"Implicit learning prevails over explicit learning during prediction of possible outcomes under perceptual uncertainty"

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Implicit learning vs. Explicit learning
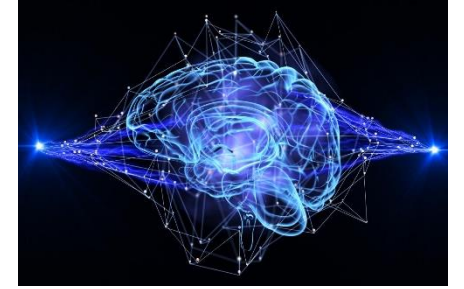
Implicit learning includes the ability to:

- **learn** also **without awareness** (*Reber, 1989*; *Kaufman et al., 2010*)
- **extract the statistical regularities** occurring among sensorial events (*Saffran et al., 1996; Schapiro & Turk-Browne, 2015*)
- leverage previous **experience** (*Liebermann, 2000*) to manage the sensorial world

Stable, long-term

Explicit learning concerns:

- monitoring one's performance allowing a prompt updating in reaction to **feedback** (*Ullsperger et al., 2020*)

Flexible, short-term

Everyday life and implicit learning

During social interactions, we try to guess the action intentions of our peers on the basis of **kinematics** (*Killner et al., 2007*) and **contextual cues** (*Kilner, 2011*)

Both sources of information are provided by **previous experience of the sensory world**, but context plays a major role in case of ambiguous kinematics information (*Amoruso & Urgesi, 2016*)

Kinematics vs. Contextual information

Although changes in kinematics are quite enough to understand action intention (*Cavallo et al., 2018*), **contextual information** might drive the prediction of future events, **in situations of perceptual uncertainty** (*Amoruso et al., 2019;Bianco et al., 2020; Betti et al., 2021*)

Action prediction performance is improved when actions are embedded in congruent/high-probability contexts and hampered in incongruent/low-probability contexts as a result o**f implicit learning mechanisms**

Amoruso & Urgesi, 2016
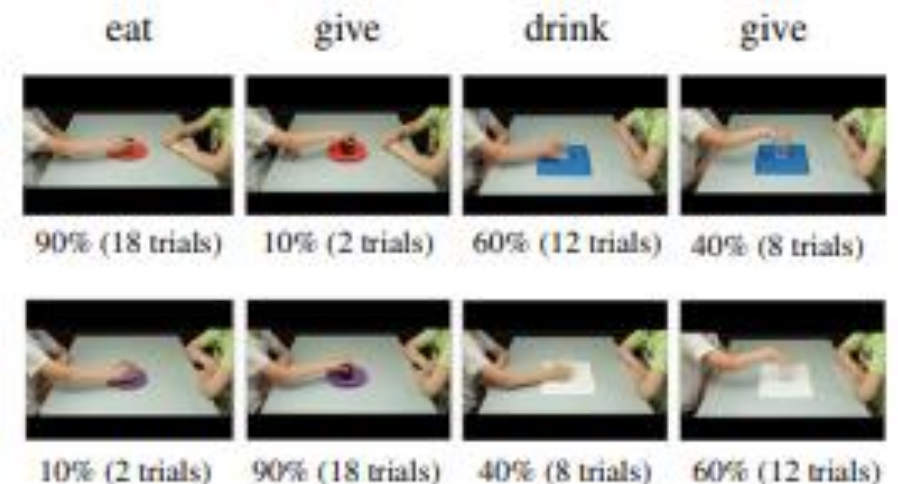
Amoruso et al., 2019

Study 1

Given that, in situations of perceptual ambiguity, <u>implicitly learnt contextual associations affect performance</u> we aimed to understand if this can be influenced **by explicit performance feedback**

The feedback could:

- <u>reinforce contextual information</u> independently from the sensorial information (contextual feedback)
- <u>reinforce sensorial information</u> independently from the contextual information (sensorial feedback)

Hypotheses on prediction performance:

1) <u>contextual feedback</u> should ***exacerbate the difference*** between high-probability and low-probability scenarios

2) <u>sensorial feedback</u> should improve low-probability and ***cancel out the difference*** with high-probability scenarios
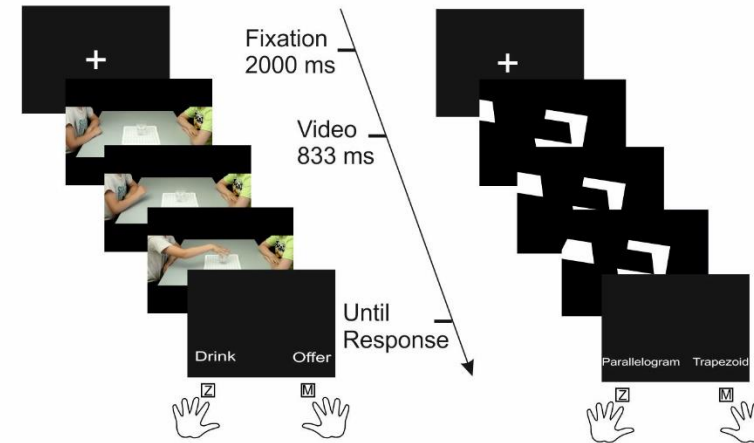
Tasks and design

42 Ss ,24 F, 21.9±3.6 years

Results

Discussion

The **contextual feedback exacerbated the effects of the contextual facilitation**

→ **Top-down expectations** (predictive coding, *Friston, 2010*) generated by context deeply affect the prediction of social and non-social events
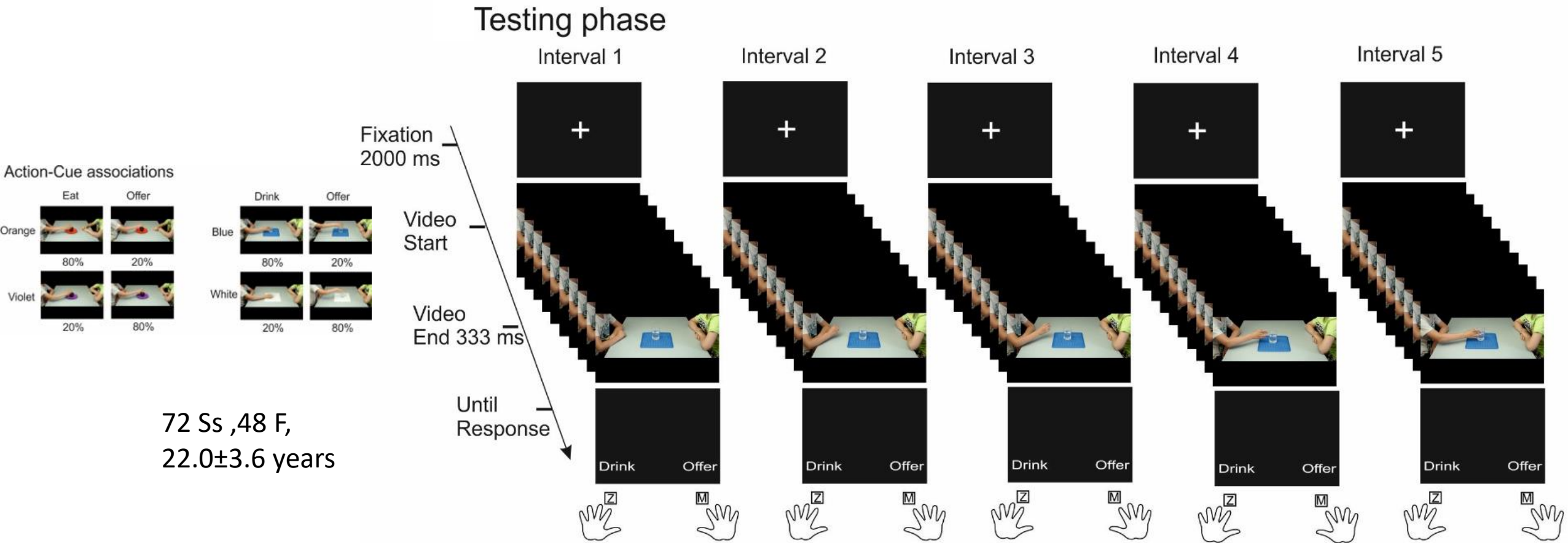
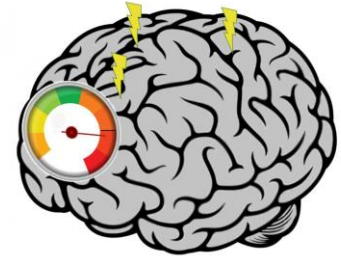**The sensorial feedback did not suppress the contextual prior effect**

→ **It is difficul to ignore contextual information** (*Amoruso et al., 2016, 2018, 2019;Iacoboni et al., 2005; Wurm & Schubotz, 2017*)

Study 2

We aimed at understanding if contextual priors are only used in case of *uncertain kinematics* or also in case of *fully available kinematics*

72 Ss ,48 F,
22.0±3.6 years

Context and Autistic traits

It has been shown that *contextual learning is impaired in ASD* (*Pellicano and Burr, 2012*) and **the presence of subclinical autistic traits would correlate with the lack of benefits associated to contextual exposure** (*Amoruso et al., 2016, 2018b, 2020; Palmer et al., 2015*)

Autistic traits have been measured with the **Autism Quotient** (AQ, *Baron Cohen et al., 2001*) a self-report questionnaire assessing five domains related to ASD deficits (social skills, attention to detail, communication, imagination, attention switching)

Results and discussion

For all time intervals, *selecting the action inferred by the most probable scenario suggested by the color cue was always the preferred option compared to that associated to low-probability priors*

Even in the last time interval, where the kinematics cues clearly unveil the type of action for trials previously associated to low probability scenarios, **participants were not able to ignore the contextual prior**
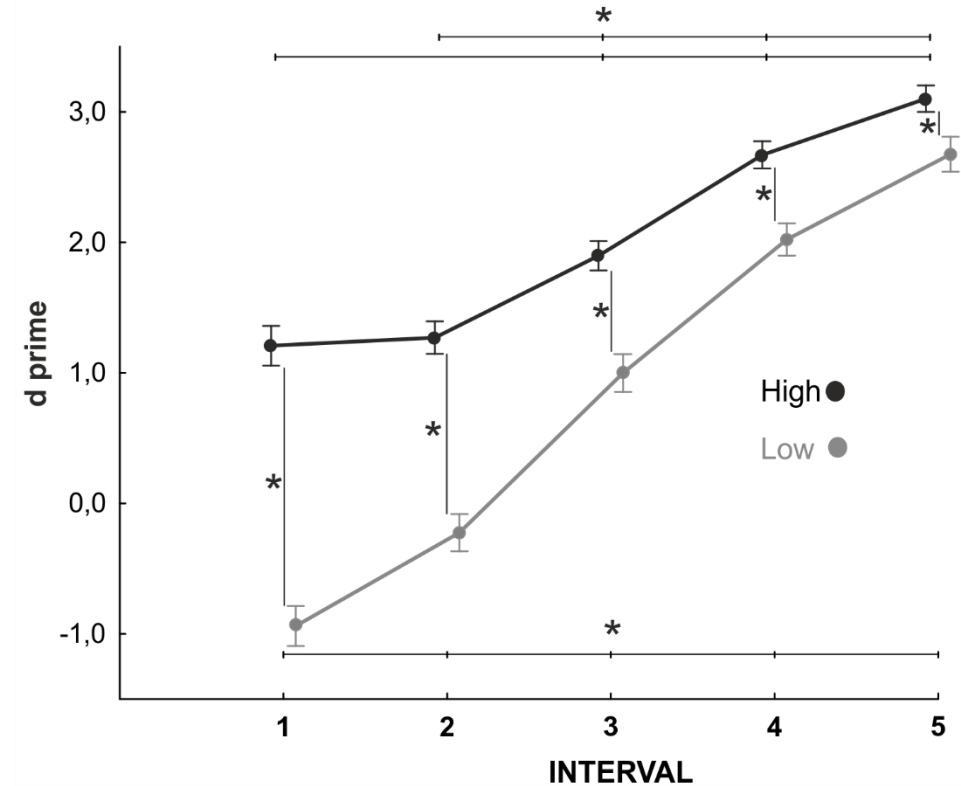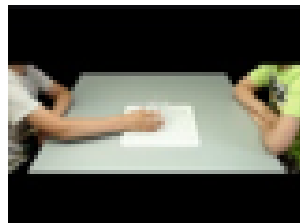
Contextual Facilitation Index Interval 5				
Coefficients	β	t	p-Level	Tolerance
Attention Switching	0,207	1,474	0,145	0,661
Attention to detail	0,248*	2,073	0,042	0,913
Communication	-0,093	-0,648	0,519	0,636
Imagination	-0,141	-1,200	0,234	0,940
Social skills	0,142	1,058	0,293	0,726

Correlation with Attention to Detail (AQ, Autism Quotient, *Baron-Cohen 2001*)

General discussion

- **Kinematics and Contextual information are** always **integrated at all stages of the unfolding of a motor act**, independently from the ambiguity of kinematics cues

- Contextual information biased action prediction even *in case of fully visible kinematics*

- **Explicit feedback on kinematics** (sensorial) information **does not cancel out contextual effects**

- *Tasks manipulating contextual information* can aid to a *better understanding of sublinical/clinical ASD*

Upcoming studies will use TMS to test to what extent motor cortex excitability reflects the observed behavioural results

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Thanks for your attention!!