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# A Hybrid Robotics System for Children with Autism: A longitudinal Study of Social Interaction inside the Classroom



National Center of Neurology and Psychiatry

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# Context

Robot and children with ASD (= Autism Spectrum Disorder)

The most common characteristics of autism are:

- (i) inappropriate social interactions, impaired capacity to understand other's feelings or mental states;
- (ii) impairment of social communication skills (e.g. understanding gestures, facial expressions, tone of voice);
- (iii) significantly reduced repertory of activities and interests (stereotypical behavior, fixation to stable environments)

→ It is the reason why children with ASD prefer a **stable, ordered and secure** environment, that **robotics systems can offer**.





# Context

## Robot and children with ASD

= robot can be relevant if:

→ Focusing on **communication**  
**communicative skills**

→ Focus on **human-like** appearance  
(interaction facilitators)

But:

- Often expensive
- Laboratory situation (vs. classroom?)
- Individual activity (vs. communication? Cooperation?)
- Robotics skills?
- Human-like appearance as a barrier to interaction? (Dinet *et al.*, 2020; Dinet & Vivian, 2018)



# Context

Cozmo©, because :

- Small, compact (on a table, on the floor, ...)
- Cheap (< 120€)
- No specific skills required for a quick use (smartphone, tablet, ...)
- Hybrid ("truck" with face)
- Provided with many pre-programmed activities
- Face recognition (and thus routine children)
- Expression of emotions

→ Robotics device = robot + cubes + usage scenarios



# Method

**Context** : quasi-experimental situation in an ecological environment

An **UEEA** (Ecole Élémentaire pour Enfants Autistes\*)  
= « *Une classe spéciale dans une école ordinaire* »

= a medical-educational establishment (IME)  
located in a regular school...

... for children for whom the support of a ULIS or  
human assistance is insufficient

Project involving all partners of the educational  
community (teachers, parents, caregivers, ...)

\*In France, 100 000 children with ASD,  
only 36 000 are in schools



UEEA located at  
Dieue-sur-Meuse  
(Meuse, 55)





# Method

**Participants** : 9 children (7 Males ; mean age= 9.1 years)

**Duration** : 20 weeks (4 sessions per week: each session = 20-45 min.)

**Task** : perform different tasks

- Collaborative or competitive
- with / against others
- with / against Cozmo©

Video-audio recordings

➔ Analyses of

**six behaviours**

related to communication

(coding inter-judges with 3 judges)



(a) *“Point toward robot”*



(b) *“Say hello to the robot”*



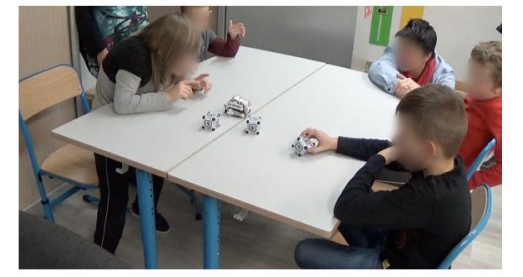
(c) *“Touch/take a cube”*



(d) *“Point toward a peer”*



(e) *“Touch/take the robot”*



(f) *Joint attention*

# Main results

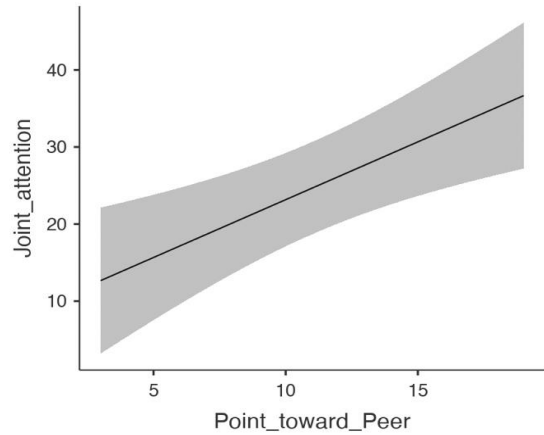
➔ Pointing to peers is key factor in joint attention

Model Coefficients - Joint\_attention

Predictor	Estimate	SE	t	p
Intercept	8.17	0.9233	8.85	0.072
Point_toward_Peer	1.50	0.0722	20.78	0.031

Model 1 :  $R = 0.999$  ;  $R^2 = 0.998$

“Joint attention” =  $8.17 + 1.50 * \text{“Point toward peer”}$



		Say_Hello_to_Cozmo	Point_toward_robot	Touch_Cube	Point_toward_Peer	Touch_Robot	Joint_attention
Say_Hello_to_Cozmo	Pearson's r	—					
	p-value	—					
Point_toward_robot	Pearson's r	-0.481	—				
	p-value	0.681	—				
Touch_Cube	Pearson's r	0.070	-0.908	—			
	p-value	0.955	0.275	—			
Point_toward_Peer	Pearson's r	0.327	-0.986	0.966	—		
	p-value	0.788	0.107	0.168	—		
Touch_Robot	Pearson's r	-0.866	0.855	-0.560	-0.756	—	
	p-value	0.333	0.347	0.622	0.454	—	
Joint_attention	Pearson's r	0.282	-0.977	0.977	<b>0.999*</b>	-0.724	—
	p-value	0.818	0.138	0.137	<b>0.031</b>	0.485	—

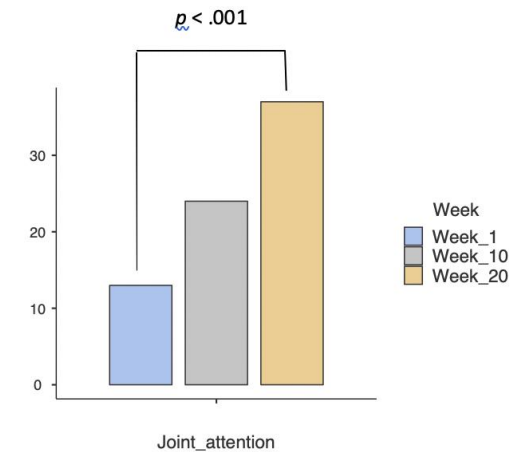
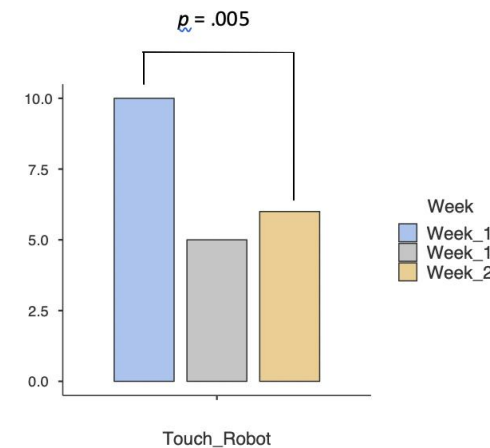
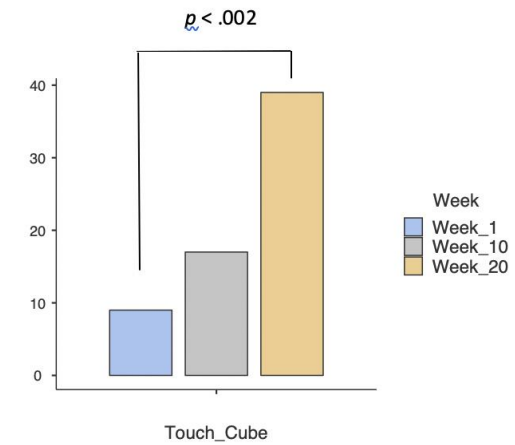
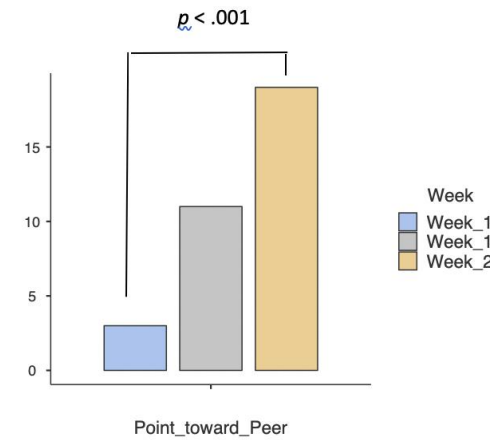
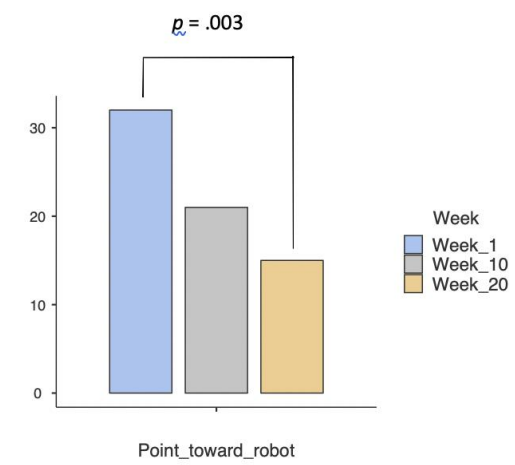
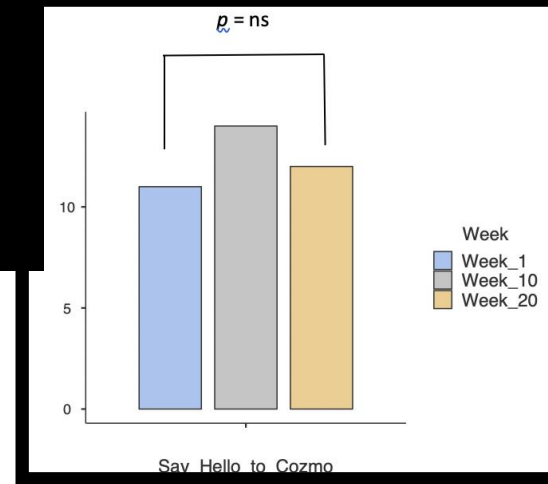
Note. \* p < .05, \*\* p < .01, \*\*\* p < .001



# Main results

After 20 weeks, frequency of:

**one** behavior does not change (« *say hello to Cozmo©* »)

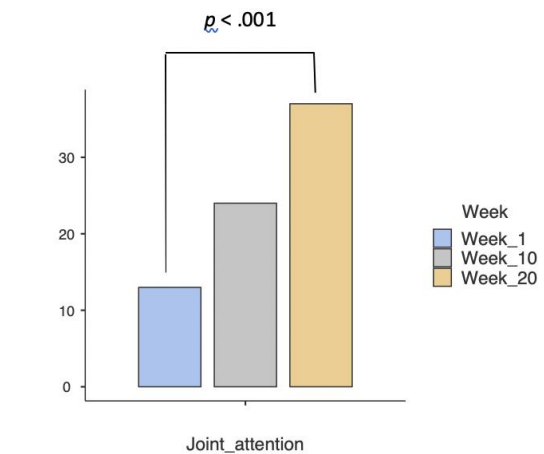
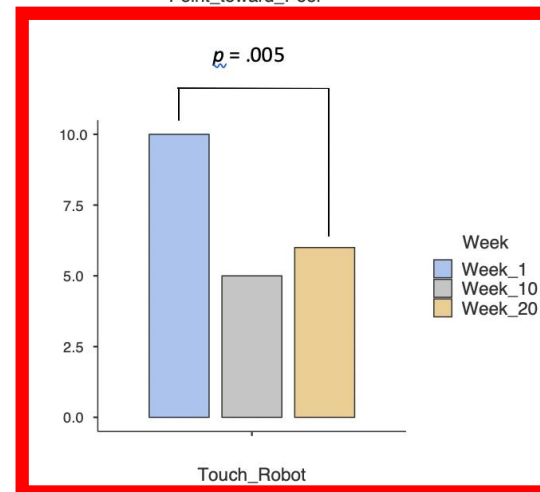
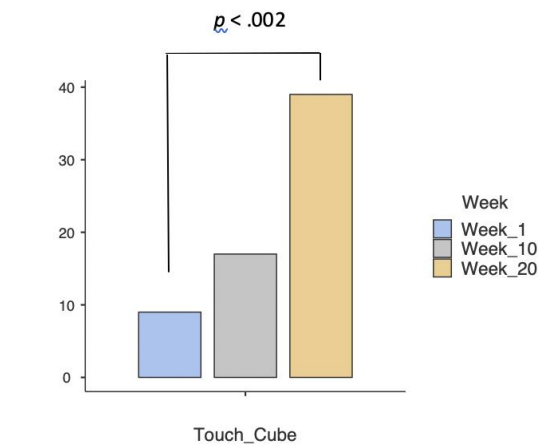
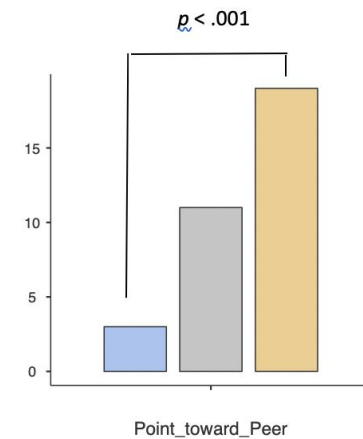
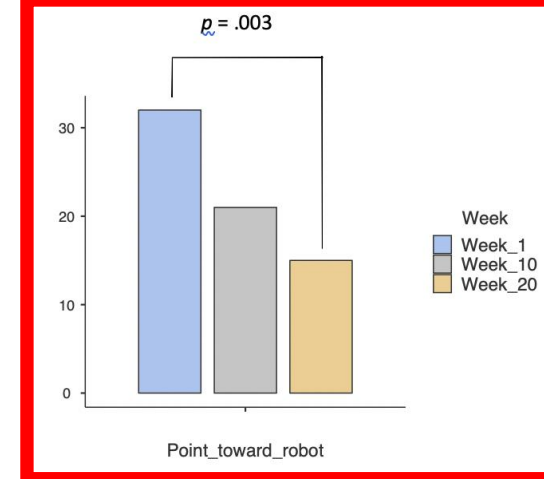
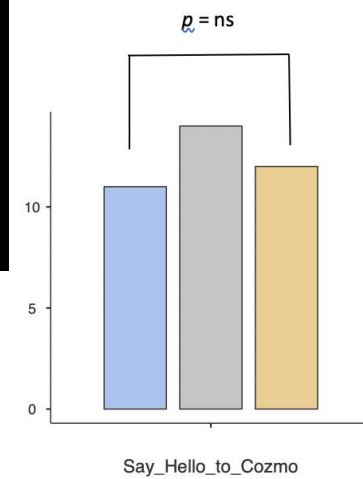


# Main results

After 20 weeks, frequency of:

**one** behavior does not change (« *say hello to Cozmo©* »)

**two** behaviors decrease significantly  
(« *pointer vers Cozmo©* » et « *toucher Cozmo©* »)



# Main results

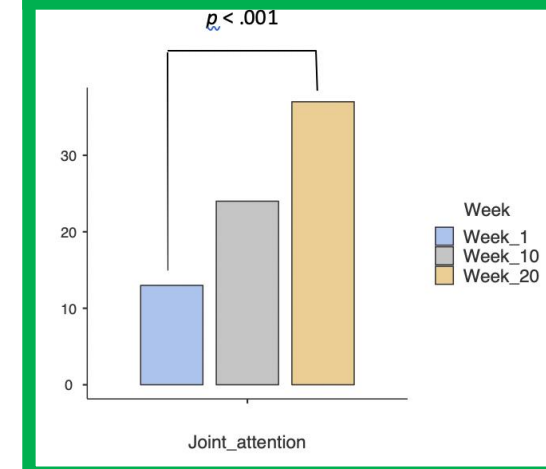
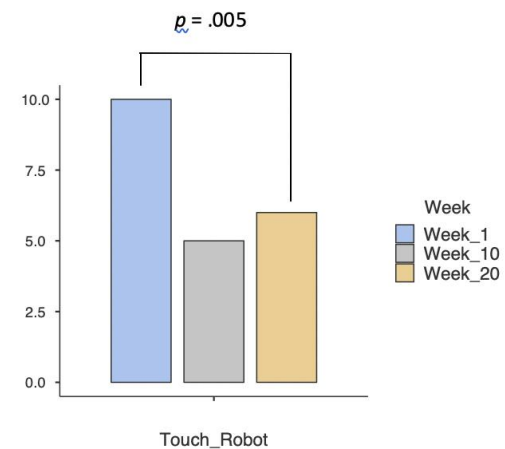
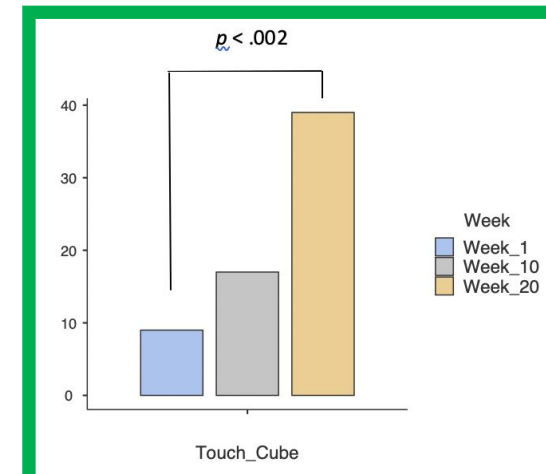
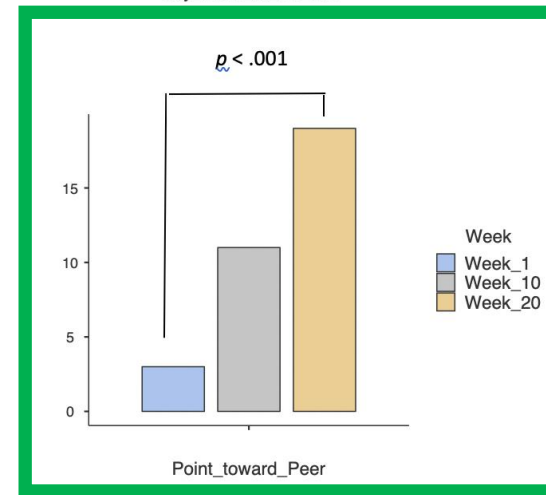
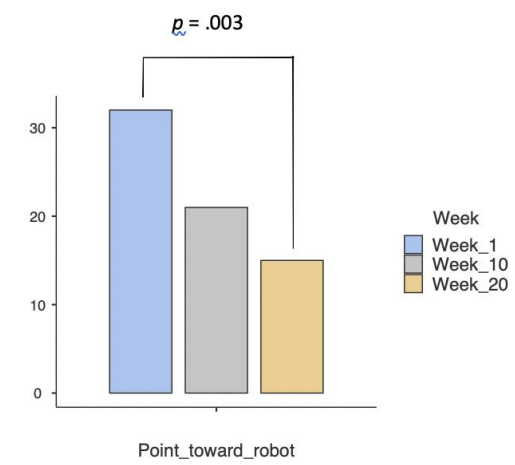
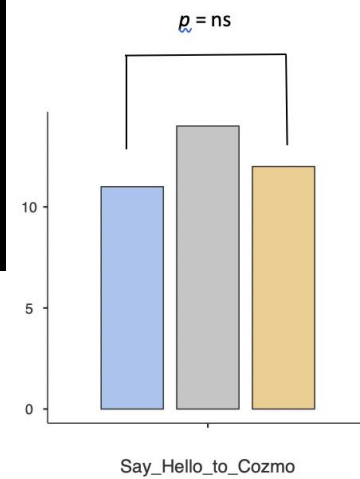
After 20 weeks, frequency of:

**one** behavior does not change (« *say hello to Cozmo©* »)

**two** behaviors decrease significantly  
(« *pointer vers Cozmo©* » et « *toucher Cozmo©* »)

**three** behaviors increase significantly  
(« *pointer vers les pairs* », « *toucher les cubes* »,  
« *attention conjointe* »)

→ attention is increasingly focused **on others**  
and **the object of the activity** (i.e., the cubes)  
(and less and less towards the robot)





# Discussion

→ **Direct** positive impacts (after 20 weeks) of interactions

between children and Cozmo©

- Children initiate and respond more to interaction behaviors
- Development (and stabilization) of joint attention (crucial for communication)
- Development of attention to others

→ **Indirect** positive impacts (verbalizations, surveys) of interactions

between children and Cozmo©

- Changing parents' perceptions about their children's skills
- Involvement of the UEEA staff in the uses
- Willingness to continue « being a force of proposal » to co-design scenarios

# Discussion → experiment n°2

Perspectives → and with more complex tasks ???

Pilot study = experiment n°2:

Participants:

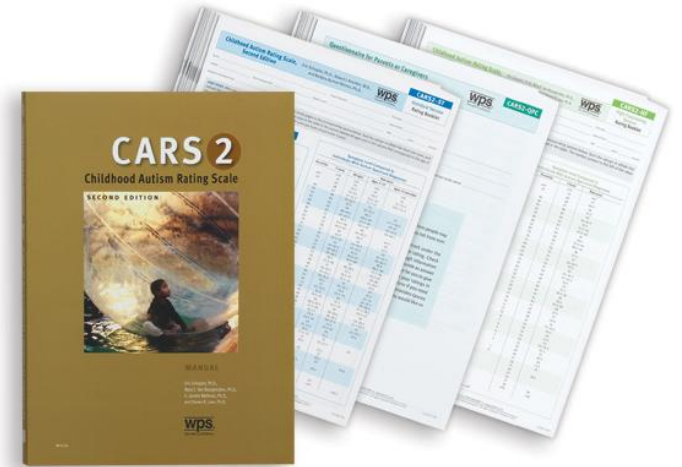
→ 12 Children without ASD ("Non-ASD group")

Average chronological age of 9.3 years (SD = 5.4 months, range = 8.8–9.9 years)

→ 12 children with ASD ("ASD group")

Average chronological age of 9.1 years (SD = 8.8 months, range = 6.8–9.7 years)

Distinction between the two groups → Childhood Autism Rating Scale (CARS-2)

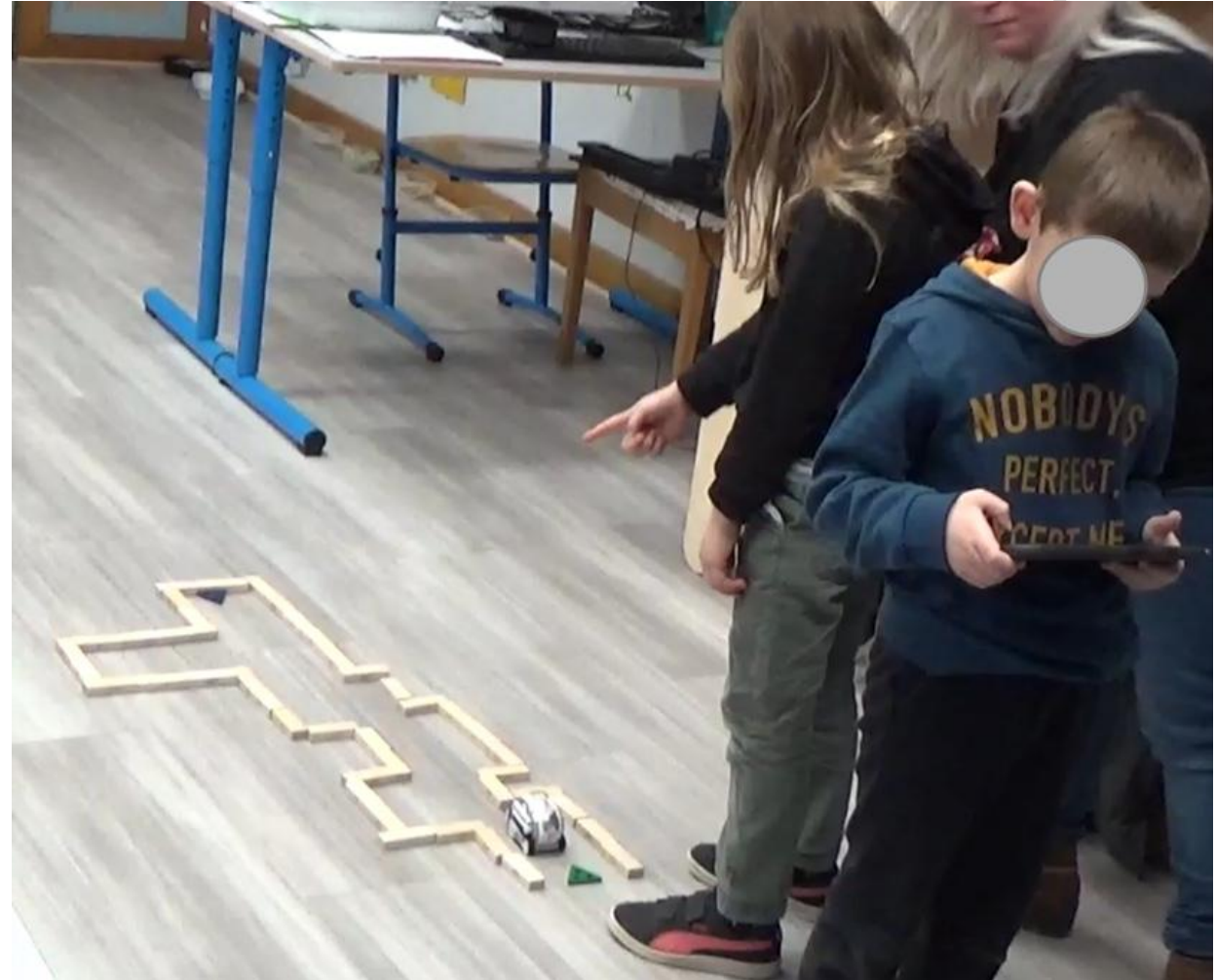


# Discussion → experiment n°2

## Procedure and task:

Experiment conducted **over 10 weeks**

Dyads of children with or without ASD were asked to perform cooperative tasks in a **double-blind situation** →





# Discussion → experiment n°2

One child (the "**instructor**") gives instructions to another child (the "**pilot**") as follow: "*right*", "*left*", "*forward*", "*backward*", "*stop*";

The "pilot" must guide the hybrid robot called Cozmo(c) through a route on the floor

The two children are placed back-to-back;

Neither child should turn around, so neither child should look at what is happening behind them

The "pilot" of the robot was asked to use the specific tool provided with the robot

In the same way, the "instructor" does not look behind him/her.



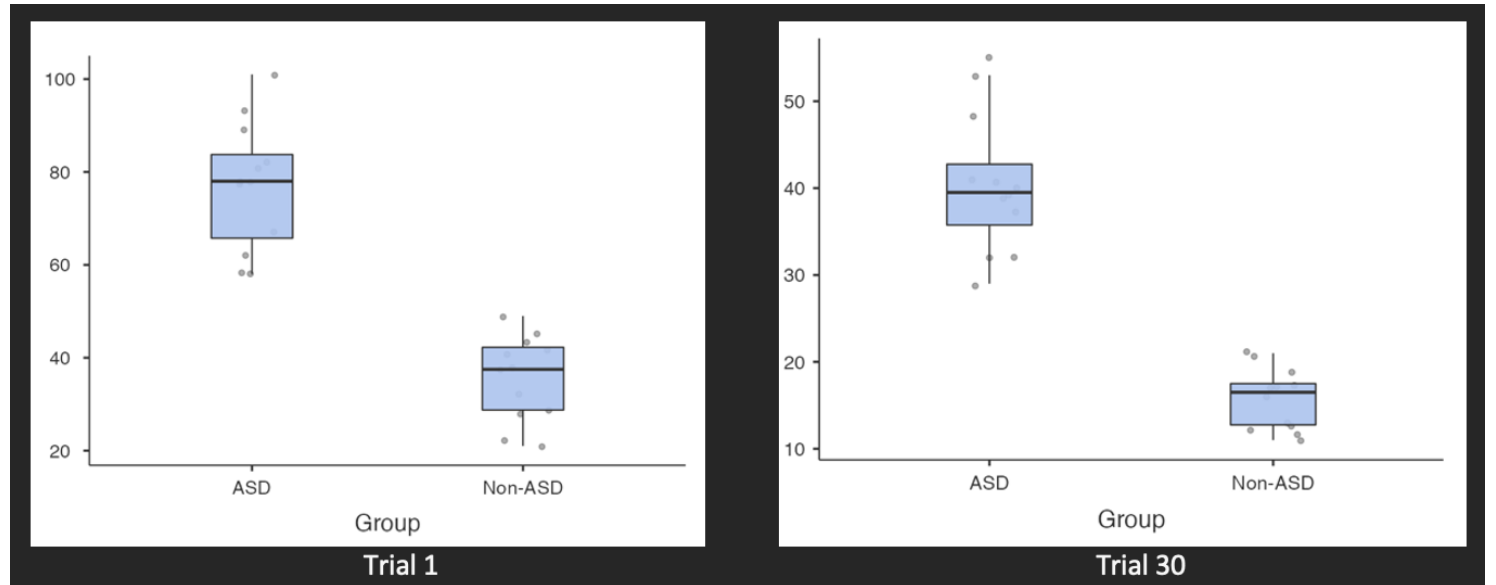
# Discussion → experiment n°2

From the first trial to the last trial (10 weeks later):

**time spent** to perform the cooperative task decreases significantly

- for the Non-ASD group (respectively: 35.6 and 15.8,  $p < .001$ )
- and for the ASD group (respectively: 77 and 40.5,  $p = 0.02$ )

→ All children (with or without ASD) become **more efficient** to perform the cooperative task with Cozmo(c) over time



# Discussion → experiment n°2

From the first trial to the last trial (10 weeks later):

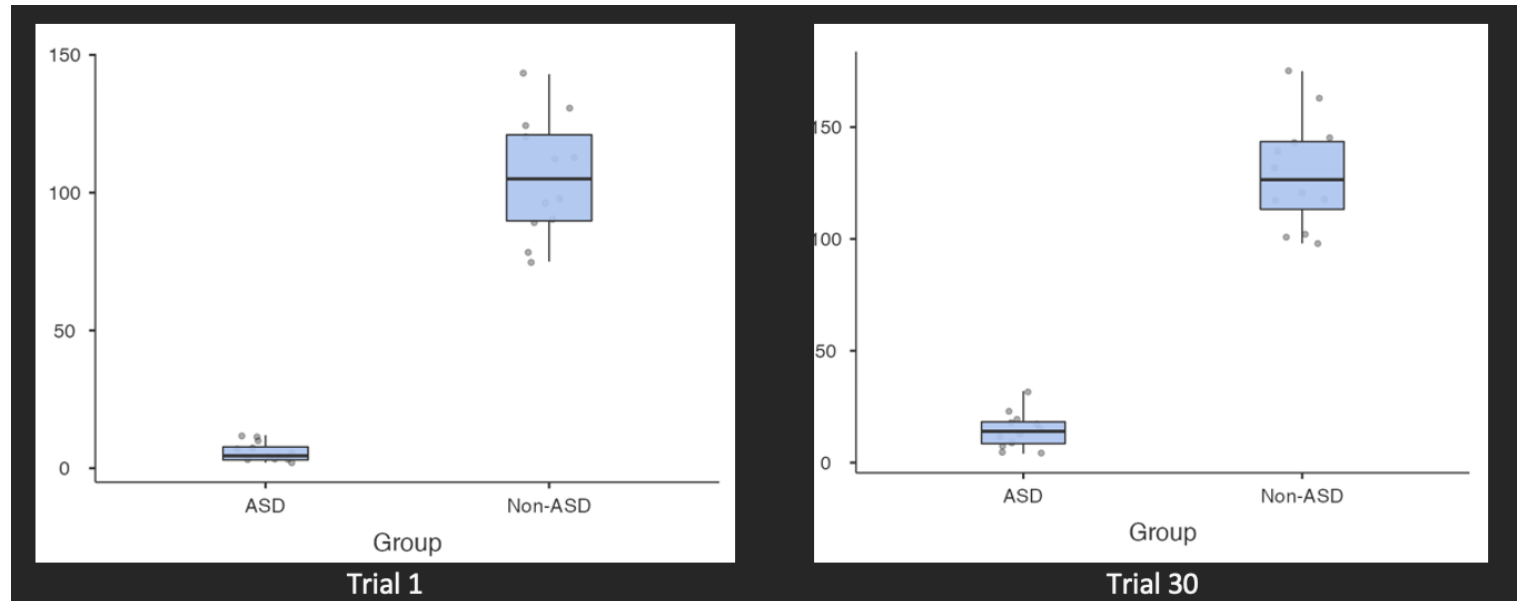
the **number of turn-taking** increases significantly

- for the Non-ASD group (respectively: 106 and 130,  $p < .001$ )
- and for the ASD group (respectively: 4.5 and 14.5,  $p = .001$ ).

→ all children (with or without ASD) **interact more often** during the cooperative task to accomplish this task



Turn-taking **occurs in a conversation when one person listens while the other person speaks**. As a conversation progresses, the listener and speaker roles are exchanged back and forth (a circle of discussion)





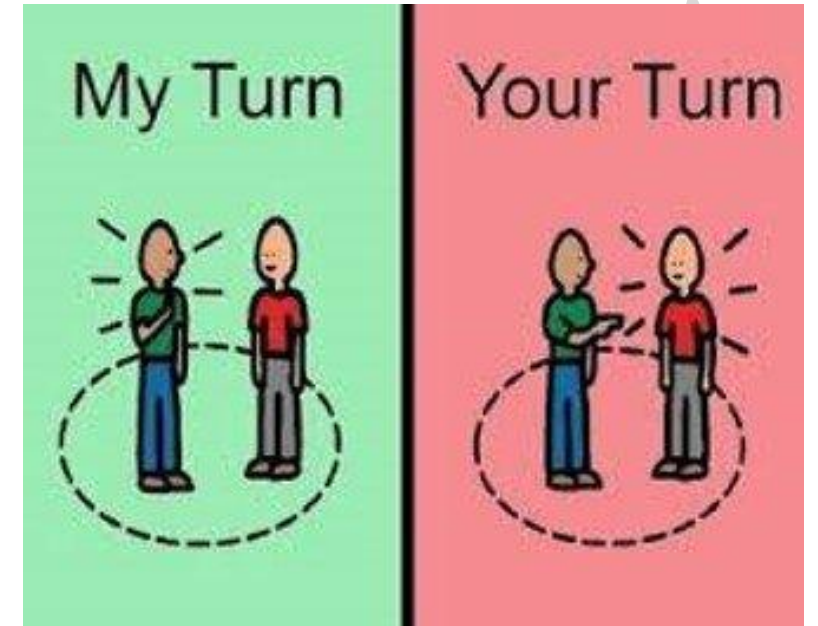
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→ all children (with or without ASD) **interact more often** during the cooperative task to accomplish this task



**+ additional correlation**

→ the number of turn-taking and time spent to perform the task are negatively and significantly related (first trial:  $r = -0.841$ ,  $p = .001$ ; last trial 10 weeks later:  $r = -0.838$ ,  $p < .001$ ). → the more children (with or without ASD) interact, the more efficient they are.



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***Thank you for your  
attention ...***

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