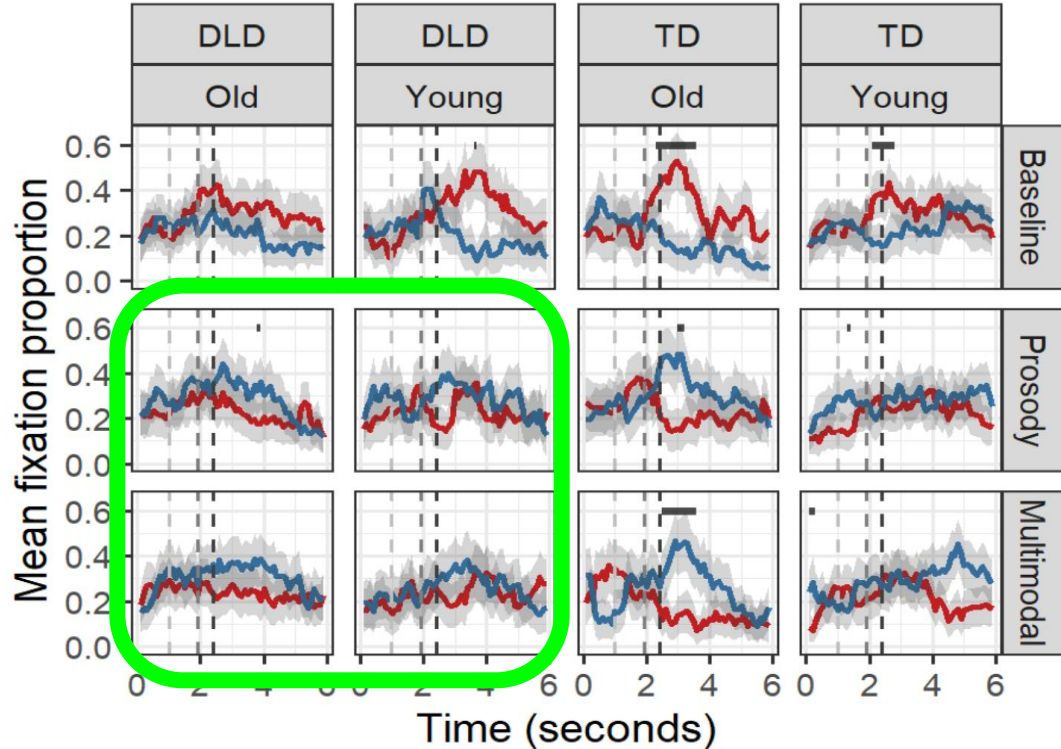
Children with DLD benefit more from multimodality than TD children ($\beta=2.24$,
SE=0.97, $z=2.304$)

3-way interaction Condition * Age * LingGroup

Older children with DLD benefit from multimodality over prosody & baseline, while older children with TD also benefit from prosody ($\beta=2.24$, SE=0.97,
 $z=2.304$)



Block 1 (interrogativity)

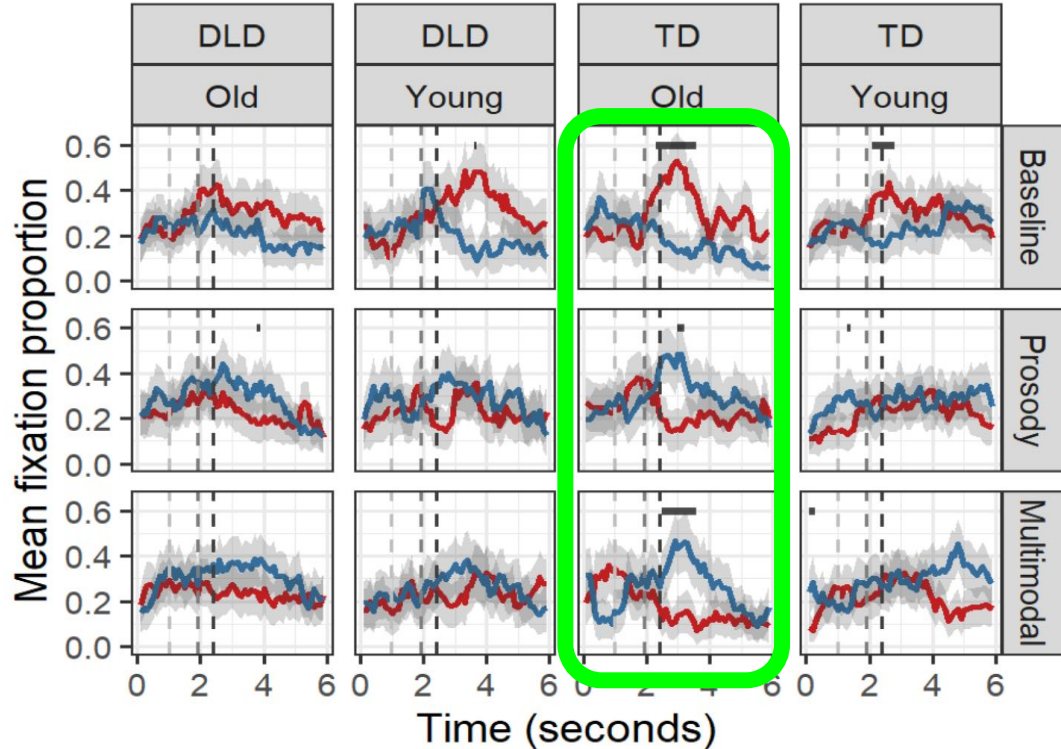


- Children with DLD **look equally Target and Competitor** throughout the trial even if there are prosodic and multimodal cues to IT, and despite selecting target image appropriately

Object

- Competitor
- Target

Block 1 (interrogativity)



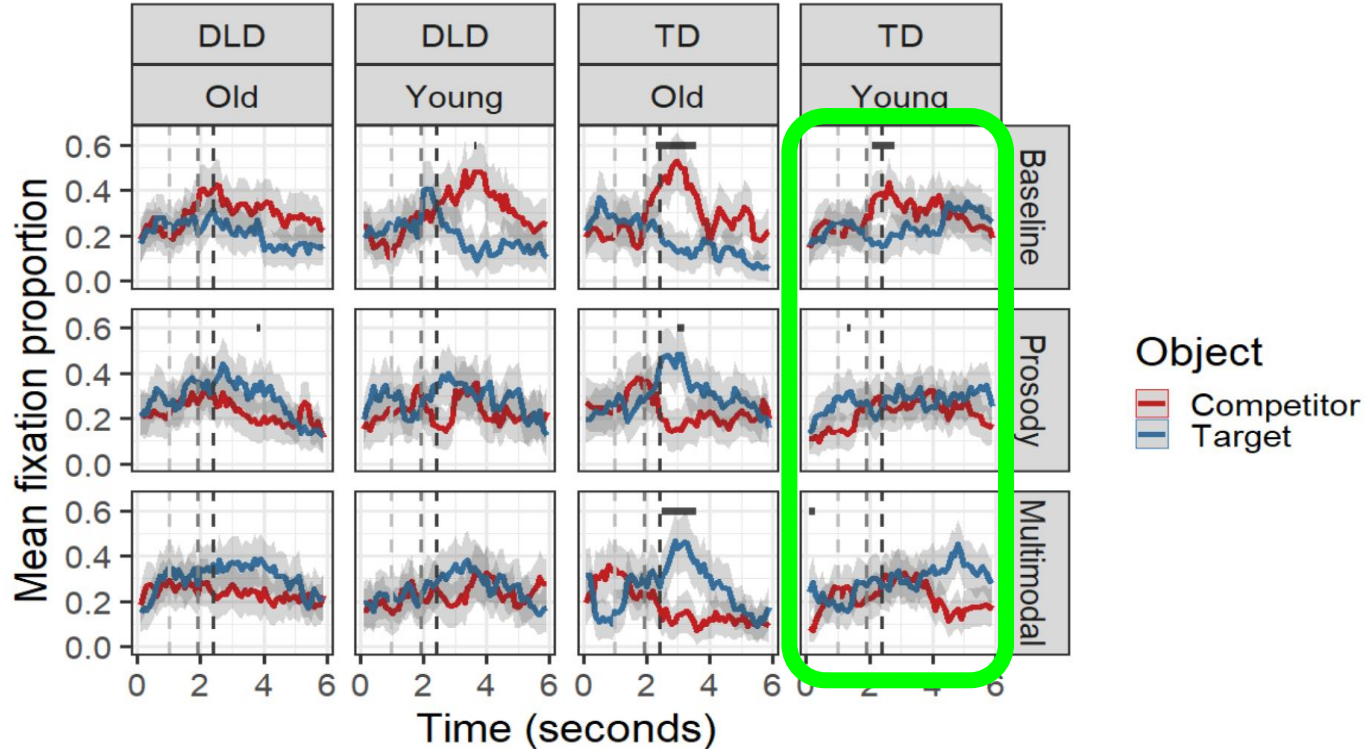
- **Older TD children** shift their gazes towards the Target upon the presentation of prosodic and multimodal cues to IT. If no cues, they interpret literal statement.

Object

- Competitor
- Target

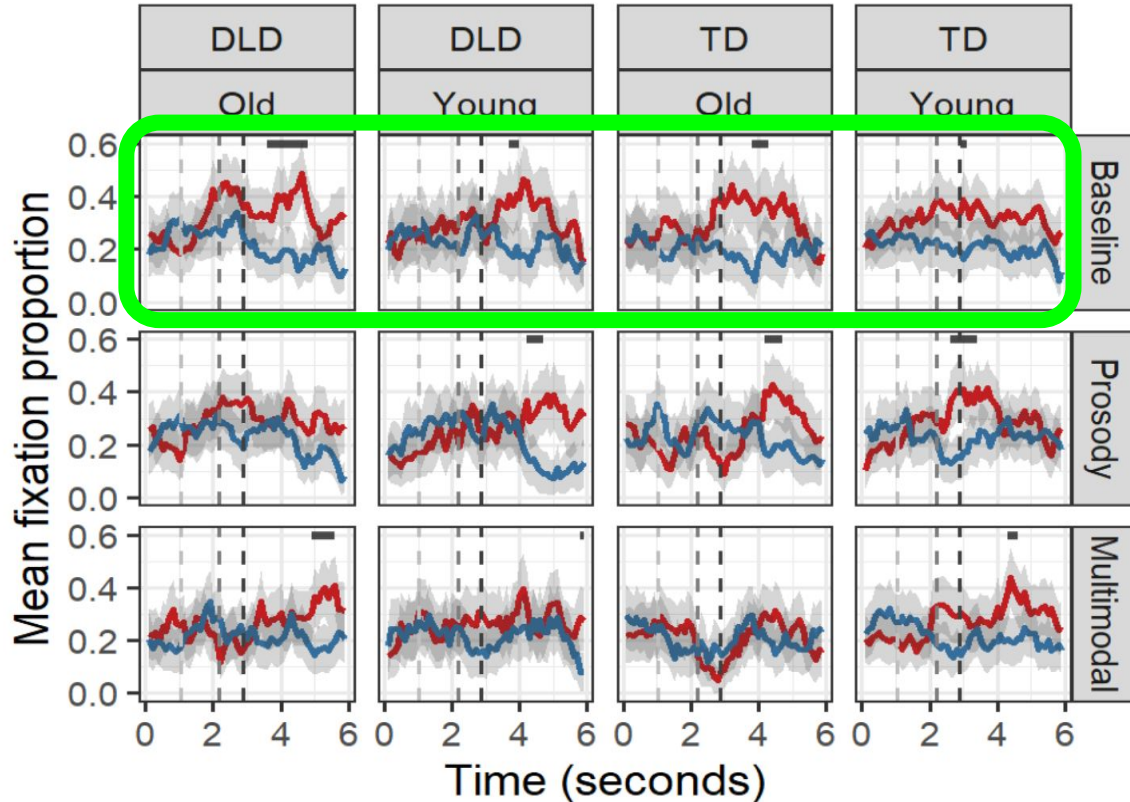
Block 1 (interrogativity)

- Gaze patterns of younger TD children resemble those of children with DLD (**developmental effect**)



Block 2 (indirect requests)

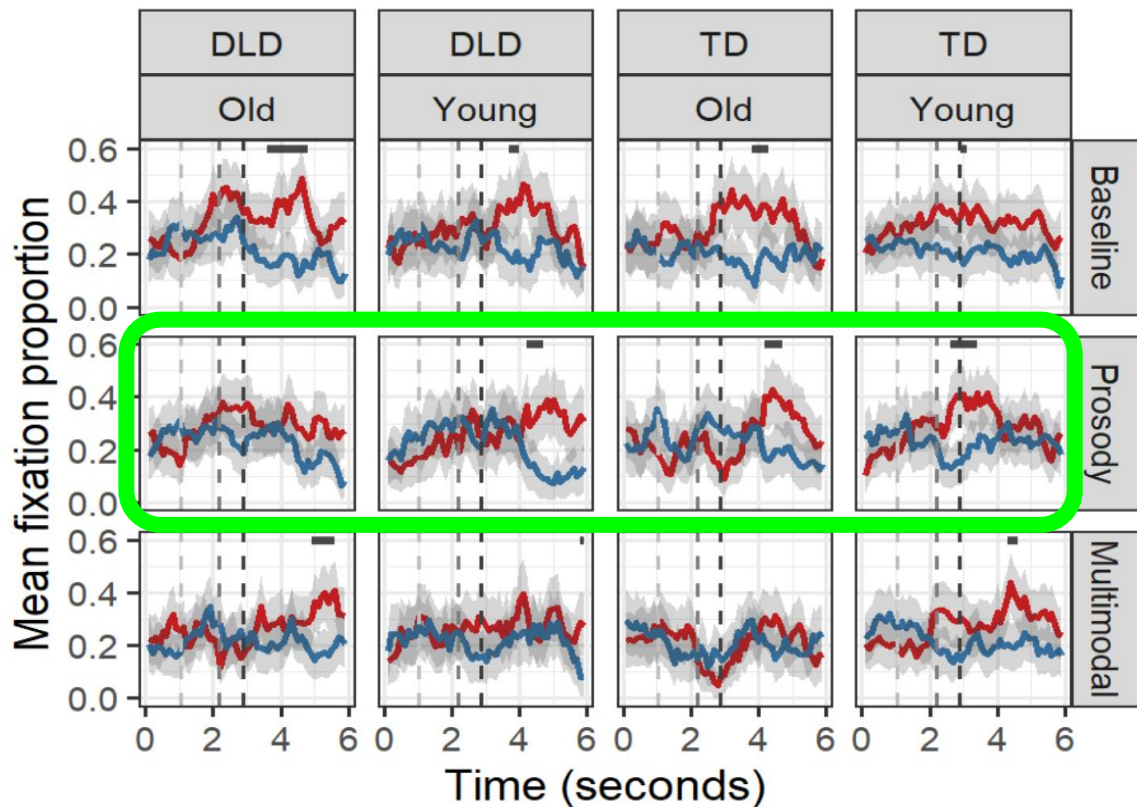
- When children **perceive the absence of prosodic or multimodal cues** to IR, they all look more at the image depicting a literal statement



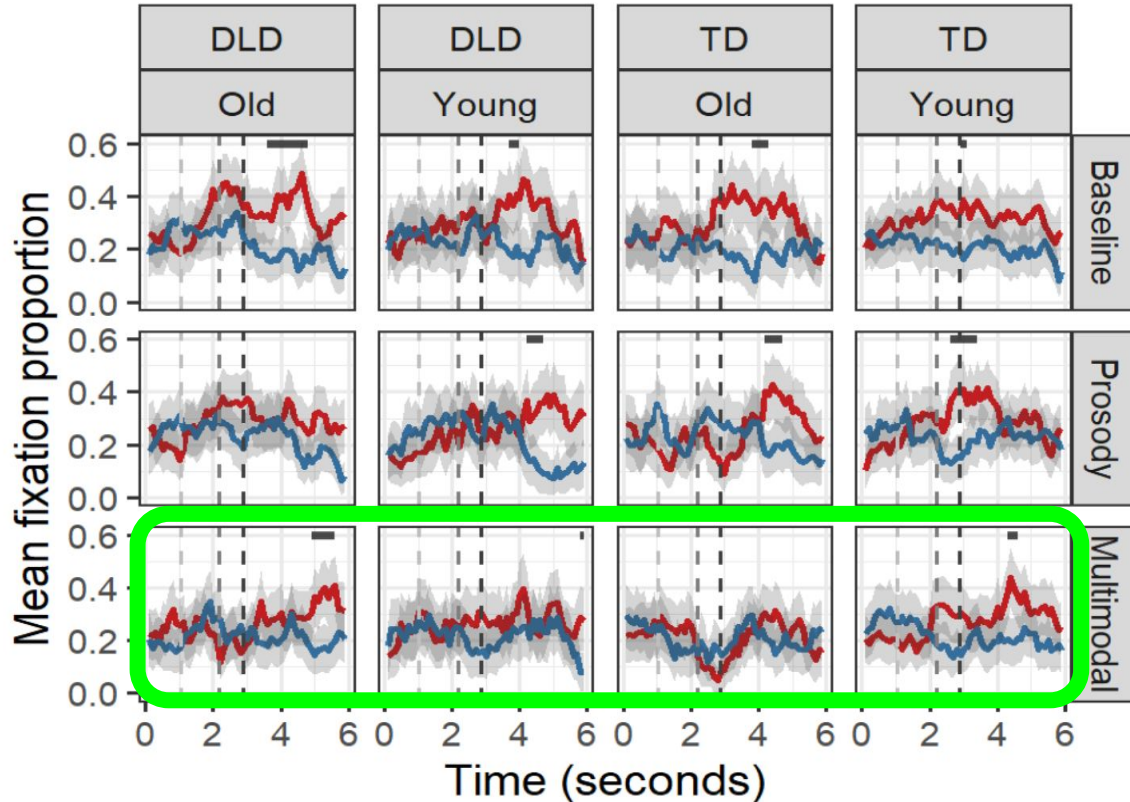
Object
— Competitor
— Target

Block 2 (indirect requests)

- The unfolding of prosodic cues triggers all children's **looks to the Competitor** more than to the **Target**



Block 2 (indirect requests)



- The unfolding of **multimodal** cues to IR **reduces de children's bias** to look at the Competitor, although they also explore it throughout the trial
- Gaze patterns of older children with DLD resemble those of younger TD children

Object
— Competitor
— Target

Main results

- Spoken prosody and bodily signals helped all children decode all pragmatic meanings (consistent with previous literature)
- The comprehension of the older DLD group resembled that of the younger TD groups (developmental effect) (consistent with previous literature on language-matched TD groups)
- Prosodic cues are processed by both language groups and are sufficient for understanding less complex meanings, while visual cues do not boost comprehension (contrary to our expectations)
- Multimodal cues facilitate the children's comprehension of more complex meanings (especially in the DLD group) by reducing literal biases
- Children (especially those with DLD) look both alternatives even if prosodic and body signals unfold and even if they select the appropriate image (cf. Esteve-Gibert et al., 2018)

Children with ASD (vs TD children)

32 Catalan-speaking children

~ 16 children with ASD and ~ 16 TD children

Age range: 7-10

Inclusion criteria

ASD group

- Language assessment through CELF-5: score in core language > 1 SD
- Clinical diagnosis of ASD
- Diagnosis confirmation with SCQ questionnaire
- Cognitive assessment through K-BIT: score in non-verbal subtest ≥ 70
- Dominant in Catalan language (as reported by family and school)

TD group


- Language assessment through CELF-5: score in core language > 1 SD
- No clinical, school and/or parental concerns about their socio-communicative development
- Cognitive assessment through K-BIT: score in non-verbal subtest ≥ 70
- Dominant in Catalan language (as reported by family and school)

Children with ASD (vs TD children)

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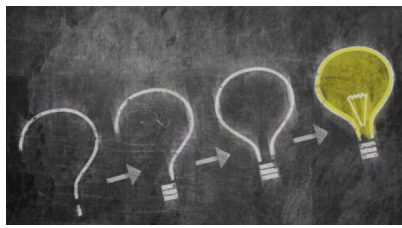
Age range: 7-10

ASD group		TD group
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Worried about us testing something that children with ASD are not really exposed to in their everyday interactions



Albert Giberga
(UOC)



Parental use of spoken prosody and bodily signals to indicate pragmatic meanings



Albert Giberga
(UOC)



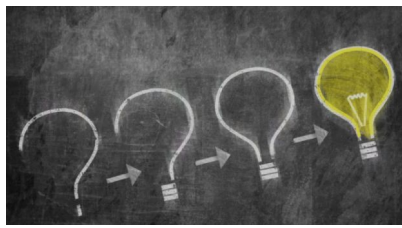
Roy Hessels
(Utrecht)



Aoju Chen
(Utrecht)



Neus Martorell
(Fund. Esment)



Parental use of spoken prosody and bodily signals to indicate pragmatic meanings

- Do parents use them at all when speaking to their children with ASD?
- If they use them, is it because it is their own communicative style or because they are adapting it for their child with ASD?
- Does it depend on the type of indirect meaning (indirect request vs. metaphor vs. ironic criticism)?



Albert Giberga
(UOC)



Roy Hessels
(Utrecht)



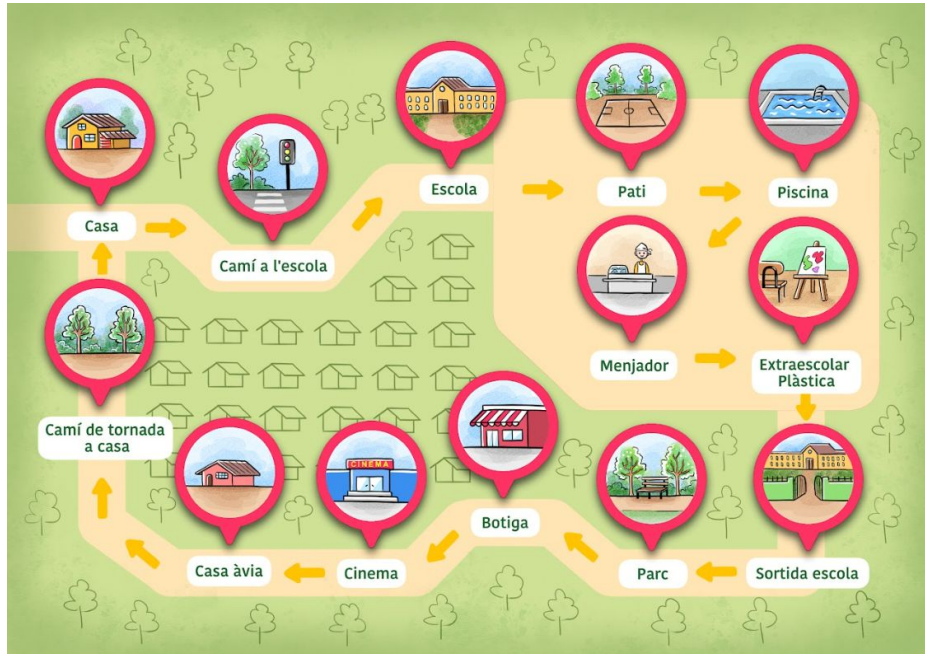
Aojun Chen
(Utrecht)



Neus Martorell
(Fund. Esment)

Production-elicitation task based on:

- CASL (comprehension of pragmatic meanings)
- Map task (elicitation of prosodic information)
- Routine-based interviews



Parents propose everyday complex pragmatic situations to the child and asks the child what he or she would interpret in these situations

Parents read aloud the context (“After the swimming class, you are at the changing room and you are putting on your socks. Your socks do not match. Then your friend says to you...”)

+

Parents read for themselves the utterance in blue (“These socks look bad to you”)

+

Parents read aloud the utterance in green (“These socks look great to you!”)

+

Parents ask: what does your friend mean?

Context: Després de la classe de natació, sou al vestidor de la piscina i t'estàs posant els mitjons. Avui has portat mitjons desaparellats, que no són iguals. Llavors, el teu amic et diu:



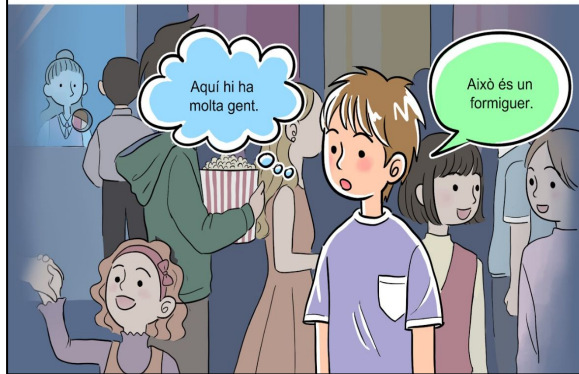
ironic criticism

Context: Després de la classe de natació, sou al vestidor de la piscina i l'estàs posant els mitjons. Avui has portat mitjons desaparellats, que no són iguals. Llavors, el teu amic et diu:



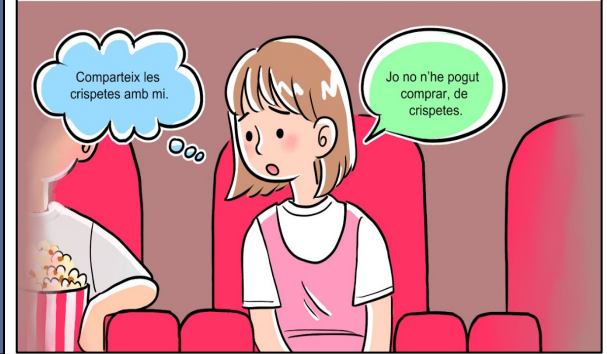
metaphor

Context: Els teus amics i tu arribeu al cinema. A l'entrada hi ha moltíssima gent, i el teu amic diu:



indirect requests

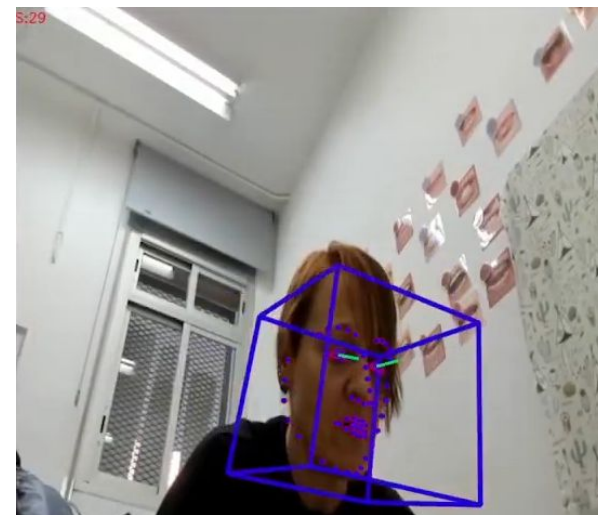
Context: Ja heu comprat les crispes i us heu assegut als vostres seients per veure la pel·lícula, que ja comença. Llavors arriba la teva amiga, a qui també li agraden molt les crispes però, com que ha arribat tard, no n'ha pogut comprar. Llavors, la teva amiga et diu:



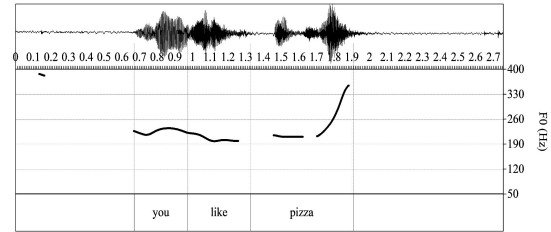
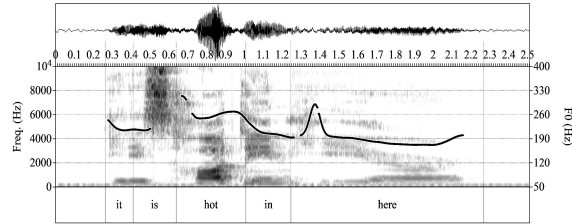
Two control groups:

- Parents interacting with children with TD
- Parents interacting with TD adult

Piloting



Processing pragmatic intent in oral language through prosodic and multimodal cues when linguistic and socio-communicative abilities are compromised



Thank you very much



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