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Department of Educational and Counselling Psychology | Département de psychopédagogie et de psychologie du counseling

Hôpital Rivière-des-Prairies
Centre hospitalier de soins psychiatriques
Université de Montréal

L'intégration multimodale en autisme : une perspective développementale

Armando Bertone, PhD

Perceptual Neuroscience Laboratory
(PNLab.ca) for Autism and Development

Summit Center for Education, Research and Training (SCERT) /
Centre pour l'Éducation, la Recherche et la Formation le Sommet

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PNLab
Perceptual Neuroscience Laboratory for Autism and Development

Troisième colloque de l'AFNA,
Université Toulouse Jean-Jaurès, 2022

DR. ELIZABETH PELLICANO

PhD in Psychology, Professor

Professor Liz Pellicano has long been committed to transforming autism science so that it more accurately reflects everyday autistic life.

DR. LAURENT MOTTRON

MD, Psychiatrist, PhD in Psycholinguistics

Dr. Mottron is researcher-clinician specialized in the cognitive aspects of autism.

https://www.summit-scert.com/conference2022

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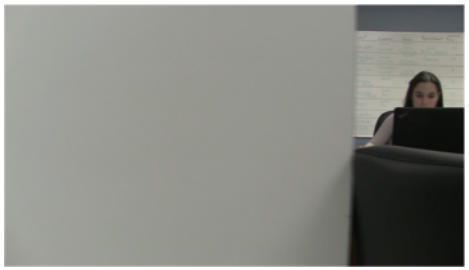
perceptual neuroscience lab (PNLab.ca) for autism and development

PNLab
Perceptual Neuroscience Laboratory for Autism and Development



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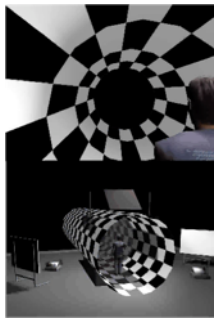
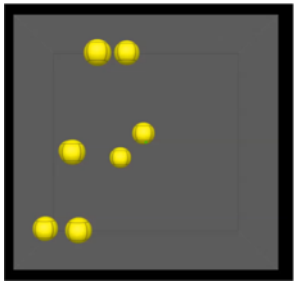
- development of social and non-social visual information processing in autism and related neurodevelopmental conditions (NDCs).

- visually-based cognitive intervention (attention) in autism and other NDCs

- sensory-related cognition and behavior across NDCs.

- development of multisensory information (MSI) processing in autism and during typical development.





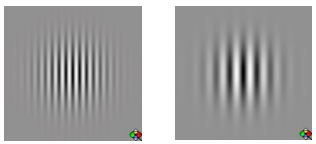
visual (unimodal) perception in autism :
atypical at different levels of processing / complexity

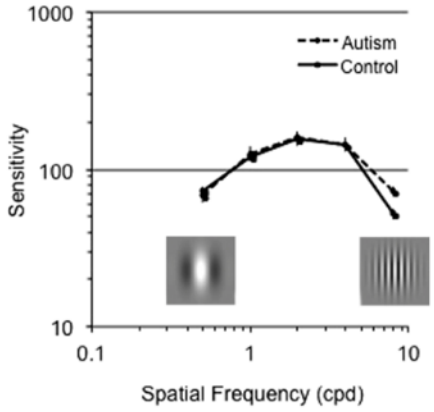
approach and context = systematic assessment of **unimodal visual perception** at different levels of processing / complexity :

- low-level = elementary / non-social information processing = local information
- mid-level = integration of elementary information / non-social = global information
- high-level = complex / social information processing = global information + social content

An early origin for detailed perception in Autism Spectrum Disorder: biased sensitivity for high-spatial frequency information.

Luc Kéïta[1], Jacalyn Guy[2,3], Claude Berthiaume[4], Laurent Mottron[4] & Armando Bertone[2,4,5]

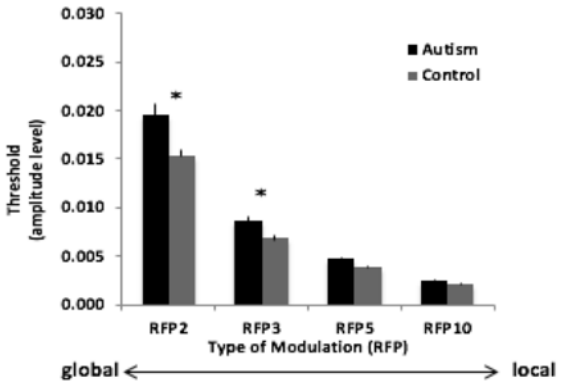




“ low-level “

Behavioral evidence for a functional link between low- and mid-level visual perception in the autism spectrum

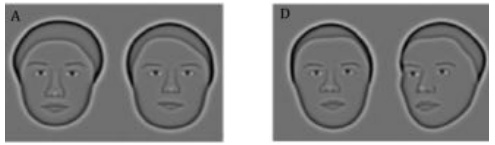
Audrey Perreault[a,b,*], Claudine Habak[c], Franco Lepore[b], Laurent Mottron[d], Armando Bertone[d,e,f]

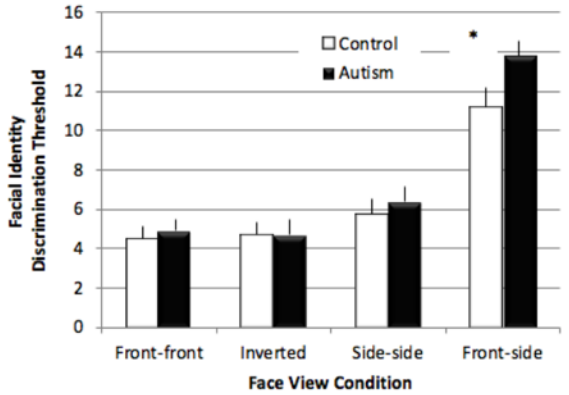


“ mid-level “

Atypical Face Perception in Autism: A Point of View?

Karine Morin, Jacalyn Guy, Claudine Habak, Hugh R. Wilson, Linda Pagani, Laurent Mottron, and Armando Bertone





“ high-level “

complexity

DSM-5 : sensory issues now explicitly included as criteria for autism

DSM 5 : 2 symptom domains (3 domains in DSM-IV : SC, SI & RIRBs)

A. persistent deficits in social communication and social interaction

B. restricted, repetitive patterns of behavior, interests, or activities,

- B4. Hyper- or hyporeactivity to sensory input or unusual interests in sensory aspects of the environment (e.g., apparent indifference to pain/temperature, adverse response to specific sounds or textures, excessive smelling or touching of objects, visual fascination with lights or movement).

↑ sensory abnormalities in ASD

- prevalence : 69-95% (Caminha et al., 2012; Hazen et al., 2014; Leekam et al., 2007)
- differ across age, symptom severity, & modalities (Ben-Sasson et al., 2009; Pellicano, 2013; Kern, 2006)

do sensory processing underlie core features in autism? (Iarocci & McDonald, 2006; Marco, Hinkley, Hill, & Nagarajan, 2011)

- cascading effect = disruption in sensory processing → higher-level atypicalities (cognitive, behavioral, etc.) (Hilton, Graver & LaVesser, 2007; Lane, et al., 2010; Maekawa et al., 2011)

« we currently have more functional imaging data about how the autistic brain processes a face or a theory of mind than we do about the way it processes location, colour, orientation, or spatial frequency; at what level of processing do the perceptual and cognitive abnormalities begin? »
(Belmonte et al 2004, p 658.)

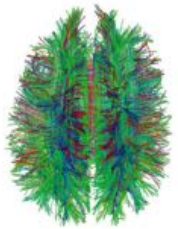
FEATURE REVIEW

Autism as a disorder of neural information processing: directions for research and targets for therapy[1]

MK Belmonte[1], EH Cook Jr[2], GM Anderson[3], JLR Rubenstein[4], WT Greenough[5], A Beckel-Mitchener[6], E Courchesne[6], LM Boulanger[7], SB Powell[8], PR Levitt[9], EK Perry[10], YH Jiang[11], TM DeLorey[12] and E Tierney[13]

Molecular Psychiatry (2004) 9, 646–663

" systems-level approach "



Mottron et al., 2007

multisensory integration - MSI

multisensory integration (or MSI) = ability to efficiently and simultaneously integrate stimuli from multiple sensory modalities integrated into 1 coherent percept (Stein, Wallace & Stanford, 1999; Stein & Meredith, 1993)

- automatic
- advantage conferred by MSI = multisensory *facilitation*
- leads to an efficient & accurate interpretation of world
- adaptive response to environment / efficient decision making

multisensory integration (MSI) = audio-visual integration …

consequences of MSI impairment in NDCs & ASD ? (Foxe & Molholm, 2009) environment complex & confusing | incoherent information | withdrawal / avoidance | cognitive overload | lack of cognitive flexibility

atypical MSI consistent with cognitive theories

- weak central coherence (Happé & Frith 2006)
- temporal binding deficit (Brock, Brown, Boucher & Rippon, 2002)

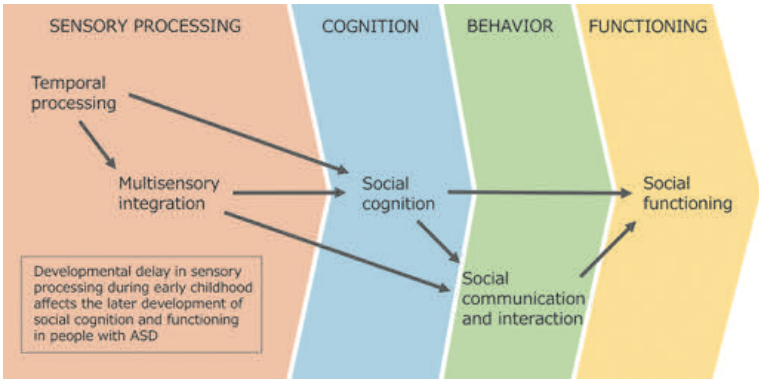


Figure 3. A hypothetical model. Illustration of our hypothetical model on the impact of developmental delays in sensory processing on the later development of higher-order functions in people with ASD. From a developmental perspective, multisensory integration is thought to partly underlie social cognition, which in turn underlies social interactions and functioning. Thus, if treatment can promote the development of multisensory integration in individuals with ASD, it may improve social cognition, core symptoms, and social functioning. ASD, autism spectrum disorder.

Kawakami & Otsuka (2021)

MSI & autism

interest in MSI and autism ↑

- accelerated since since Foxe & Molholm's (2009) " call to arms paper "
- need to translate fundamental MSI to clinical populations, and autism in particular = many empirical and review papers since

MSI abilities in autism still not that well understood

MSI in autism more consistently impaired when using using **social stimuli**

- McGurk effect (Taylor, et al., 2010; Williams et al., 2004; ++++) |speech with lip-reading (Foxe et al., 2015; Smith & Bennetto, 2007) | speech with gestures (Silverman, et al., 2010)

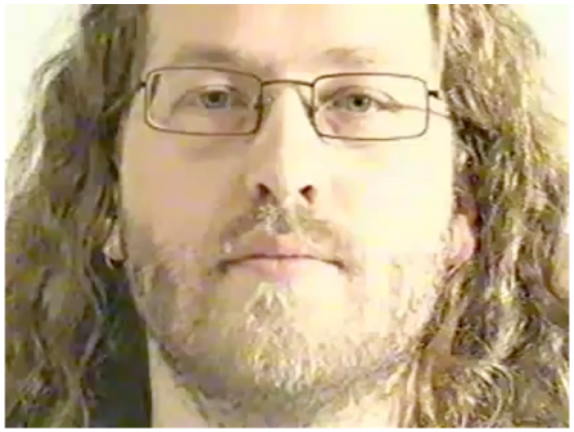
less consistent findings when using **non-social stimuli / illusions**

- sound-induced flash illusion (Shams et al. 2000)

not clear why (Wallace, Woynaroski & Stevenson, 2020)

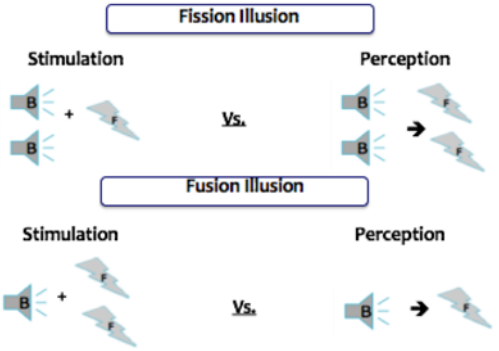
- differences between multisensory impairments when processing social vs non-social stimuli ?
- developmental trajectory of multisensory integration is delayed or disordered ?

McGurk Illusion
(McGurlk & McDonald, 1976)



speech components &
dynamic face

sound-induced flash illusion
(Shams et al. 2000)



beeps & flashes

Research motivation

regardless of task / paradigm, most studies make generalized conclusion of altered MSI in autism (Mulleur et al., 2020)

- do they assess a fundamental MSI impairment = “low-level”,
- ***or*** are results confounded by the complex, socio-communicative nature of the stimuli ?

relatively few developmental assessments of MSI are available

- across different periods of development

questions …

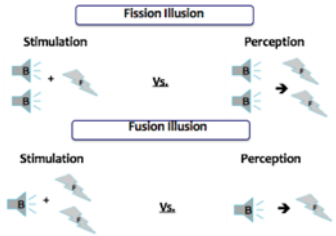
- is the MSI (audio-visual integration) altered in autism ?
- if so, is altered MSI in autism contingent on the type of information being integrated ?
- is altered MSI in autism different in the same way at different periods of development ?

several recent review papers (2019-) all cite these two variables as

- stimulus complexity and age

as critical to understanding MSI in autism (Feldman et al, 2019; Kawakami & Otsuka, 2021; Wallace et al., 2021; Mulleur et al 20221)

beeps & flashes



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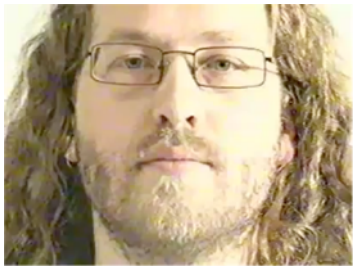
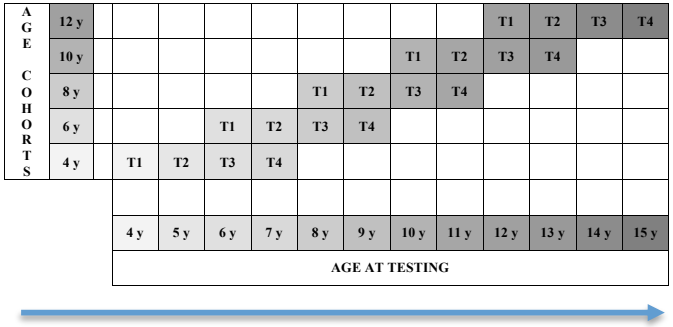


speech / faces

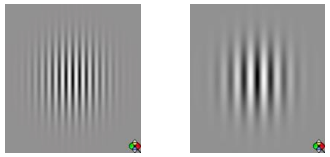


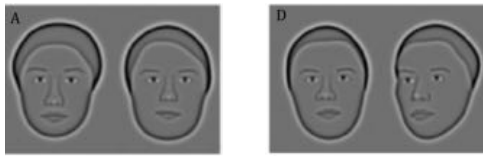
MSI in autism : atypical at different levels of processing / complexity ?

approach = systematic assessment of **MSI** at different levels of processing / complexity :

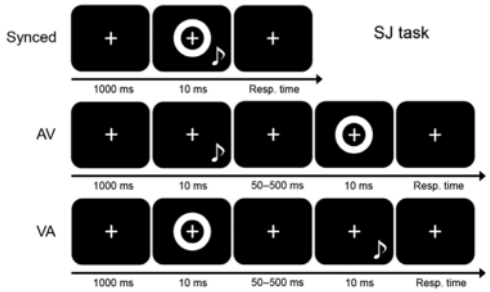
- low-level = elementary / non-social
- mid-level = integration of elementary information / non-social
- high-level = complex / social

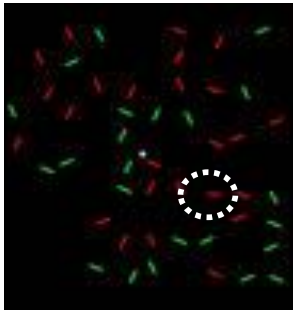
unimodal

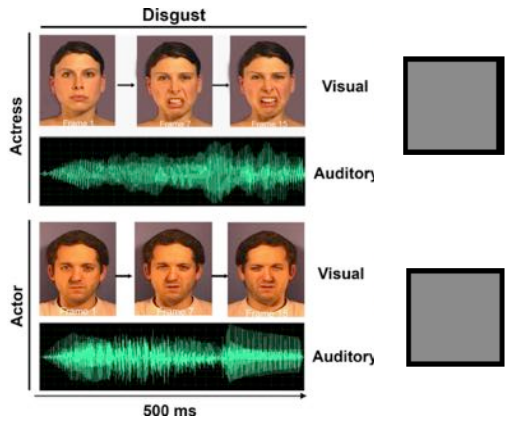




multimodal







“ low-level “ **“ mid-level “** **“ high-level “**

complexity

How is MSI defined and assessed

RT most often used measure in MSI tasks

redundant signals effect (gain) = responses are faster when stimuli presented together ($F_A + F_V$) vs separately (F_A OR F_V)

however …

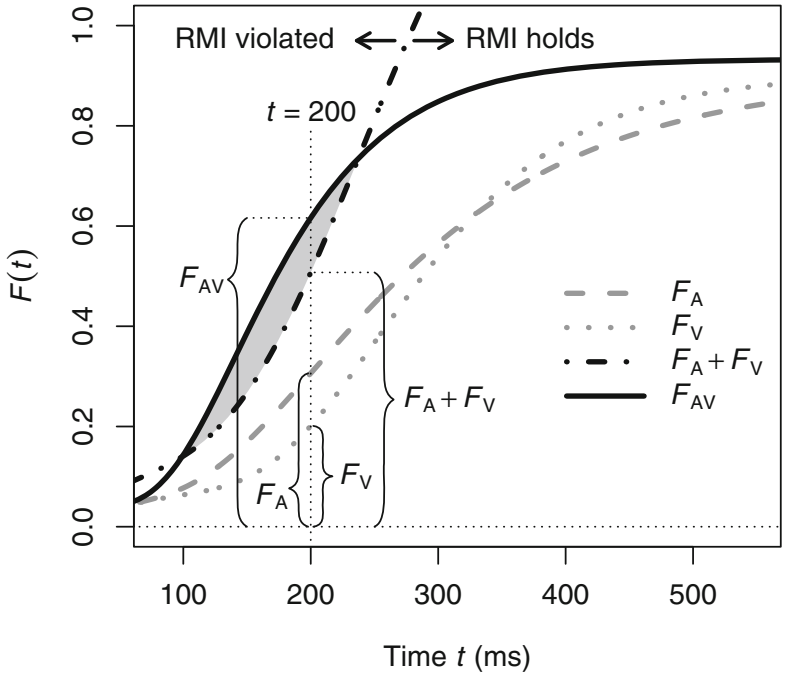
need to distinguish between;

- statistical facilitation (race model) = faster of the two unisensory (F_A or F_V) inputs always determines the speed of response to multisensory trails = $F_A + F_V$
- **multisensory** facilitation (coactivation model) = assumes ***integrated*** processing = decreased RT on multisensory conditions goes above and beyond the effect of redundant stimulation = F_{AV} should always be ≤ $F_A + F_V$

race model inequality (RMI) (Miller, 1982) : violation of RMI = presence of an integrative multisensory facilitation (grey area)

the race model analysis : compares the RTs on the AV condition to a bound value computed from the unimodal RTs that reflects the effect of redundancy = gold standard process for assessing present of MS *facilitation*

Gondan & Minakata, 2015; Miller, 2016



neurotypical : multi-sensory integration (MSI) - **low-level, non-social info**

first developmental assessment of MSI in neurotypicals

- [school ages → adulthood] + [Race Model Analysis]

111 typically-developing individuals - 4 age groups :

- 6-9 ys |10-13 ys | 14-17 ys & 18+
- target detection task completed

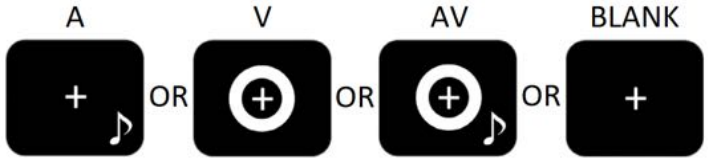
race model analysis applied for each age group

- race model inequality : evaluated at 10 different points of the RT distributions (the 5th, 15th, 25th… 95th %-iles)
- %-iles with the shortest RT for each participant computed
- bound value computed
- for each %-iles, the mean RTs for the AV condition compared to the bound using t-test.
- violations (*)= MSI facilitation

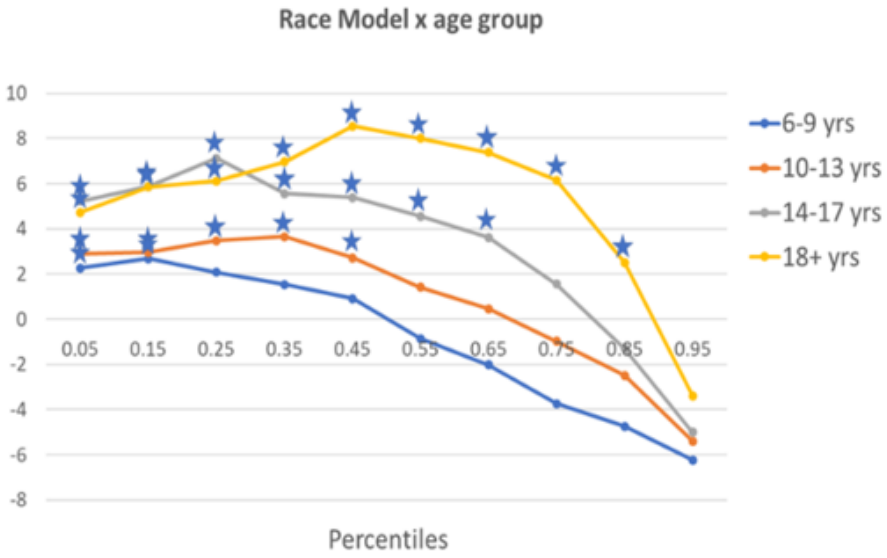
results : violations of the race model increase as a function of age group

- MSI for simple information develops / improves across developmental periods
- MSI abilities for low-level information do not reach adult-like level during **late adolescenc**e : 14-17 ys.

target detection task : A trials = beep | V trials = flash, AV trials = beep + flash



respond to the stimulus as fast as possible : reaction time (RT) recorded for each trial.



adult group : race model violated through the 85th percentile

violations increased with age group

RM violation at any percentile is sufficient to provide evidence of multisensory **facilitation**.

autism : multi-sensory integration (MSI) - **low-level, non-social info**

target detection task and ASD : only one previous study used this simple task and AND race model analysis (Brandwith et al., 2103)

- MSI of younger (7–10) and older (11–16) children compared = no MSI facilitation found in ASD group

assessed older autistic group: adolescents & adults

- autism group (n = 20)
- neurotypical group (n = 19)
- 13-29 years

	AS (n = 20)	TD (n = 19)	*t*	*p*
Sex				
Male	16	17		
Female	4	2		
Chronological Age			−0.252	0.802
M	19.21	19.61		
SD	4.71	5.15		
Range	13–29	13–28		
Age groups				
Adolescents	10	9		
Adults	10	10		
Wechsler Full-Scale IQ			−1.189	0.242
M	102.95	107.79		
SD	13.71	11.55		
Range	79–120	86–125		

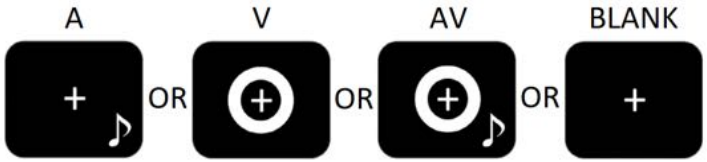
MSI for low-level, non-social information is atypical and less efficient for autistic adolescents and adults

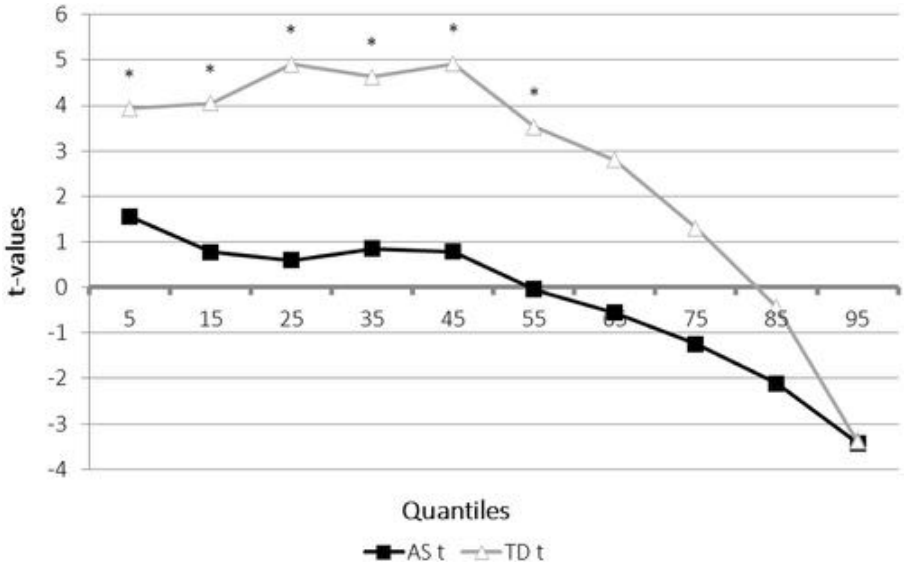
- what about M<SI abilities at different periods of development ?

Reduced multisensory facilitation in adolescents and adults on the Autism Spectrum

Alexia Ostrolenk[1,3], Vanessa A. Bao[1,2], Laurent Mottron[3], Olivier Collignon[4,5] & Armando Bertone[1,2,3]

SCIENTIFIC REPORTS
natureresearch





NT group : RM violated through the 55th percentile

ASD group : RTs did not violate the race model at any of the percentiles (but MS gain evidenced by +ve numbers)

autism : multi-sensory integration (MSI) - **low-level, non-social info**

at what age does MSI improve in autism?

- Brandwith (2013) no MS facilitation across (7–10) & (11–16) year old age rages
- Ostrolenk (2019) no MS facilitation 13-29 year-olds group

investigate developmental change in MSI in autism :

- younger (< 14 years) and older (> 15 years) participants

Table 1 – **Participant characteristics across all participants age groups.**

Participant Characteristics				
	Autistic: 14 or <	Autistic: 15 or >	Neurotypical: 14 or <	Neurotypical: 15 or >
N=	23	22	55	56
Age				
Age Range	7–14	15–29	6–14	15–29
Age M	11.91	19.05	10.78	19.96
Age SD	2.00	4.10	2.39	4.27
IQ				
PIQ M	112.85	107.16	111.43	109.27
PIQ SD	17.89	11.57	13.83	12.42

redundancy gain : RT for [A + V] conditions < A or V conditions alone

- evidenced for both group
- but significantly lower in the of autism group

MSI facilitation (RM violation)

- younger (45% %-ile) and older (75%-ile) TD group
- only younger autism group (5th %-ile)

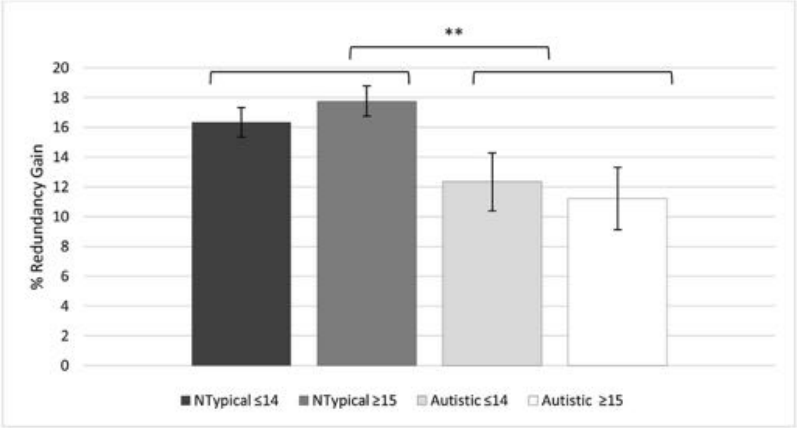
MSI facilitation for low-level, non-social information develops differently in autism

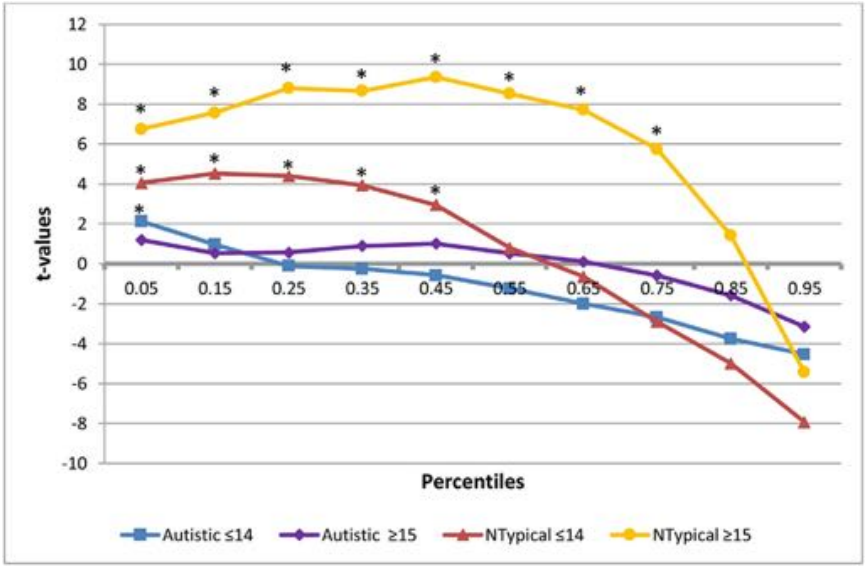
- MSI facilitation less evidenced for younger age groups

Reduced multisensory facilitation exists at different periods of development in autism

Kirsty Ainsworth [a,b,], Alexia Ostrolenk [a,c], Catherine Irion [d] and Armando Bertone [a,b,c]*

$$RG = \frac{Mean\ bimodal\ RT - Fastest\ mean\ unimodal\ RT}{Fastest\ mean\ unimodal\ RT}$$





multi-sensory integration (MSI) - **low-level**, **non-social info**

temporal binding window (TBW) : multisensory information is perceived as being simultaneous even when it is asynchronous by a longer period of time = metric of MSI

simultaneity Judgement (SJ) task :

- judge (same vs different) the perceived simultaneity of stimuli pairs with varying SOAs:
  - 50ms, 100ms, 150ms, 200ms, 250ms, 500ms, 750ms

wider TBW = increase in "same" responses for larger SOAs = ↓ efficient MSI

evidence regarding atypical TBW in autism is mixed;

- wider TBW autistic children/adolescents (Noel et al., 2017; Stevenson et al., 2014)
- comparable in adults (Turi et al. (2016); Kawakami et al. (2020)

studies explicitly assessed the differences in TBW width across <u>different age groups</u> in autism do not exist.

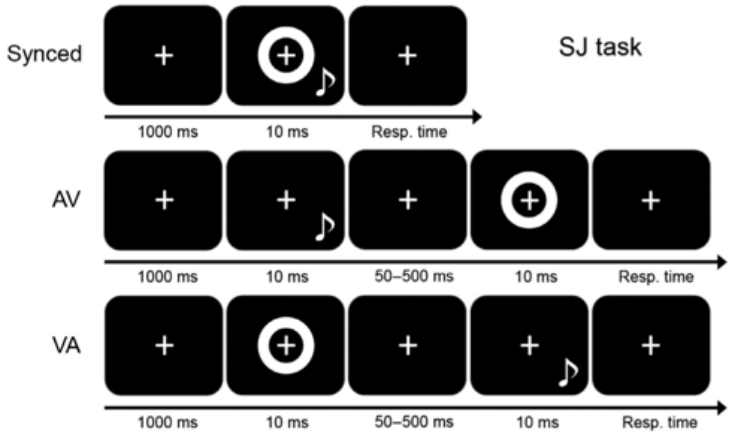
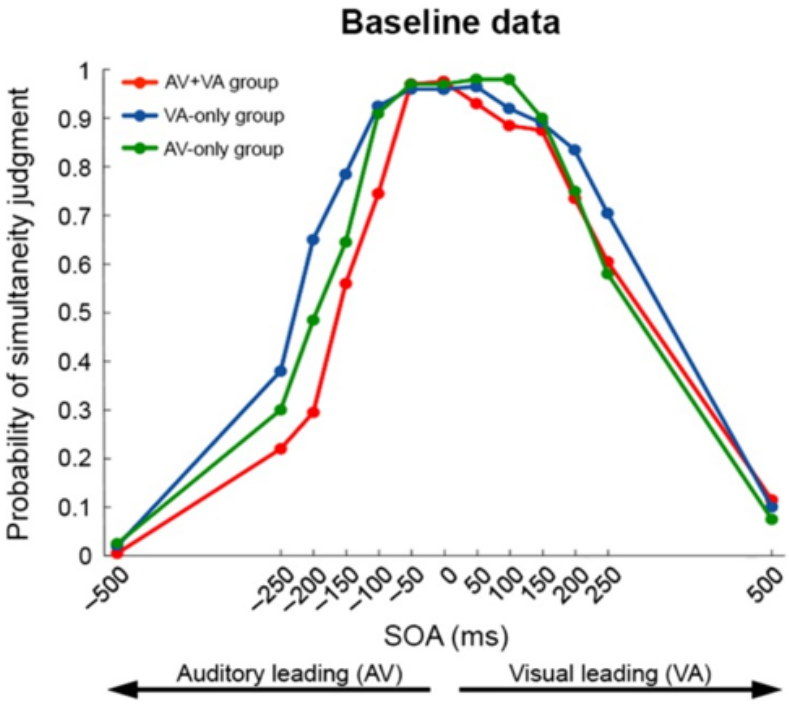


Figure 2. SJ Task: Synced, Auditory-leading and Visual-leading conditions.



Cecere, et al., 2016

autism : multi-sensory integration (MSI) - **low-level, non-social info**

TBWs assessed for autistic and neurotypical children and adolescents (6 - 18 years)

- the sensory profile of all participants also assessed (Dunn)
- TBW of child (6-12 ys) and adolescents (> 15 years) compared

Table 2. **Demographic information for autistic and neurotypical groups divided by age category**

	Autistic Children	Autistic Adolescents	*p*	Neurotypical Adolescents	Neurotypical Children	*p*
n =	16	41		16	33	
Age Mean (SD)	9.9 (1.8)	9.3 (2.1)	***0.30***	14.7 (1.7)	14.8 (1.5)	***0.83***
PIQ Mean (SD)	106.1 (22.3)	110.3 (16.3)	***0.43***	106.4 (15.2)	109.7 (16.2)	***0.51***

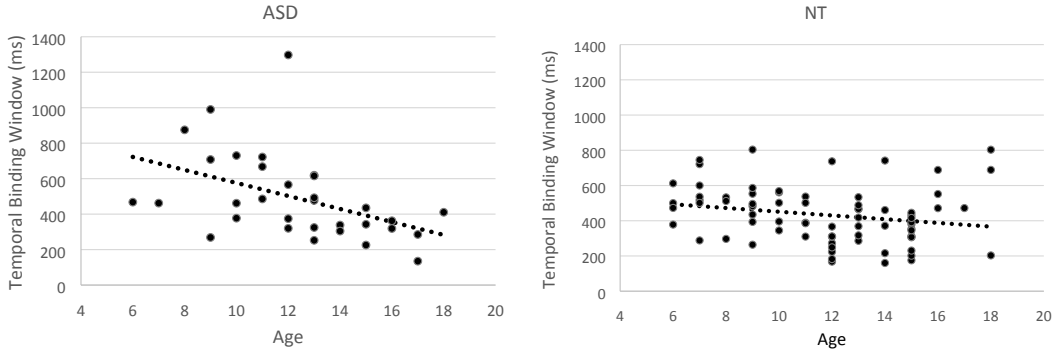
TBWs width defined via gaussian curve fitting procedures =

- wider TBWs indicate less sensitivity to temporal alignment

autism group : TBWs wider for child group

NT group : TBWs same for both age groups = autism adolescent group

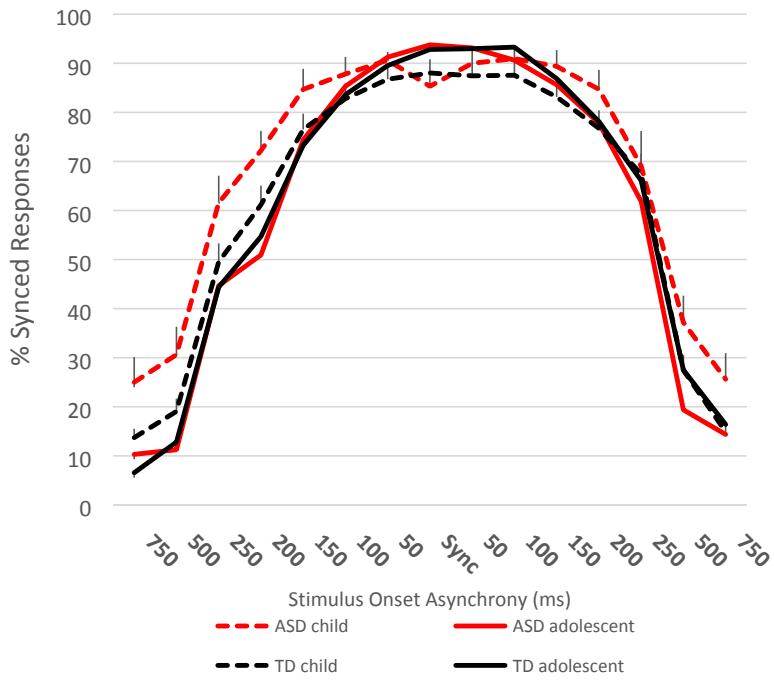
significant correlation b/n TBW and age in autism group only

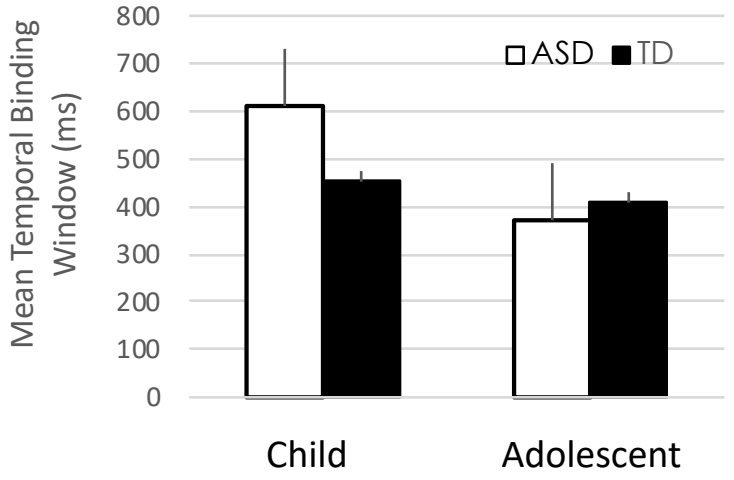


MSI in autism - development even for low-level, non-social info – must be taken into context

Audiovisual temporal binding across development in autism spectrum disorders

Ainsworth & Bertone A. (accepted) , Autism Research





autism : multi-sensory integration (MSI) – **mid-level**, **non-social info**

challenging non-social, multi-modal visual search task
(van der Burg et al., 2008)

- find vertical or horizontal line = target

visual (no pip): all items (target and distractor) alternate color :

visual + auditory (pip) : tone presented concurrent to color change of target = parallel search

methods

- task accuracy (HITs) = % correct responses.
- reaction times (RTs) = response to the target color change (only correct answers).

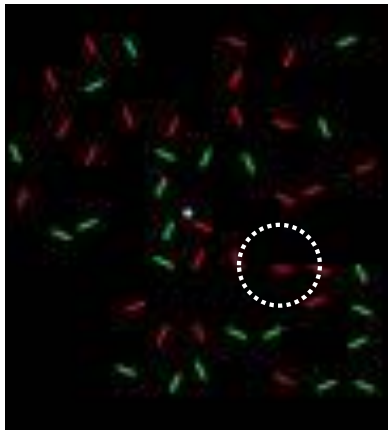
autism group : **no benefit** of concurrent auditory information during search = no MSI facilitation

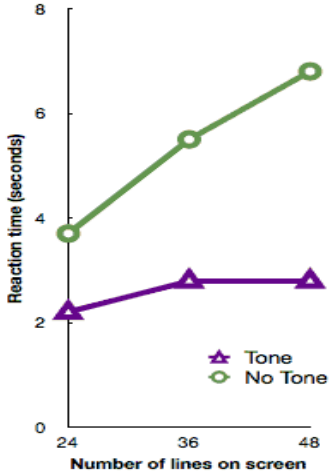
↓ multi-sensory integration **but better unimodal visual** performance in autism (large set sizes)

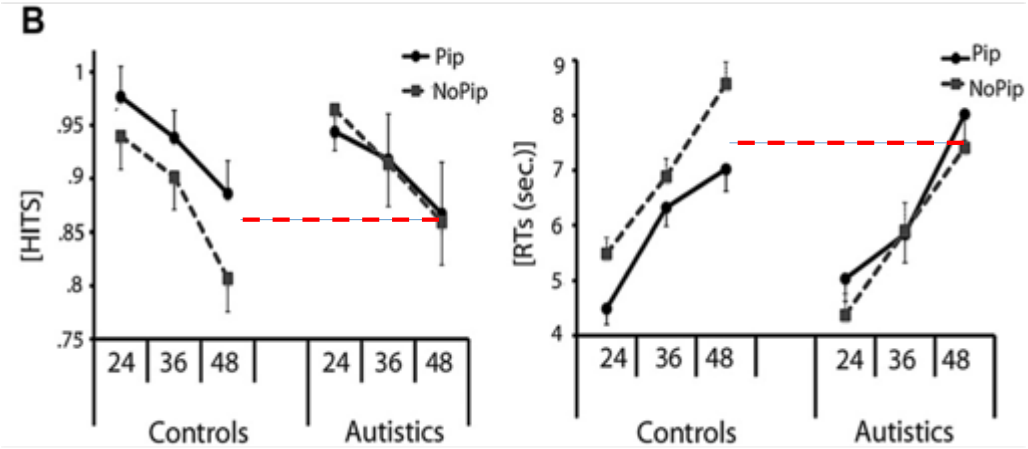
reflections : is unimodal advantage in autism ever considered in MSI research …

Reduced multisensory facilitation in persons with autism

Olivier Collignon [a,b,c,], Geneviève Charbonneau [b], Frédéric Peters [d], Marouane Nassim [e], Maryse Lassonde [a,b], Franco Lepore [b], Laurent Mottron [e] and Armando Bertone [e,f]*







autism : multi-sensory integration (MSI) - **higher-level, social info**

integration of social information - expression of emotion - impaired in autism

- children and adults (Uljarevic and Hamilton, 2013).

participants completed emotion discrimination (dynamic)

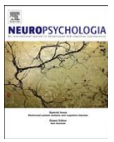
- late adolescents and young adults, between 15 - 27 years.
- discriminate between affective expressions of “fear” and “disgust”
- conditions : auditory | visual | audio-visual

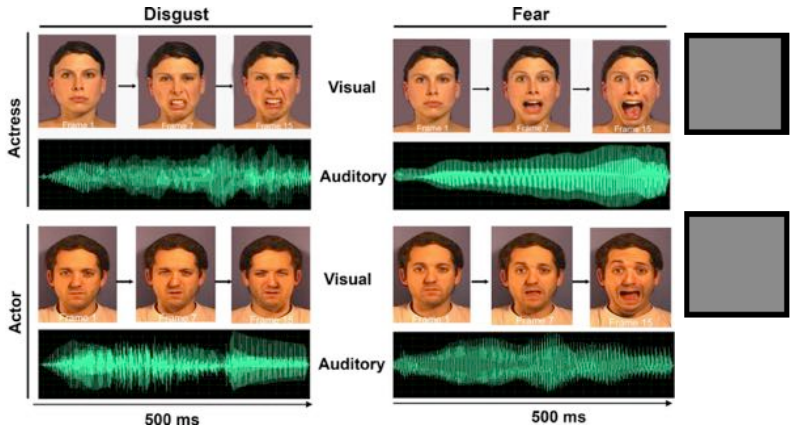
↓ auditory & visual discrimination (RT) in autism (A)

↓ MSI of higher-level, social info in autism group (B, C)

Multilevel alterations in the processing of audio–visual emotion expressions in autism spectrum disorders

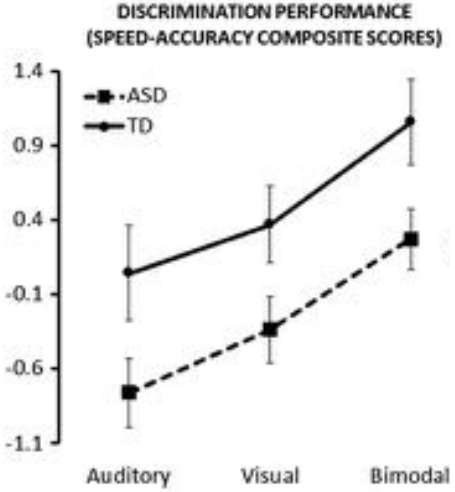
Geneviève Charbonneau [a], Armando Bertone [b,c], Franco Lepore [a,d], Marouane Nassim [c], Maryse Lassonde [a,d], Laurent Mottron [c], Olivier Collignon [a,d,e,*]



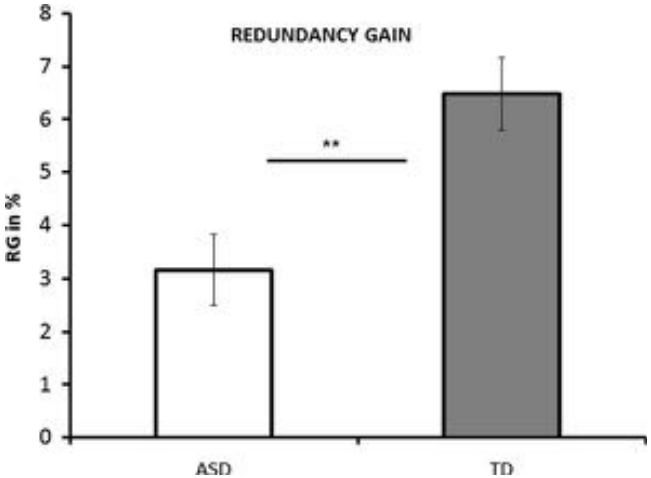


ecologically-validated stimuli comprised of dynamic visual movies and auditory (non-verbal) vocal clips of emotional expression « Montreal Affective Voices » (Belin et al., 2008; Simon et al., 2007)

A



B



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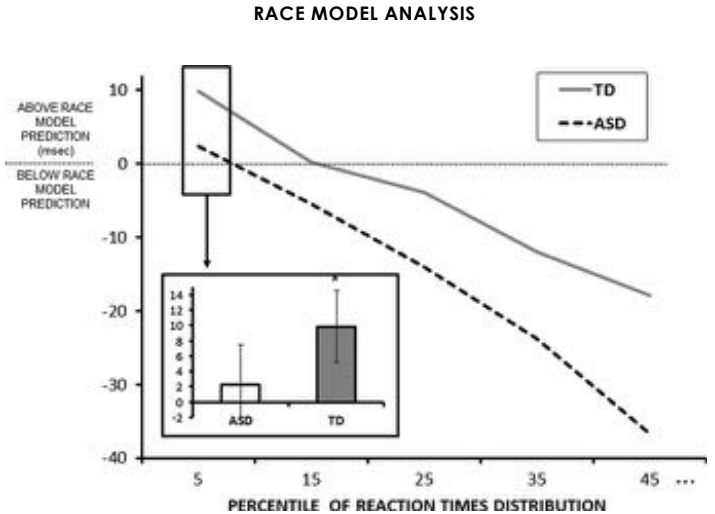


autism : multi-sensory integration (MSI) - **higher-level, social info**

Multilevel alterations in the processing of audio–visual emotion expressions in autism spectrum disorders

Geneviève Charbonneau [a], Armando Bertone [b,c], Franco Lepore [a,d], Marouane Nassim [c], Maryse Lassonde [a,d], Laurent Mottron [c], Olivier Collignon [a,d,e,*]

secondary task used to assess **unimodal** emotion discrimination using same stimuli

- signal-to-noise ratio measured for auditory and visual conditions

same task : discriminate between “fear” and “disgust”

signal-to-noise ratio adjusted in order to target a 80% accuracy rate performance = discrimination threshold

results : ↓ auditory & visual discrimination in ASD group for both auditory and visual conditions

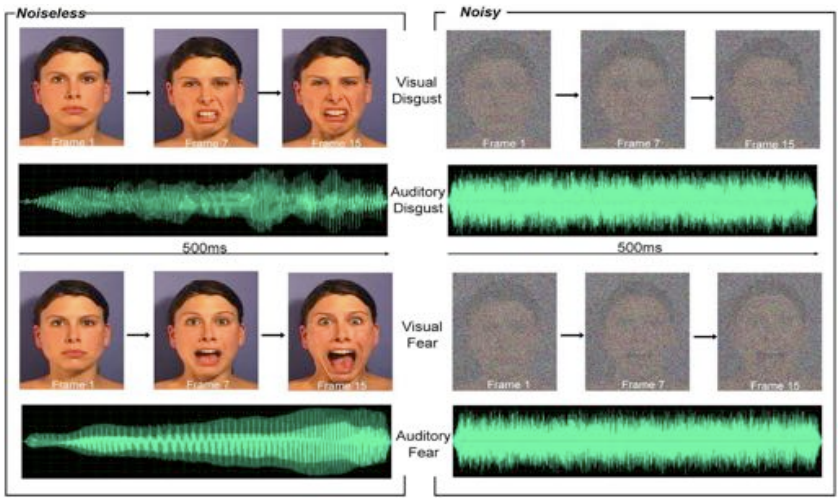
- in addition to ↓ MSI (primary task results)

= generalized alteration for processing of higher-level, unimodal social info (dynamic emotion expressions)

- unimodal (auditory and visual) estimates of emotional expressions are noisier in autism

need to take into account unimodal alterations for simple vs complex information when assessing MSI … ?

- equate individual unimodal stimulus saliency prior to multimodal presentation ??



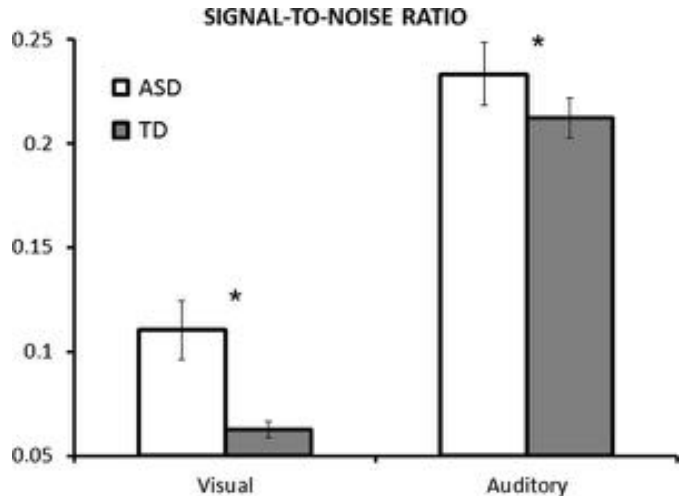


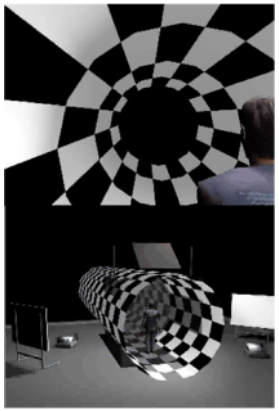
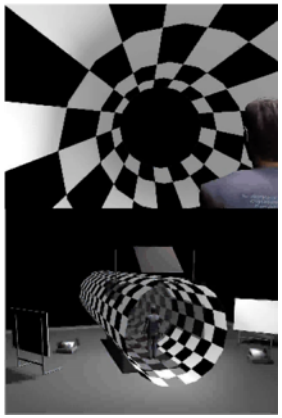
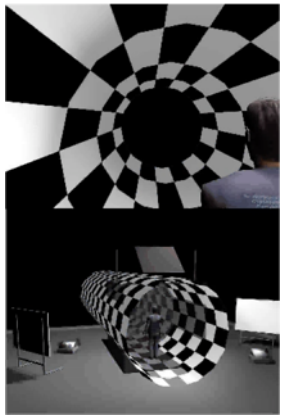
Fig. 5. Signal-to-noise ratio for an 80% accuracy rate in the discrimination of emotional expressions presented auditorily and visually in ASD and TD. This graphic illustrates the main effect of the factor “group”, suggesting inferior detection thresholds in TD than ASD for both modalities (*: $p \leq .05$).

multi-sensory integration (MSI) - **sensori-motor**

posture and balance are regulated by the continuous integration of afferent information from 3 sensori-motor systems:

- vestibular : inner ear
- proprioceptive : feedback from our limbs about our position
- visual : precedes other senses, feedback about position in environment

immersive « virtual tunnel » stimulus = dynamic visual environment that oscillated in antero-posterior fashion (3 frequencies)

also static visual environments

- static tunnel (0 Hz) + eyes closed

DVs : (1) stability and (2) reactivity to motion (body sway) as a function of oscillation frequency

Lee and Aronson “swinging room” (1974)

Fully Immersive Virtual Reality System (CAVE©) - Faubert Perception Lab, Ecole d’Optometrie

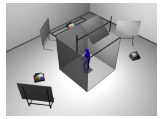
neurotypical : multi-sensory integration (MSI) - **sensori-motor**

investigate the development of visually driven postural regulation in typically developing children of different ages.

Development of visually driven postural reactivity: A fully immersive virtual reality study

Selma Greffou
Armando Bertone
Jean-Marie Hanssens
Jocelyn Faubert

Journal of Vision (2008) 8(11):15, 1–10



typical development

DV = postural perturbations induced by the moving environment = root mean squared (RMS) of total body velocity (cm/s) in angles/second

stability increased with age

5 - 7 year group
- 2 / 6 (33%) met criteria
- over-reliance of visual input on postural regulation at young ages (5-7 years)

16-19 year group
- no significant effect of frequency on postural reactivity and sway
- adult-like levels

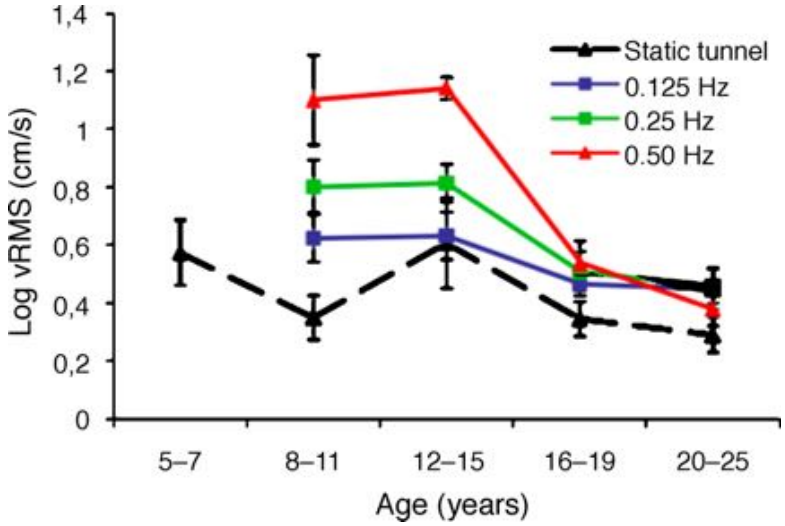


Figure 5. vRMS in log (cm/s) as a function of age and oscillation frequency. *SEM* are shown for each age group.

critical period for typical “sensori-motor” (postural stability) development between 16-19 ys of age

autism : multi-sensory integration (MSI) - **sensori-motor**

repetitive behaviours + self-stimulatory behaviours

- rocking
- hand flapping

Atypical hypo-reactivity (i.e., less postural perturbation) to a sway-inducing visual environment evidenced for highest oscillation frequency (0.50 Hz)

postural stability to visual information is present in autism, but is contingent on

(i) type of stimulus (oscillation frequency)

(ii) age (younger participants < 12 years).

results not do to motion perception nor vestibular impairments

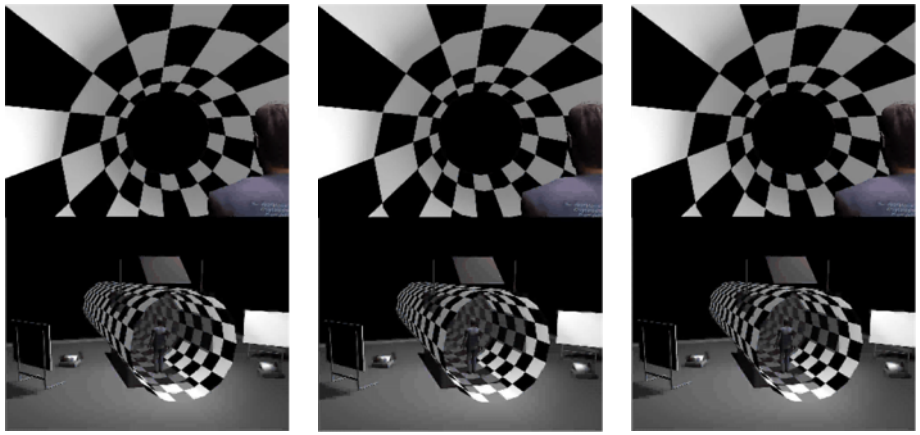
atypical integration between visual and other afferent systems (i.e., motor,/serebeallr and/or somatosensory) in youth w autism?

- ou ‘‘temporo-spatial processing disorder’’ (Gepner et al., 2009)

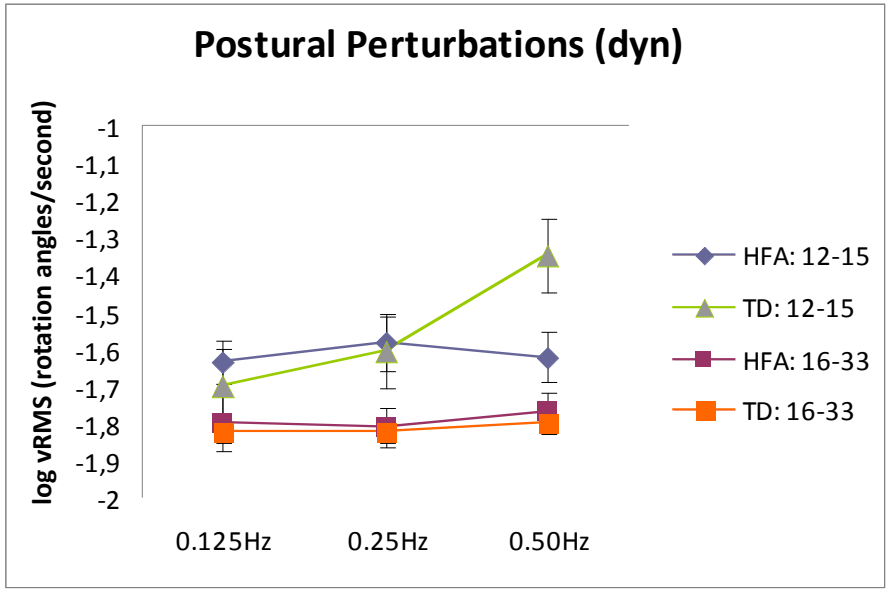
Postural Hypo-Reactivity in Autism is Contingent on Development and Visual Environment: A Fully Immersive Virtual Reality Study

Selma Greffou · Armando Bertone · Eva-Maria Hahler · Jean-Marie Hanssens · Laurent Mottron · Jocelyn Faubert

J Autism Dev Disord (2012) 42:961–970
DOI 10.1007/s10803-011-1326-6



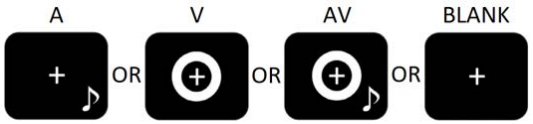
0.125 Hz (T= 8 s) 0.25 Hz (T= 4 s) 0.5 Hz (T= 2 s)

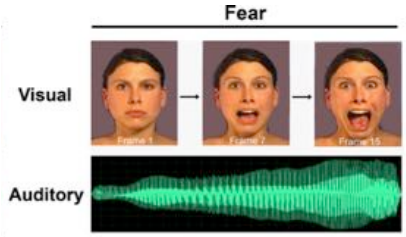


conclusions

altered MSI should not be considered an ability that is simply "impaired or absent" in autism

- findings provide a more nuanced view of MSI in autism as influenced by multiple factors : age and type of task / stimuli





- **low-level**, **non-social info** : ↓ efficient MSI for younger autistic participants (13 years and younger)
- **higher-level, social info** : ↓ efficient MSI in autism across ages

- Results are consistent with reviews/meta-analyses = group MSI differences more evidenced earlier in life (Feldman et al., 2019; +++)

altered MSI in autism not specific to audio-visual (AV) information

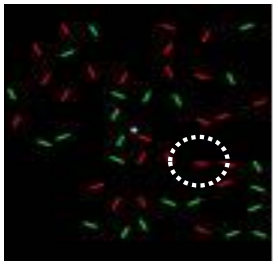
- atypical MSI also exist for other modalities : visuo-motor & visuo-tactile (Greffou et al., 2011; Charbonneau et a., 2020)
- common mechanisms? – can proposed framework/theories be applied to other modalities

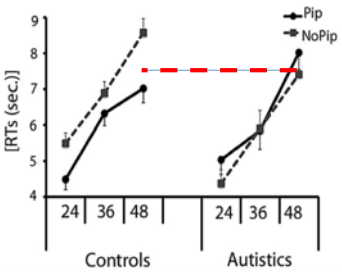
clinical implications

- communication between research and clinical domains (Foxe & Molholm, 2009)
  - accommodating differences specific to situation and age
- bottom-up approach to developing interventions ? (Cascio et al., 206;
  - perceptual training paradigms to narrow TBWs ... (Powers et al., 2016)
- do we or don't we intervene ? at what age ..
  - often superior unimodal abilities demonstrated in autism

Reduced multisensory facilitation in persons with autism

Olivier Collignon [a,b,c,], Geneviève Charbonneau [b], Frédéric Peters [d], Marouane Nassim [e], Maryse Lassonde [a,b], Franco Lepore [b], Laurent Mottron [e] and Armando Bertone [e,f]*



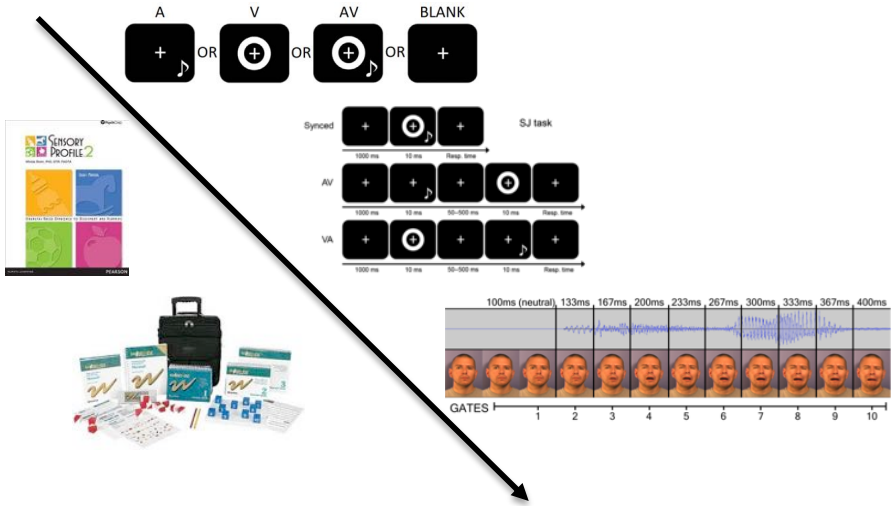


BUT enhanced unimodal (visual) abilities

current / future directions

current :

- defining MSI ability **across different periods** of **typical** and **atypical development** with different tasks **concurrently** (low and high-levels)
- assessing if altered **low-level** MSI is associated with altered **high-level** MSI
- assessing if altered MSI (low- or high-level) related to **sensory behaviours or core symptoms** ?



future

- **longitudinal assessment of MSI** using **different tasks (levels)** - compare typical trajectories to assess delayed vs disrupted MSI development ?
- lower-functioning person w autism?
- are attentional abilities related to performance
- assessing the **neural correlates** of altered MSI in autism using brain imaging (EEG / fMRI)

AGE COHORTS														
	12 y										T1	T2	T3	T4
	10 y								T1	T2	T3	T4		
	8 y						T1	T2	T3	T4				
	6 y				T1	T2	T3	T4						
	4 y		T1	T2	T3	T4								
		4 y	5 y	6 y	7 y	8 y	9 y	10 y	11 y	12 y	13 y	14 y	15 y	
		AGE AT TESTING												

collaborations - www.summit-scert.com

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