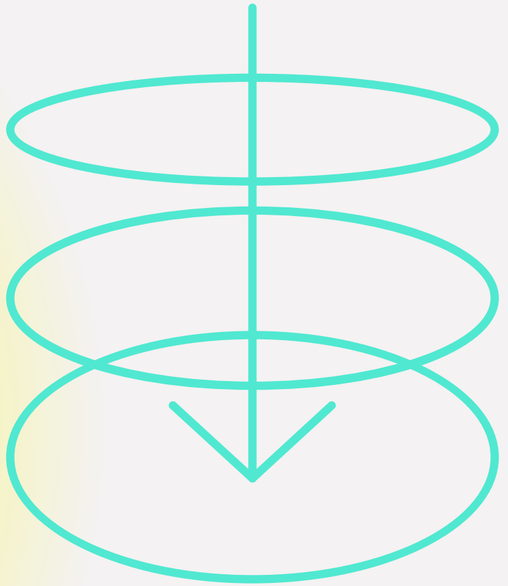
Shifting priors

Changing people's minds about autism

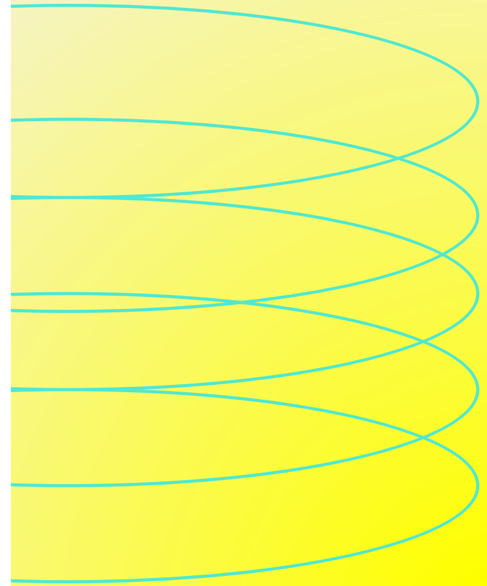


Liz Pellicano
University College London

Autistic sensory differences

> The sensory overload caused by bright lights, fluorescent lights, colours, and patterns makes the body react as if being attacked or bombarded, resulting in such physical symptoms as headaches, anxiety, panic attacks or aggression.

Donna Williams




AHHH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?
!
MELTDOWN
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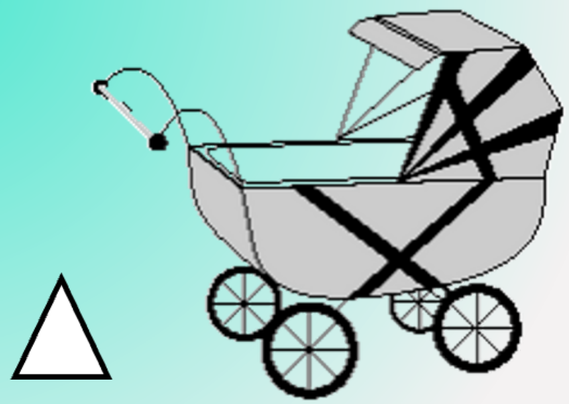
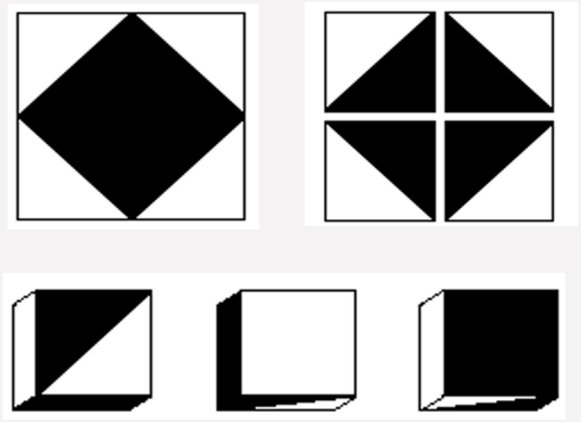
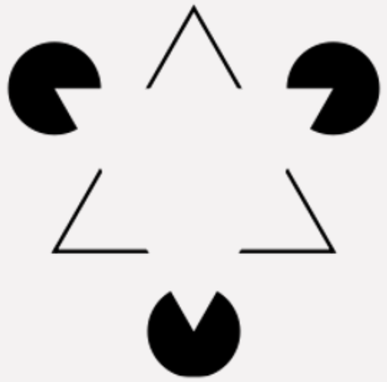






It has long been known that perceptual processing is different in autistic people - to the extent that, on some perceptual task, autistic children and adults perform significantly *better* than non-autistic children and adults

Frith and Happé's 'weak central coherence theory

Mottron's enhanced perceptual functioning account

A new approach to understanding autistic perception

Then-existing accounts focused almost exclusively on hypersensitivity in autistic people

And were unable to explain this apparent paradox:

> It is not the noise or motion itself that is dreaded. The disturbance comes from the noise or motion that intrudes itself … The child himself can happily make as great a noise as any that he dreads and move objects about to his heart’s content
>
> Kanner (1943, p. 245)

Perception as inference

Information entering our senses is inherently ambiguous

To resolve this uncertainty the brain must form perceptual hypotheses – “best guesses” – about the structure of the world (Gregory, 1997; Helmholtz, 1860)

Prior knowledge is considered essential for disambiguating ambiguous sensory evidence to achieve a coherent percept

Perception as Bayesian inference

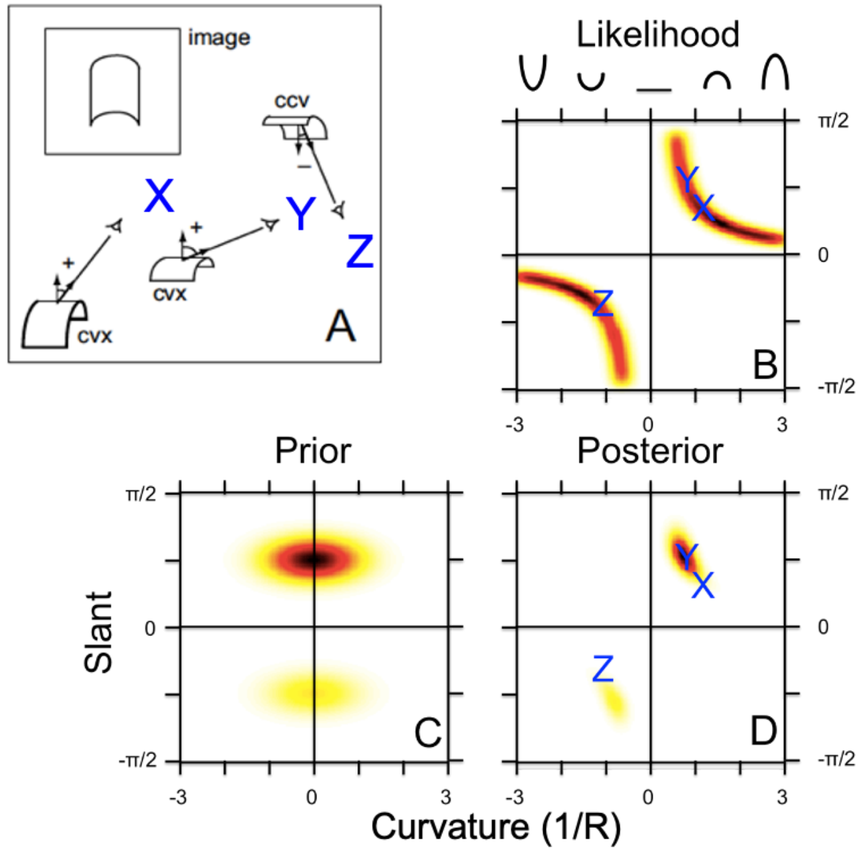
Bayesian theory is a principled method of optimal reasoning under uncertainty

To resolve this uncertainty, we make **predictions** or hypotheses about the state of the world based both on what we observe (the **likelihood** of perceiving an event) and on what we expect to observe (the **prior probabilities** or bias regarding the cause of an event based on previous experience)

$$\overbrace{P(\text{state}|\text{sensory input})}^{\text{Posterior}} = \frac{\overbrace{P(\text{sensory input}|\text{state})}^{\text{Likelihood}}\overbrace{P(\text{state})}^{\text{Prior}}}{P(\text{sensory input})}$$

A Bayesian approach

The computational principles of a Bayesian framework offered a way forward in trying to identify the mechanisms underpinning altered sensation and perception in autistic people

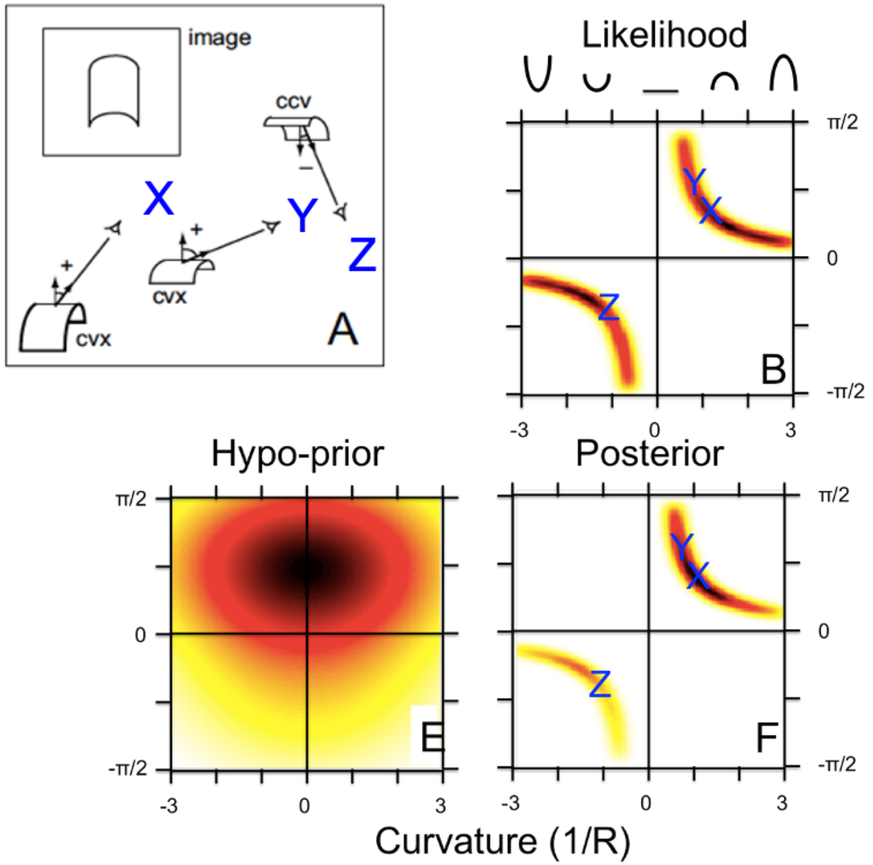


the natural statistics of the world makes the single triangle more probable

In this way, illusions are not perceptual errors or “sloppy computations”, but are a consequence of statistically optimal computations that are functionally beneficial in the real world (Weiss et al., 2002)

A Bayesian approach

We proposed that altered autistic perception results from fundamental atypicalities at the level of priors - either during the construction of the prior or in combining effectively with sensory information -- ultimately yielding unusually attenuated priors



What could it help to explain?

Attenuated priors could:

-- Sometimes result in more ‘accurate’ or veridical perception

-- Impede performance in situations where priors help resolve ambiguity

-- Explain difficulties in generalization

> I began to fear all those unknown paths, clothes, shoes, chairs and strange human voices. Each one challenged me by putting me in front of a new situation for me to face and understand (Mukchopadhyay, 2008)

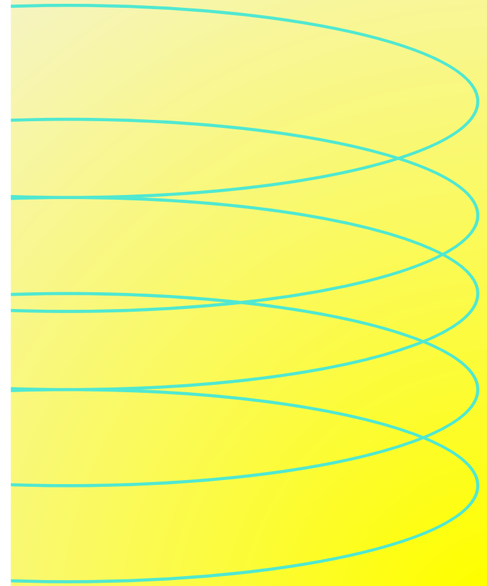
What about autistic sensory differences?

Attenuated priors could also explain:

-- enhanced sensations

-- sensory overload

-- and some of the so-called non-social features, including “insistence on sameness” and autistic people’s “stimming” behaviours



Opinion

Cell PRESS

When the world becomes 'too real': a Bayesian explanation of autistic perception

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Perceptual experience is influenced both by incoming sensory information and prior knowledge about the world, a concept recently formalised within Bayesian decision theory. We propose that Bayesian models can be applied to autism – a neurodevelopmental condition with atypicalities in sensation and perception – to pinpoint fundamental differences in perceptual mechanisms. We suggest specifically that attenuated Bayesian priors – 'hypo-priors' – may be responsible for the unique perceptual experience of autistic people, leading to a tendency to perceive the world more accurately rather than modulated by prior experience. In this account, we consider how hypo-priors might explain key features of autism – the broad range of sensory and other non-social atypicalities – in addition to the phenomenological differences in autistic perception.

sensory overload caused by bright lights, fluorescent lights, colours, and patterns makes the body react as if being attacked or bombarded, resulting in such physical symptoms as headaches, anxiety, panic attacks or aggression' ([3], p. 43).

There has been renewed research interest in these sensory symptoms, prompted in part by the possibility that the non-social symptoms of autism might be attributable to fundamental differences in sensation and perception [4–9]. In this article, we propose a new account of the sensory and other non-social symptoms of autism, which we believe provides a parsimonious explanation for such atypicalities. We argue that people with autism see the world more accurately – as it really is – as a consequence of being less biased by prior experiences.

We start with the suggestion that it is not sensory

Letter

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On hyperpriors and hypopriors: comment on Pellicano and Burr

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frontiers in PSYCHOLOGY

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A predictive coding perspective on autism spectrum disorders

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i-Comment

Weak priors versus overfitting of predictions in autism: Reply to Pellicano and Burr (*TICS*, 2012)

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REVIEW ARTICLE

Prediction in Autism Spectrum Disorder: A Systematic Review of Empirical Evidence

Jonathan Cannon, Amanda M. O'Brien, Lindsay Bungert, and Pawan Sinha

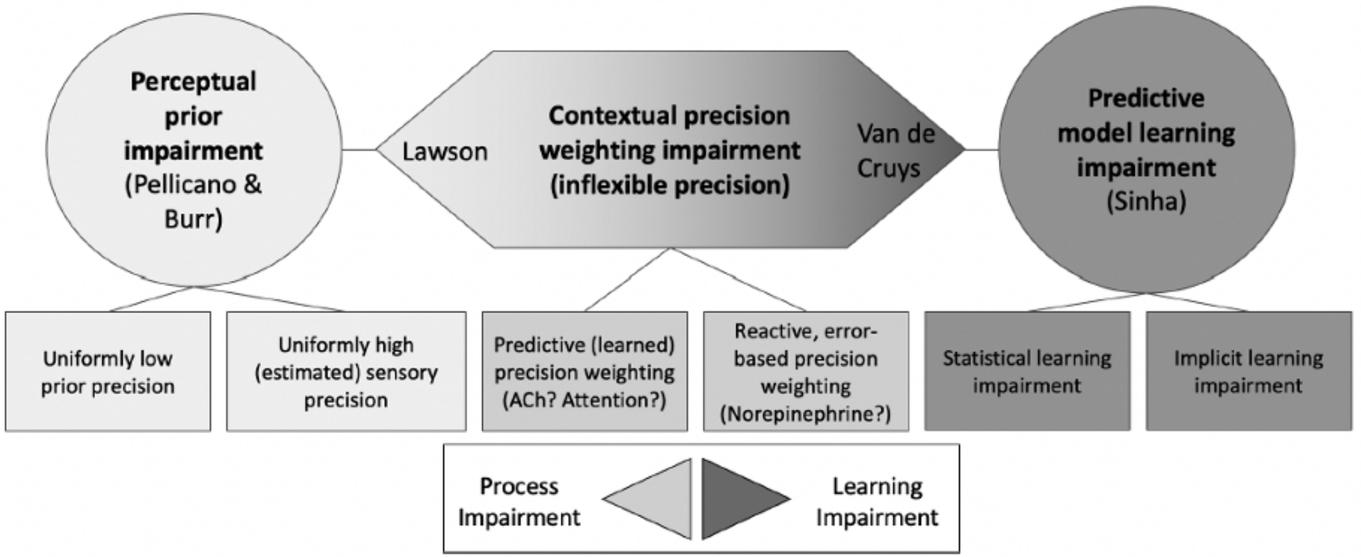
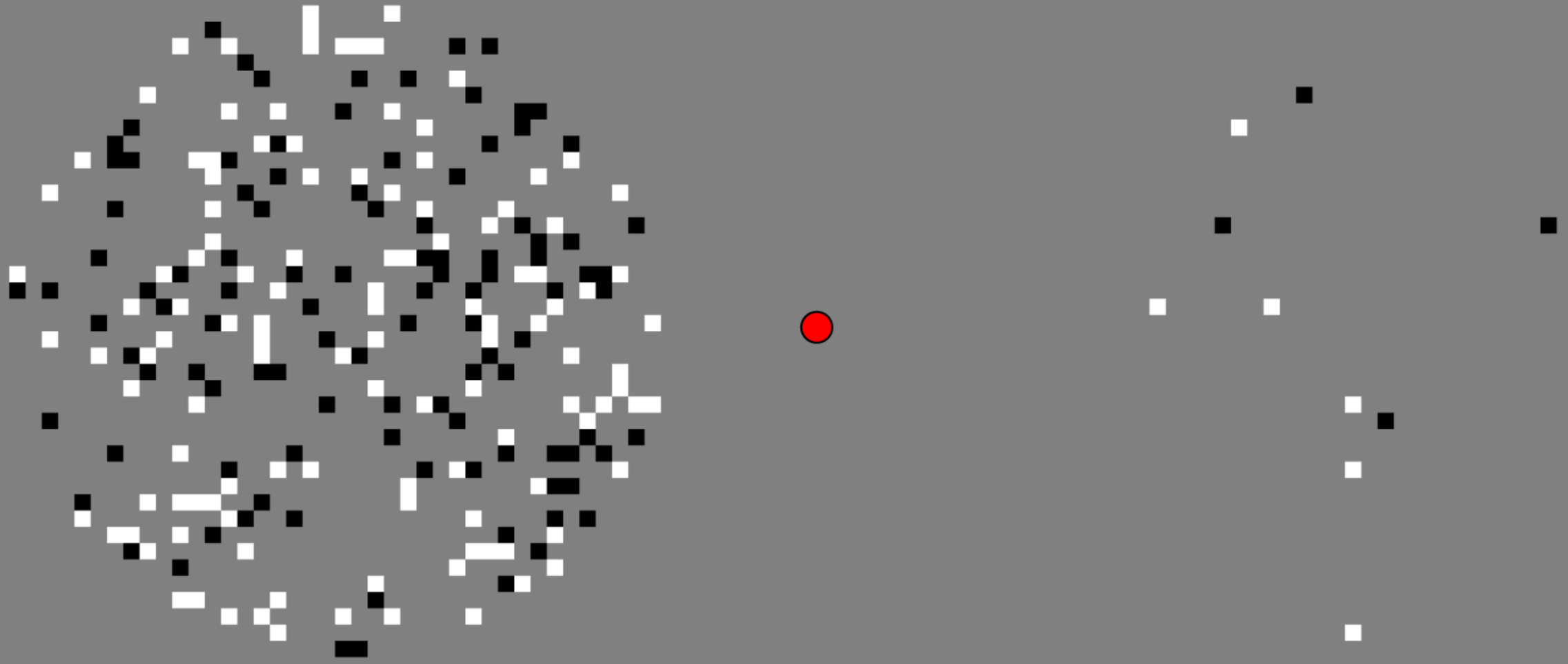


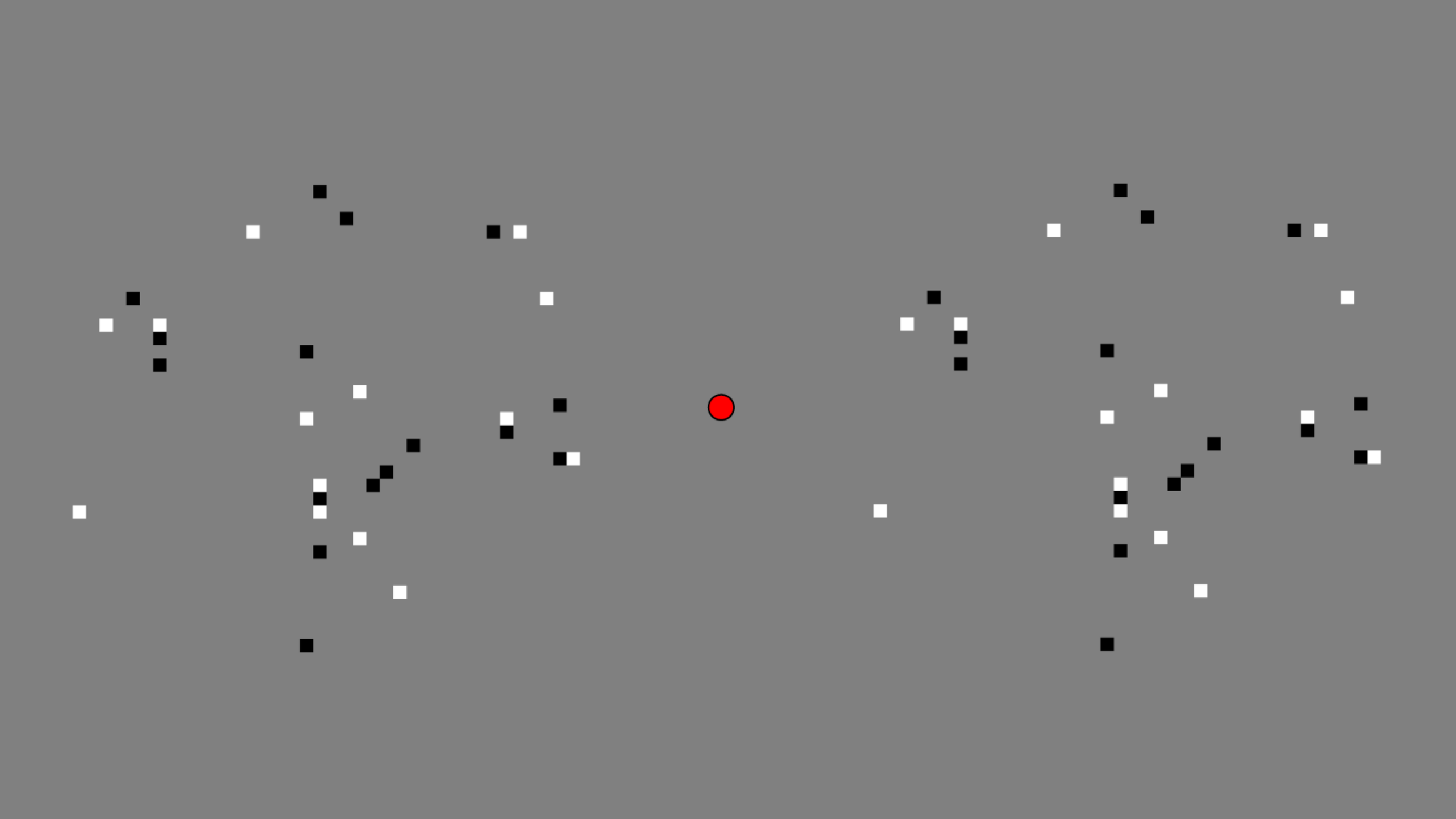
Figure 3. Visualization of the prominent theories of prediction in ASD.

What have we learned?

On priors: Seven studies have examined whether priors biased responses towards expected outcomes – all but one of these studies found that autistic people's responses were less influenced by priors than those of neurotypical people

On perceptual adaptation: much work, including our own [e.g., Pellicano et al., 2007, *Curr. Biol.;* Turi et al., 2015, *PNAS*; Turi et al., 2016, *Sci. Rep.*], has shown that autistic people show reduced adaptation compared to non-autistic people



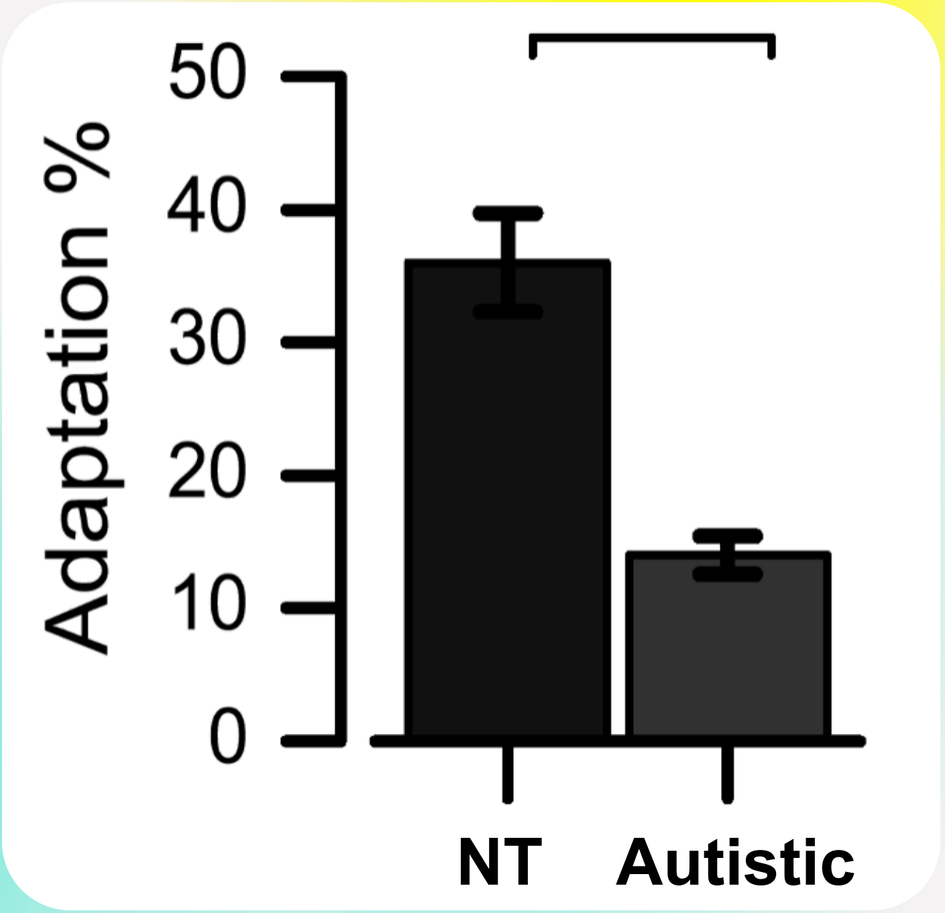


Seeing the world ‘as it really is’

Autistic children showed much weaker number adaptation than typical children, with the size of their aftereffects only one-third of those of neurotypical children

> Critically, in this study, number perception of autistic children postadaptation was more accurate, in that the target patch of dots corresponded better to physical reality than to expectations

Turi et al., 2015, *PNAS*



What have we learned?

On the role of attention: several studies have found that top-down attention might play a heightened role in precision modulation in autistic people

On predictive learning: this is a bit mixed! One study has found learning differences in differential modulation of learning rate in conditions of rapidly changing associations (“volatility”). But another study - one of our own [Manning et al., 2016, *Dev. Sci.*] - found no such differences

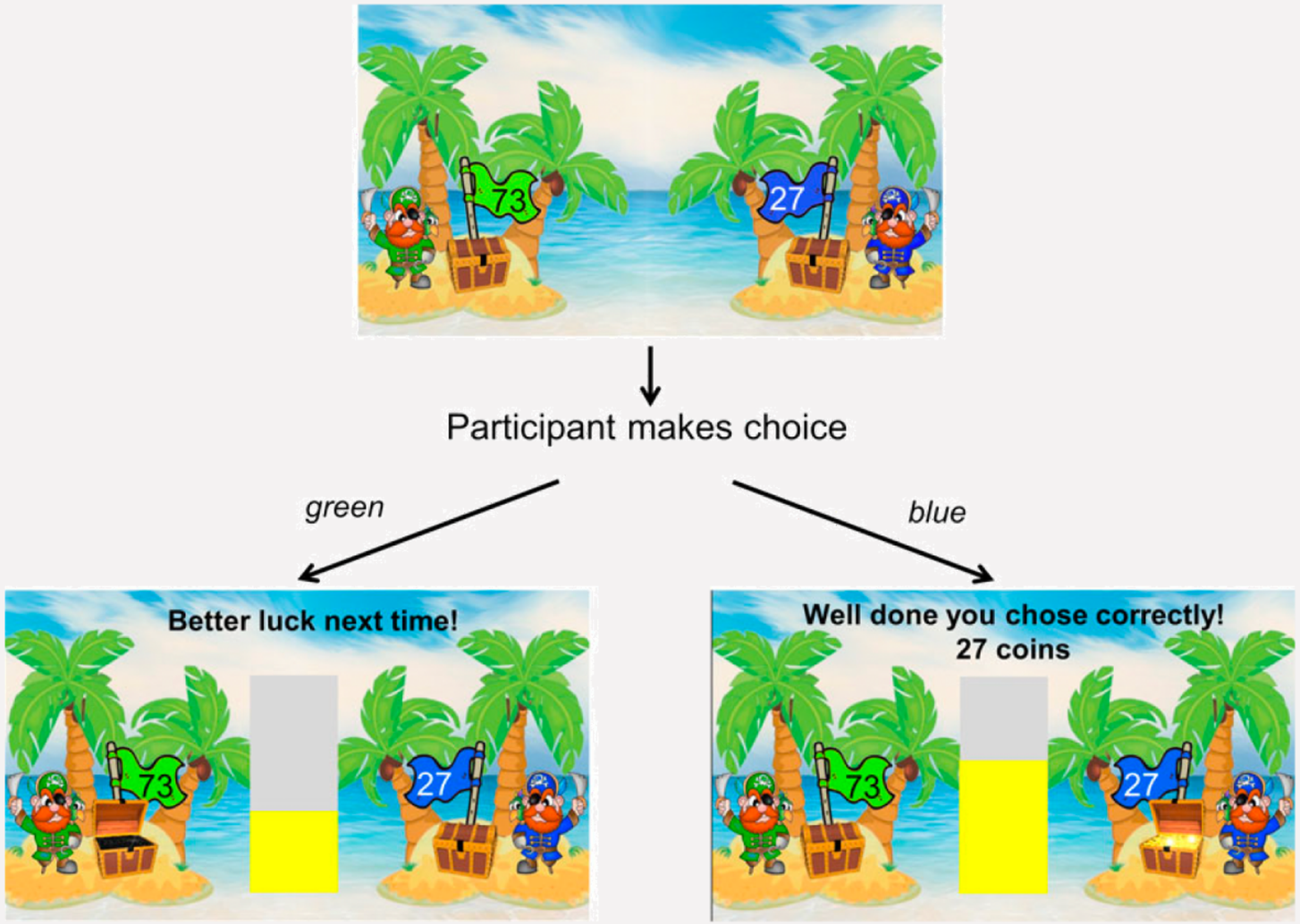
Can autistic children update their behaviour in response to the statistics of the reward environment?

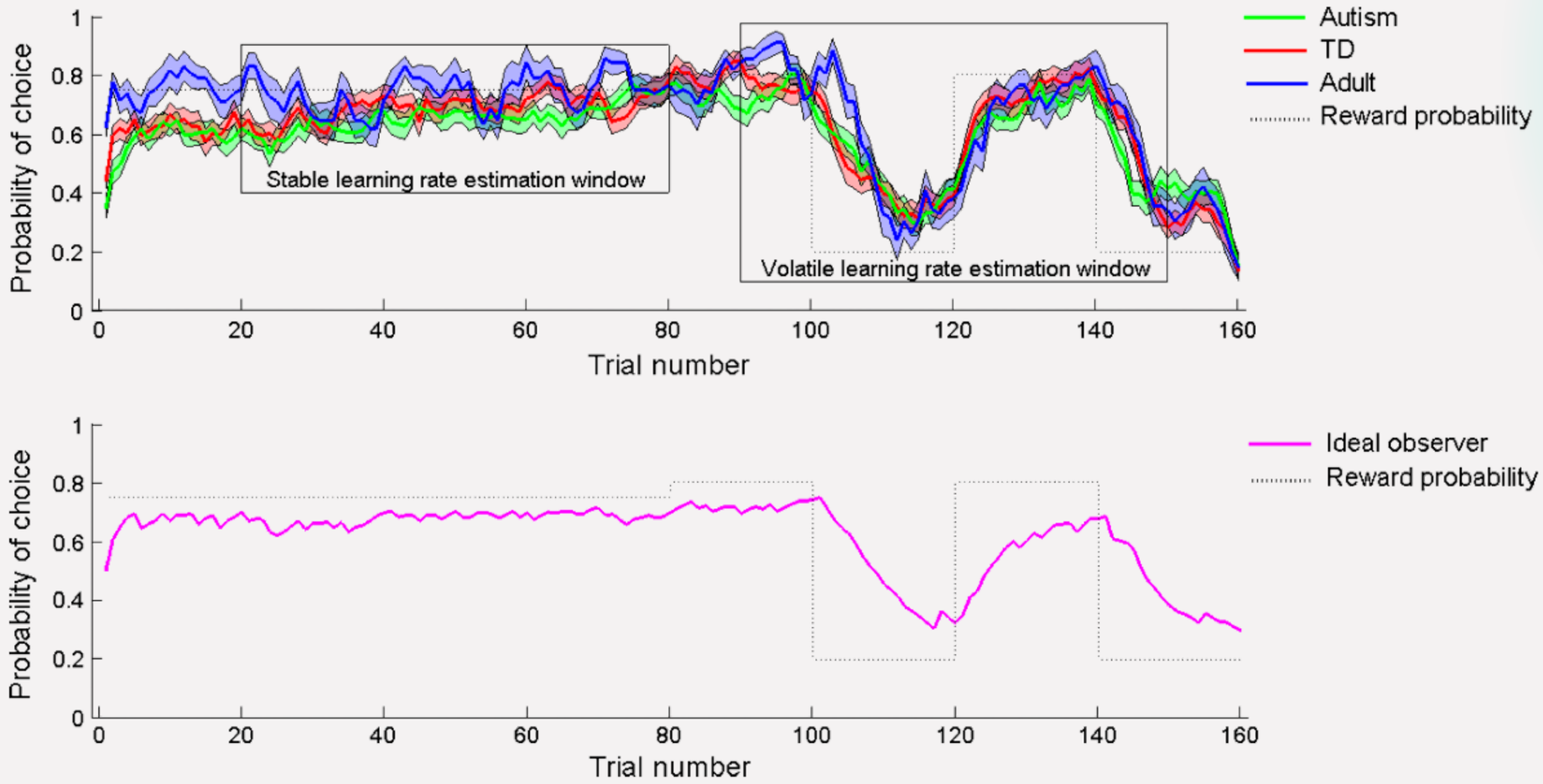
We administered a child-friendly associative learning task, based on Behrens et al. (2007)

Children had to choose the green or blue pirate chest on each trial, and win as much treasure as they could by working out in which chest the treasure would be

In the first 80 trials, the reward structure was stable. In the second 80 trials, it was volatile, alternating every 20 trials

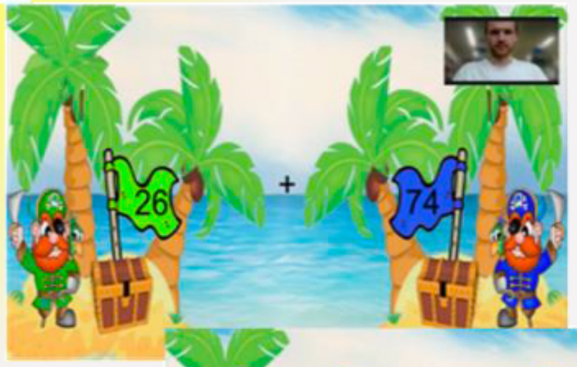
Can autistic children update their behaviour in response to the statistics of the reward environment?



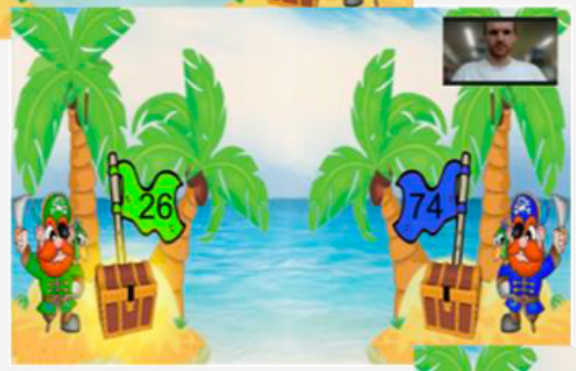


All groups increased their learning rate in the volatile compared with the stable condition. But autistic children used information about the statistics of the reward environment to guide their decisions to a similar extent as neurotypical children and adults [Manning et al., 2016, *Dev. Sci.*]

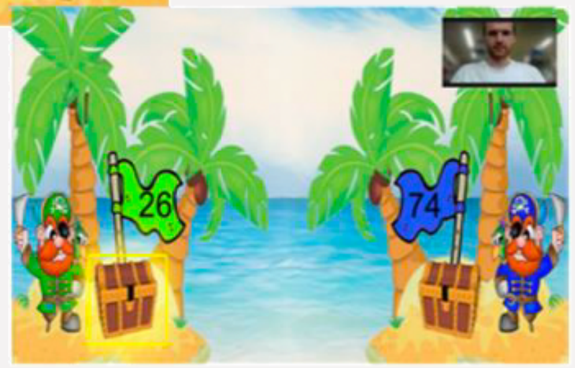
Do autistic adults adapt their learning differently to social and non-social information under varying conditions of uncertainty?



Initial cue (1000ms)

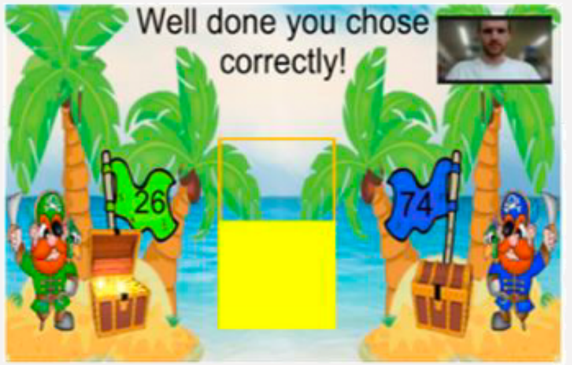


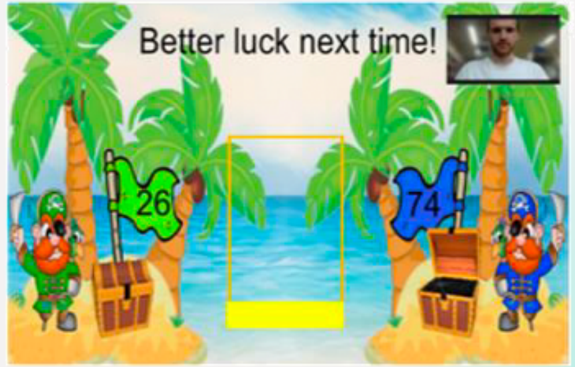
Hint "glow" begins on one chest and participants are free to choose (max 6000ms)



Choice is framed (1000ms)

Feedback (2000ms)



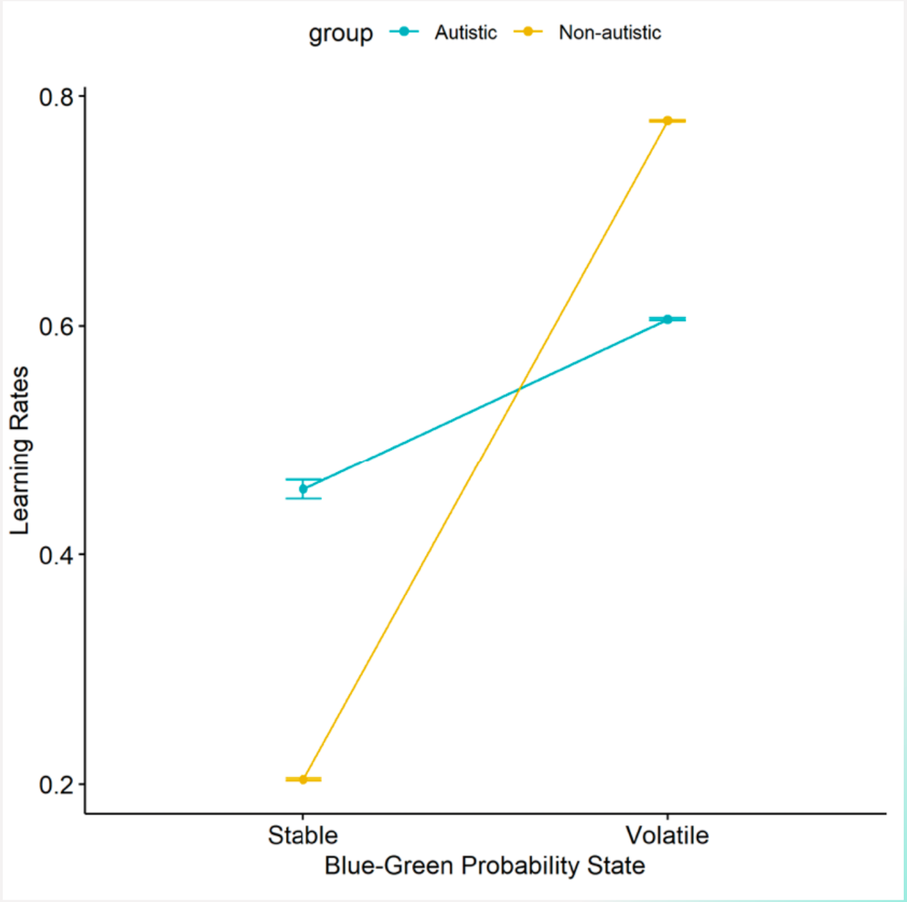


Do autistic adults adapt their learning differently to social and non-social information under varying conditions of uncertainty?

Our preliminary analysis suggests that it is complicated.

Autistic adults had higher learning rates of reward outcome information than non-autistic adults for the stable phase. But they didn't increase their learning rates during the volatile phase like non-autistic adults.

Importantly, we did **not** see this pattern for learning rates of social information



A new agenda for autism science

How might the use of social priors within social contexts shape autistic people's social challenges?

How do attenuated priors/altered predictive processing develop in autistic people over the life course?

How might atypical priors/altered predictive processing of the kind we suggested map onto the everyday experiences of autistic people?

Thanks

All of my many brilliant collaborators – Autistic and non-autistic – for their wonderful insights and all of the wonderful Autistic children, young people, adults, their families and those who support them, who have so generously taken part in our research

Australian Government
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Seeing the world...

...differently