



### **AUTISM in CONTEXT**

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## Are sensory issues in autism actually sensory?

### The predictive mind, context and sensory issues in autism

### **DSM-5** criteria for autism spectrum disorders

#### An individual must meet criteria A, B, C and D:

A. Persistent deficits in social communication and social interaction across contexts, not accounted for by general developmental delays, and manifest by all 3 of the following:

- Deficits in social-emotional reciprocity; ranging from abnormal social approach and failure of normal back and forth conversation through reduced sharing of interests, emotions, and affect and response to total lack of initiation of social interaction.
- Deficits in nonverbal communicative behaviors used for social interaction; ranging from poorly integrated- verbal and nonverbal communication, through abnormalities in eye contact and body-language, or deficits in understanding and use of nonverbal communication, to total lack of facial expression or gestures.
- 3. Deficits in developing and maintaining relationships, appropriate to developmental level (beyond those with caregivers); ranging from difficulties adjusting behavior to suit different social contexts through difficulties in sharing imaginative play and in making friends to an apparent absence of interest in people

### B. Restricted, repetitive patterns of behavior, interests, or activities as manifested by at least two of the following:

- Stereotyped or repetitive speech, motor movements, or use of objects; (such as simple motor stereotypies, echolalia, repetitive use of objects, or idiosyncratic phrases).
- Excessive adherence to routines, ritualized patterns of verbal or nonverbal behavior, or excessive resistance to change; (such as motoric rituals, insistence on same route or food, repetitive questioning or extreme distress at small changes).
- Highly restricted, fixated interests that are abnormal in intensity or focus; (such as strong attachment to or preoccupation with unusual objects, excessively circumscribed or perseverative interests).
- Hyper-or hypo-reactivity to sensory input or unusual interest in sensory aspects of environment; (such as apparent indifference to pain/heat/cold, adverse response to specific sounds or textures, excessive smelling or touching of objects, fascination with lights or spinning objects).

C. Symptoms must be present in early childhood (but may not become fully manifest until social demands exceed limited capacities)

D. Symptoms together limit and impair everyday functioning





J Autism Dev Disord (2009) 39:1–11 DOI 10.1007/s10803-008-0593-3

ORIGINAL PAPER

### A Meta-Analysis of Sensory Modulation Symptoms in Individuals with Autism Spectrum Disorders



Matthew Bennett · Amanda A. Webster Emma Goodall · Susannah Rowland

## Life on the Autism Spectrum

Translating Myths and Misconceptions into Positive Futures

### Sensory issues



🖄 Springer

## Hyporeactivity probably more autism specific

- Decreased responsivity to pain (Moore, 2014)
- Reduced detection of temperature (Duerden a.o., 2015)
- Reduced odor detection (Dudova a.o., 2011; Muratori a.o., 2017)
- Poorer identification of flavours (Bennetto a.o., 2007)

## Important difference!

### Hypersensitivity:

- Physiological response
- Sensory threshold

## Hyperreactivity:

 Psycho-emotional / behavioural response

### The Limbic System



The Sensory System



# No unambiguous, clear indications for difference in sensory thresholds in autism





**Original Article** 

Differentiating between sensory sensitivity and sensory reactivity in relation to restricted interests and repetitive behaviours Autism 1–14 © The Author(s) 2019 Article reuse guidelines: sagepub.com/journals-permissions DOI: 10.1177/1362361319850402 journals.sagepub.com/home/aut **SAGE** 

#### Samantha E Schulz and Ryan A Stevenson

#### Abstract

Recent studies have suggested that individuals who exhibit heightened sensitivity also exhibit higher rates and severity of restricted interests and repetitive behaviours. This line of research has been conducted almost exclusively through caregiver reports of sensitivity. Here, a more rigorous psychophysics paradigm was applied to assess sensory sensitivity and relate hypersensitivity to restricted interests and repetitive behaviours. In addition, commonly used questionnaire measures of sensory sensitivity were collected to determine if self-reported measures accurately reflect behavioural measures of sensory sensitivity. In all, 90 typically developing participants completed a visual detection task, a questionnaire measure of sensory processing and a measure of restricted interests and repetitive behaviours. Visual sensitivity, measured both behaviourally and with questionnaires, is positively related to restricted interests and repetitive behaviours. Surprisingly, visual sensitivity as measured behaviourally and through self-report are unrelated. Furthermore, a regression analysis suggests that while restricted interests and repetitive behaviours can be predicted based on both behavioural and self-reported sensitivity, these two predictors account for different portions of the variance in restricted interests and repetitive behaviours. Thus, while these results provide evidence supporting the contribution of sensory sensitivity to restricted interests and repetitive behaviours, these results also indicate that behavioural and questionnaire measures of sensory sensitivity are measuring two distinct constructs. We hypothesize that behavioural measures are measuring sensory sensitivity, while questionnaires measures are in fact measuring sensory reactivity.

**ORIGINAL PAPER** 



### Stop Making Noise! Auditory Sensitivity in Adults with an Autism Spectrum Disorder Diagnosis: Physiological Habituation and Subjective Detection Thresholds

Marieke W. M. Kuiper<sup>1,2</sup> · Elisabeth W. M. Verhoeven<sup>1</sup> · Hilde M. Geurts<sup>1,2</sup>

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### Abstract

Auditory sensitivities are common among people with autism spectrum disorder diagnoses (ASD). As underlying factors are unknown, we examined whether ASD adults ( $N_{ASD}$ =33;  $N_{Typically Developing}$ =31; 25–45 years; IQ>70): (1) habituated slower to auditory stimuli; (2) had lower auditory detection thresholds; and (3) whether these mechanisms related to self-reported auditory sensitivities. Two auditory stimuli (tone, siren) were repeated, whilst skin conductance responses were recorded to measure habituation. Detection thresholds were measured by stepwise reductions in tone volume. We found no evidence in favor of our hypotheses, but ASD adults did rate the auditory stimuli as more arousing. Based on explorative analyses, we argue that studying the strength of physiological responses to auditory stimuli is needed to understand auditory sensitivities.

### Understanding Sound Sensitivity in Individuals with Autism Spectrum Disorders

### Lillian N. Stiegler and Rebecca Davis

### Abstract

Literature on sound sensitivity in individuals with and without autism spectrum disorders (ASD) is reviewed in this article. Empirical evidence is examined, and physiologic and psychoemotional-behavioral perspectives are described. There is virtually no evidence of true physiological differences in auditory systems of individuals with ASD. It is evident, however, that many people with ASD (a) feel fearful and anxious about sound, and (b) may experience unpleasant physiological sensations because of autonomic and/or behavioral responses to nonpreferred sounds, but (c) can learn to react in less stigmatizing, more effectively self-regulating ways. Current assessment and intervention practices are discussed, and a case is presented. Heightened understanding of this issue among caregivers and interventionists may ultimately improve life participation for individuals with ASD.

HAMMILL INSTITUTE ON DISABILITIES

Focus on Autism and Other Developmental Disabilities 25(2) 67–75 © 2010 Hammill Institute on Disabilities Reprints and permission: sagepub.com/journalsPermissions.nav DOI: 10.1177/1088357610364530 http://focus.sagepub.com

### Auditory Hypersensitivity in Children With Autism Spectrum Disorders

Focus on Autism and Other Developmental Disabilities 28(3) 184–191 © Hammill Institute on Disabilities 2013 Reprints and permissions: sagepub.com/journalsPermissions.nav DOI: 10.1177/1088357613475810 focus.sagepub.com

**SAGE** 

Jay R. Lucker, EdD<sup>1</sup>

### Abstract

A review of records was completed to determine whether children with auditory hypersensitivities have difficulty tolerating loud sounds due to auditory-system factors or some other factors not directly involving the auditory system. Records of 150 children identified as not meeting autism spectrum disorders (ASD) criteria and another 50 meeting that criteria were reviewed. All participants had normal hearing. Tolerance was measured up to 110 dBHL. Findings revealed a smaller-than-expected percentage of children were unable to tolerate loud sounds. The conclusion drawn is that auditory hypersensitivity is not based in the auditory system, but rather is a conditioned response to sounds perceived as aversive or annoying. Treatments for auditory hypersensitivity should not be auditory based but should include desensitization training. Implications for practice are provided.

## Probably even increased perceptual capacity

Research in Developmental Disabilities 85 (2019) 197-204



Contents lists available at ScienceDirect

Research in Developmental Disabilities

journal homepage: www.elsevier.com/locate/redevdis

Implications of capacity in the classroom: Simplifying tasks for autistic children may not be the answer



Research

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ARTICLE INFO

#### ABSTRACT

Number of review	s completed is 2
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Keywords: Autism Attention Perception Learning *Background*: Research has demonstrated evidence for increased perceptual capacity in autism: autistic people can process more information at any given time than neurotypical individuals. The implications of this for educating autistic pupils have not been investigated. For example, this ability to process more information at any given time may explain why autistic children sometimes process more peripheral task-irrelevant information than neurotypical individuals (e.g. in background classroom wall-displays).



## Are sensory issues really sensory?

### CONCLUSIONS

• We found significant reported sensory problems in adults with ASD. This persistence of reported sensory problems in adults suggests that while there is less focus on sensory problems in adults than in children with ASD, the problems may be no less severe.

• We found little evidence however that these problems have a true sensory base. Brain responses to increases in sensory stimulus intensity were typical in ASD as was the neural refractory period (typically reduced neural response to an immediately repeated stimulus).

• The ASD adults did show evidence of increased levels of arousal during continued auditory sensory stimulation, as well as reduced habituation of sensory response to unattended sensory stimuluation over time.

• These findings suggest that in adults with ASD, sensory difficulties that are experienced in daily life may be a function of differences in the modulation of general arousal and the effects of attentional state rather than abnormalities in basic sensory response.

• We are currently investigating these effects in children to determine whether or not there is evidence of an abnormal basic sensory response in children with ASD. Such a finding would indicate that these effects change with behavioral intervention over the course of development.

#### References

Brown, et al. (2001, Jan-Feb). The adult sensory profile: measuring patterns of sensory processing. *Am J Occup Ther.*, 55(1), 75-82. Jung, T.P., et al. (2000). Removing electroencephalographic artifacts by blind source separation. *Psychophysiology*, *37*, 163-178.

### No stronger sensory response, but stronger experience of stimuli

#### **RESEARCH ARTICLE**

Perceptual and Neural Response to Affective Tactile Texture Stimulation in Adults with Autism Spectrum Disorders

Carissa J. Cascio, Estephan J. Moana-Filho, Steve Guest, Mary Beth Nebel, Jonathan Weisner, Grace T. Baranek, and Gregory K. Essick

J Autism Dev Disord (2008) 38:127-137 DOI 10.1007/s10803-007-0370-8

#### Tactile Perception in Adults with Autism: a Multidimensional Psychophysical Study

Carissa Cascio · Francis McGlone · Stephen Folger · Vinay Tannan · Grace Baranek · Kevin A. Pelphrey · Gregory Essick



### Interventions should focus on the limbic system, rather than on the sensory system ...

Our ideas about sensory issues are based on the old computer

metaphor

Sensory Processing and Integration







From the Senses:

- Touch
- Taste
- Smell
- Sight
- Hearing
- Movement
  - Gravity





Attention and Concentration Abstract Thought & Reasoning Organisation and Planning Productivity and Creativity Academic Learning Ability Social Interaction Self-regulation Emotional Expression The brain does *not* process stimuli, only what is different from the stimuli it predicted...

## Why so complicated?

## Bayesian brain:

Working with probabilities is appropriate in situations that are uncertain

The input coming from the senses is unreliable!



# The brain does not receive sensory input, it predicts it and processes the prediction errors

## Predictability plays a major role in sensory issues

REVIEW

**NEUROREPORT** 

### Why can't you tickle yourself?

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### Hyperresponsivity: reduced habituation in autism because of **reduced predictivity** (Turi et al., 2015)



## Children with autism spectrum disorder show reduced adaptation to number

Marco Turi<sup>a,b</sup>, David C. Burr<sup>b,c</sup>, Roberta Igliozzi<sup>d</sup>, David Aagten-Murphy<sup>e</sup>, Filippo Muratori<sup>d,1</sup>, and Elizabeth Pellicano<sup>c,g,1</sup>

"A key determinant of habituation is stimulus predictability. ... **a lack of predictability** would compromise habituation and lead to hypersensitivity." (Sinha et al., 2014)



### Autism as a disorder of prediction

Pawan Sinha<sup>a,1</sup>, Margaret M. Kjelgaard<sup>a,b</sup>, Tapan K. Gandhi<sup>a,c</sup>, Kleovoulos Tsourides<sup>a</sup>, Annie L. Cardinaux<sup>a</sup>, Dimitrios Pantazis<sup>a</sup>, Sidney P. Diamond<sup>a</sup>, and Richard M. Held<sup>a,1</sup>

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### Precise Minds in Uncertain Worlds: Predictive Coding in Autism

Sander Van de Cruys, Kris Evers, Ruth Van der Hallen, Lien Van Eylen, Bart Boets, Lee de-Wit, and Johan Wagemans KU Leuven

#### PREDICTIVE CODING IN AUTISM

(e.g., under the form of enhanced discomfort to bright light; Kern et al., 2001). When the gain of the neural units representing the prediction errors is fixed at a high level, it is easy to see that hypersensitivity becomes very likely, especially for unexpected input, as is the case in ASD. Overweighting of irrelevant prediction errors causes sensory overload.

Seeing that unpredictability is at the core of the sensory overload, we can also attempt to explain its negative affective impact. Uncertainty has long been identified as a factor that intensifies stress and anxiety (Herry et al., 2007; Miller, 1981). In addition to leading to increased stress and anxiety, persistent significant prediction errors may actually by themselves generate negative affect (Huron, 2006; Van de Cruys & Wagemans, 2011). When prediction theories (Chevallier et al., 2012) that this is an important aggravating factor in the syndrome. Indeed, social interactions are not perceived to be that enjoyable or rewarding in individuals with ASD (Chevallier et al., 2012). Unsurprisingly, a lot of interventions focus on increasing the reward of social interactions. If social situations are avoided from early on in life, the number of social learning experiences decreases, and so, in a vicious circle, even more social impairments ensue.

Taken together, these factors arguably make individuals with ASD more vulnerable to mood and anxiety problems, which are indeed overrepresented in ASD (Kim, Szatmari, Bryson, Streiner, & Wilson, 2000). Hence, mood problems, anxiety, and anxious avoidance should in our view be considered as secondary symp-

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## Tactile Hypersensitivity and GABA Concentration in the Sensorimotor Cortex of Adults with Autism

Laurie-Anne Sapey-Triomphe<sup>D</sup>, Franck Lamberton, Sandrine Sonié, Jérémie Mattout, and Christina Schmitz

Sensory hypersensitivity is frequently encountered in autism spectrum disorder (ASD). Gamma-aminobutyric acid (GABA) has been hypothesized to play a role in tactile hypersensitivity. The aim of the present study was twofold. First, as a study showed that children with ASD have decreased GABA concentrations in the sensorimotor cortex, we aimed at determining whether the GABA reduction remained in adults with ASD. For this purpose, we used magnetic resonance spectroscopy to measure GABA concentration in the sensorimotor cortex of neurotypical adults (n = 19) and ASD adults (n = 18). Second, we aimed at characterizing correlations between GABA concentration and tactile hypersensitivity in ASD. GABA concentration in the sensorimotor cortex of adults with ASD was lower than in neurotypical adults (decrease by 17%). Interestingly, GABA concentrations were positively correlated with self-reported tactile hypersensitivity in adults with ASD (r = 0.50, P = 0.01), but not in neurotypical adults. In addition, GABA concentrations were negatively correlated with the intra-individual variation during threshold measurement, both in neurotypical adults (r = -0.47, P = 0.04) and in adults with ASD (r = -0.59, P = 0.01). In other words, in both groups, the higher the GABA level, the more precise the tactile sensation. These results highlight the key role of GABA in tactile sensitivity, and suggest that atypical GABA modulation contributes to tactile hypersensitivity in ASD. We discuss the hypothesis that hypersensitivity in ASD could be due to suboptimal predictions about sensations. Autism Research 2019. © 2019 International Society for Autism Research, Wiley Periodicals, Inc.

## Autism, CONTEXT and predictions

COGNITIVE NEUROSCIENCE https://doi.org/10.1080/17588928.2019.1593126

### COMMENTARY

### Sensory sensitivity in autism mostly depends on contextual predictions

Laurie-Anne Sapey-Triomphe, Thiago Leiros Costa and Johan Wagemans

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#### ABSTRACT

A signal detection theory was elaborated in order to account for three types of sensory sensitivity (subjective, behavioral and neural) in neurotypical individuals and in autism. Here, we argue that the predictive coding framework could better account for the atypical pattern of sensory sensitivity in autism. We review the idea that sensory sensitivity should be considered as mostly depending on contextual predictions and that these account for the heterogeneous pattern of neural responses.

#### **ARTICLE HISTORY**

Received 8 February 2019 Published online 21 March 2019

#### **KEYWORDS**

Autism spectrum disorder; predictive coding; sensory sensitivity; hypersensitivity; predictions; inflexibility



Check for updates

## Sensory issues, **context** and predictions

• Steph Lietz & Francesca Happé





## What defines your sensory reactivity?

**SENSORY INPUT** 

## (UN)CERTAINTY

PREDICTIONS (prior beliefs)



## We cannot avoid prediction errors

That's why the brain uses a **variable precision** of its own predictions

Sometimes, it must be precise Sometimes, good enough is OK

## Autism and the predictive brain

### HIPPEA: High, Inflexible Precision of Prediction Errors in Autism (Van de Cruys e.a., 2013, 2014)

Psychological Review 2014, Vol. 121, No. 4, 649-675 © 2014 American Psychological Association 0033-295X/14/\$12.00 http://dx.doi.org/10.1037/a0037665

Precise Minds in Uncertain Worlds: Predictive Coding in Autism

Sander Van de Cruys, Kris Evers, Ruth Van der Hallen, Lien Van Eylen, Bart Boets, Lee de-Wit, and Johan Wagemans KU Leuven

## Autism and the predictive mind: context!

- In autism, there seems to be a problem with predictions, the precision of input and priors, and the handling of prediction errors.
- There's a deficit in the flexible adjustment of predictions and their precision in function of context

## Hypothesis Palmer, Lawson, Hohwy (2017)

### **Psychological Bulletin**

### Bayesian Approaches to Autism: Towards Volatility, Action, and Behavior

Colin J. Palmer, Rebecca P. Lawson, and Jakob Hohwy Online First Publication, March 23, 2017. http://dx.doi.org/10.1037/bul0000097

The autistic brain *treats* sensory information as being more informative (relative to prior information) when estimating the state of the environment. The relative weight you give to the sensory input and predictions depends **on the context** 



How much weight you give to a prediction error depends on the certainty about your model of the world and the predictions based on that model (Lawson, Mathys & Rees, 2017)

## Precision determines the filter in our brain

sensory input



prediction (prior beliefs)



## Sensory or anxiety and uncertainty?



## Uncertainty drives anxiety, sensory issues in autism

BY ANN GRISWOLD / 8 APRIL 2016

https://www.spectrumnews.org

NEWS

## Sensory overload in autism may stem from hypervigilant brain

BY NICHOLETTE ZELIADT

29 JULY 2019

J Autism Dev Disord (2016) 46:1962-1973 DOI 10.1007/s10803-016-2721-9

ORIGINAL PAPER

The Relationship Between Intolerance of Uncertainty, Sensory Sensitivities, and Anxiety in Autistic and Typically Developing Children

Louise Neil<sup>1</sup> · Nora Choque Olsson<sup>2</sup> · Elizabeth Pellicano<sup>1,3</sup>



Sensory overload: Children with autism may perceive uncertainty as a threat.

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## Strategies for sensory issues: traditional way



But from **Hyperacusis – Tinnitus** we learned:

- Do not eliminate sounds, but make sounds predictable and controllable :
- Working on 'feedforward' (*prediction*) instead of 'feedback' (*stimulus*)

## We need to 'feed' the brain so it can update its models and reduce the prediction errors

(prediction errors = stress / unpleasant)

## Predictability, not repetition leads to habituation



Fig. 1 — Perceptual expectations paradigm. (a) Examples of fixed stimulus pairings. During a practice task, participants implicitly learned that some stimuli are most likely to repeat, whereas others are most likely to alternate, thus creating expected repetitions (ER) and expected alternations (EA), as well as unexpected repetitions (UR) and unexpected alternations (UA). (b) Stimulus display, here showing an expected repetition (ER) trial. In the behavioural discrimination task, participants responded to the category of the second stimulus (vehicle or animal) during the inter-trial interval (ITI). During the fMRI task, participants responded to occasional targets (17.4% of trials) in which the stimulus was shown at 60% of its normal size.

### Again...context

## **Archival Report**

Biological Psychiatry: CNNI

### Sensory Prediction Errors Are Less Modulated by Global Context in Autism Spectrum Disorder

Judith Goris, Senne Braem, Annabel D. Nijhof, Davide Rigoni, Eliane Deschrijver, Sander Van de Cruys, Jan R. Wiersema, and Marcel Brass

### Mismatch negativity P3b



## Strategies for sensory issues?

## Tackle the prediction errors!



- Predictability in (changes) in sensory environment
- Contextual clarifying of stimuli: **PUSH THE CONTEXT BUTTON**
- Changing the brains model of the world

## Strategies for sensory issues? Tackle the prediction errors!



## Reduce stress by optimistic predictions

The insular cortex does not only respond to pain but to a wide range of aversive events.

"This will be bad" leads to the same predictive information as "this will hurt"

This will be bad  $\rightarrow$  stress  $\neg \rightarrow$  sensory overload

This will be good  $\rightarrow$  stress  $\searrow \rightarrow$  no sensory overload



## The

## importance of control

Perception, 2015, volume 44, pages 569-586

doi:10.1068/p7833

The sensory experiences of adults with autism spectrum disorder: A qualitative analysis

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Abstract. It has been well established that individuals with autism spectrum disorder report unusual experiences with sensory stimuli compared with typically developing individuals. However, there is a paucity of research exploring the nature of such experiences. A focus group was conducted with six adults with a diagnosis of autism or Asperger syndrome. Data were coded and analysed using an inductive, qualitative thematic analysis. Four main themes encompassing both positive and negative sensory experiences emerged from these data: (a) the importance of particular aspects of stimuli in their perception, (b) the importance of having control over stimuli, (c) how emotions/mental states could impact/be impacted by sensory stimuli, and (d) physical responses to stimuli. These data are discussed alongside extant literature. Limitations, possible implications, and potential directions of future research are also discussed.

Keywords: autism spectrum disorders, sensory, qualitative, focus group

## And what about **hypo**reactivity?

- Interoception is affected in autism
- Lower cardiac awareness (Palser e.a., 2019)
- Lack of awareness of hunger, thirst, pain and the need to make bowel or bladder movements



## Hyporeactivity in interoception

- The outside world is so stressful that the hypervigilant brain does not have time and energy to process the predictions and prediction errors regarding the inner world
- Overestimation of own interoceptive abilities (too certain about one's own interoceptive sensibility)
- Link with anxiety!
  - Anxiety (but also depression) linked to alexithymia
- Autistic brains have not learned to read their own body
- Recognizing inner body signals requires contextual sensitivity





## Conclusion

 Take the stress / discomfort caused by sensory environment seriously



- Address the stress and the arousal rather than the stimuli
- Address the prediction-errors: reduce uncertainty, not stimuli
  - Make the sensory environment more predictable
  - Clarify the sensory environment
  - Give information about sensory environment
- Empowering approach: not avoiding, but coping
  - No "one size fits all" interventions
  - Give (feeling of) control over the sensory environment
  - Teach how to survive sensory stress

# Thank you very much for your attention!





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