Applying models of visual attention to gaze patterns of children with autism

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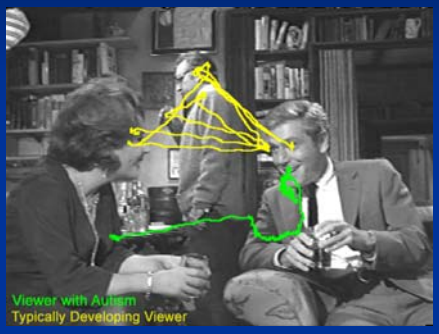
Gaze Patterns differ between Autism and Control Populations



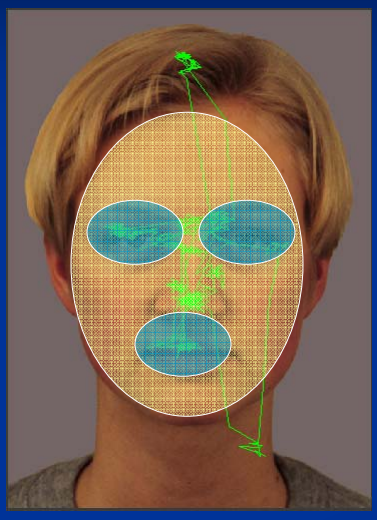
Stimulus:

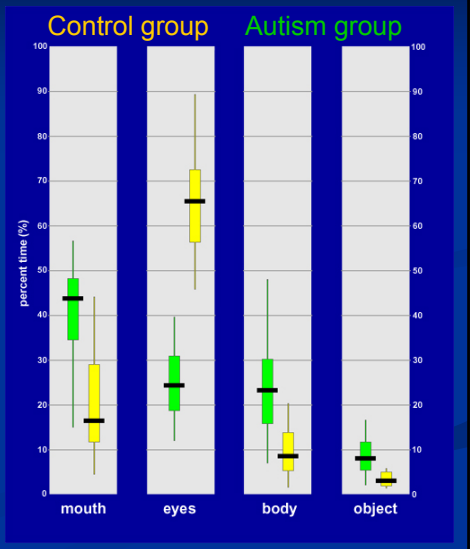
Who's Afraid of Virginia Woolf? (1966)
with Elizabeth Taylor, Richard Burton, George Segal

Participant Characterization:

Autism group: N=15, Age 15.37 (7.23), VIQ 101.33 (24.89)
Normal controls: N=15, Age 17.91 (5.63), VIQ 102.47 (20.40)
(Klin, Volkmar & Jones, 2003/Shic & Scassellati, 2005)

Typical Analysis

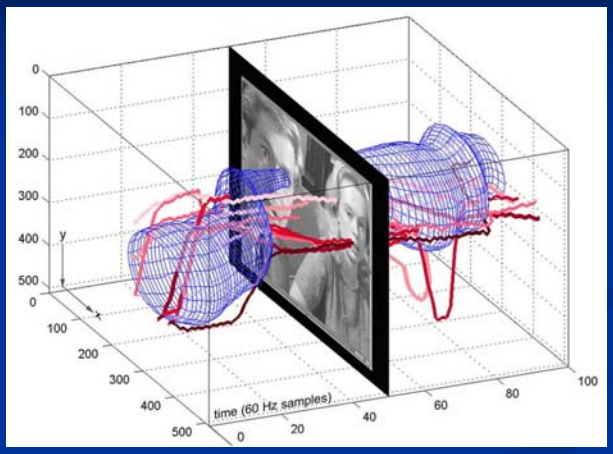




Gaze patterns also differ at very early ages

- Data from 24-month-old toddlers
- Before a standard diagnosis can be performed
- Now collecting from 12-month-olds

Data is Much Richer



- Autistic gaze patterns are
  - Not random
  - Not always different from typical controls
  - Clustered, but with higher variance than typical controls

Linking Basic Perception with Behavioral Investigation

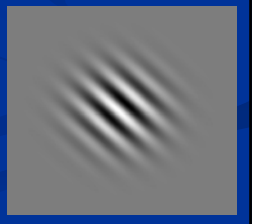
Behavioral Investigation

- high-level concepts
- clinical observations
- naturalistic settings

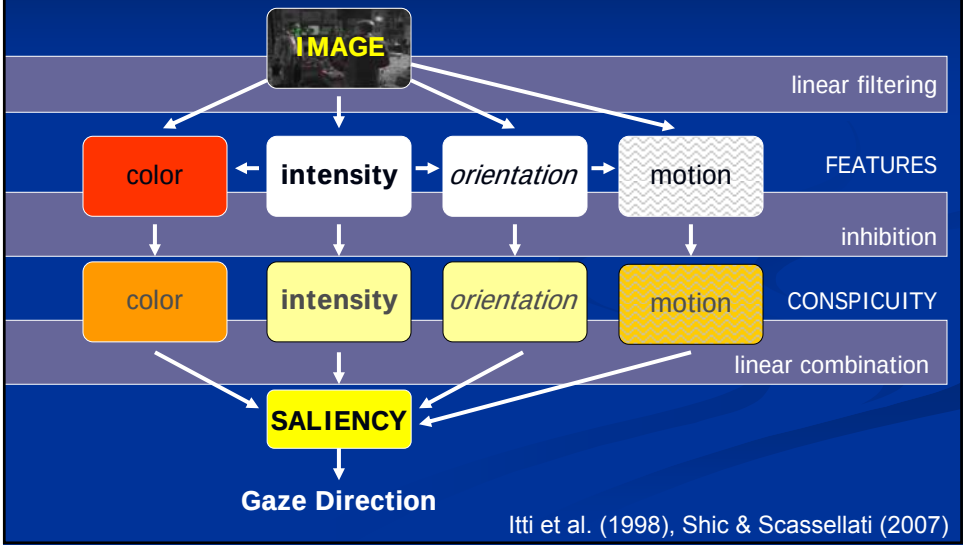
Computational Gaze Models

Perceptual Experiments

- basic perception
- artificial stimuli
- laboratory setting

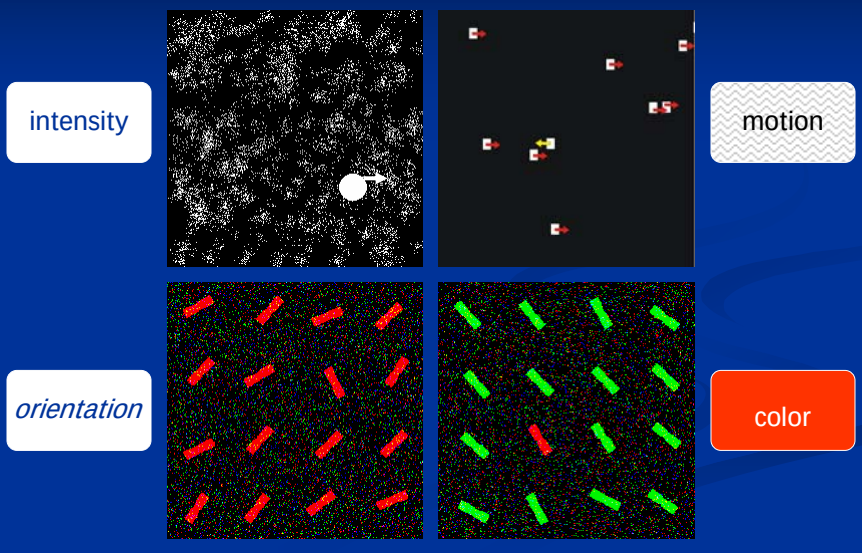


Computational (Robotic) Models of Attention

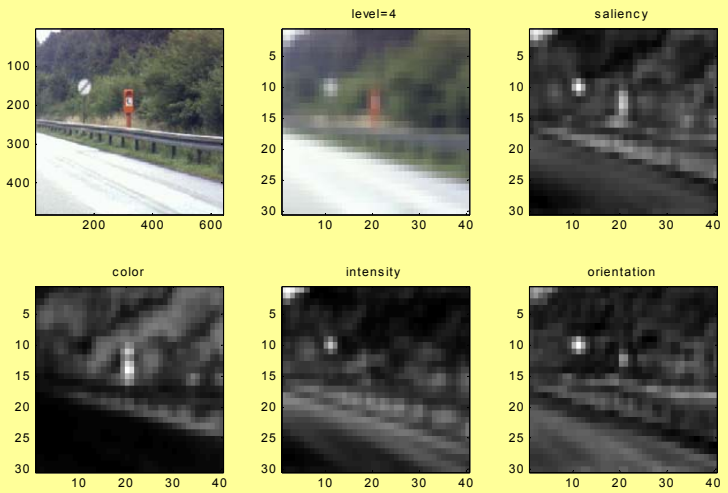


Itti et al. (1998), Shic & Scassellati (2007)

Computational Model



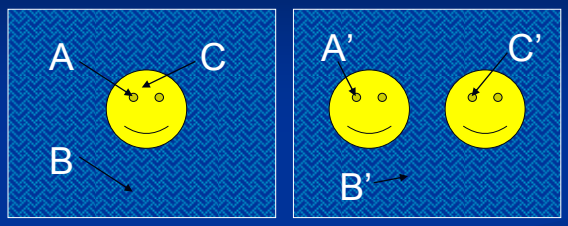
Computational Model



Usefulness of the Computational Model

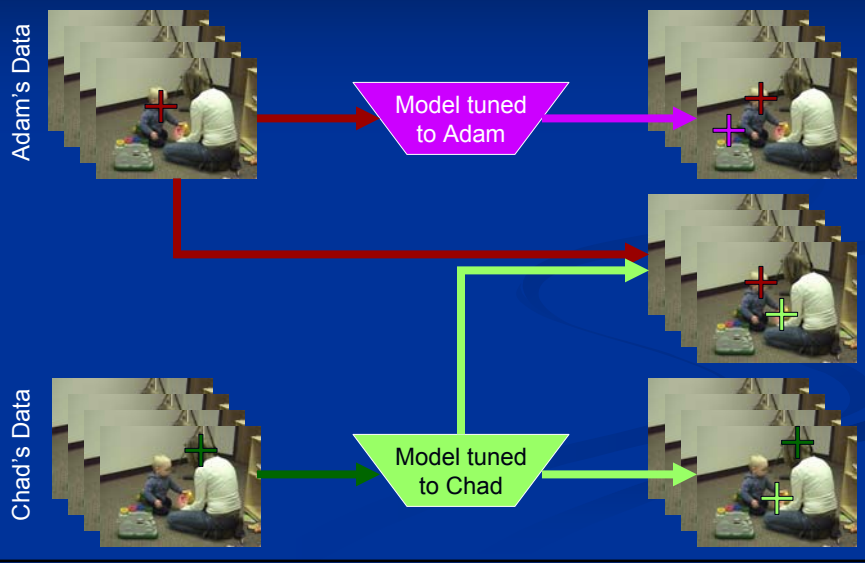
- Attention models are parametric
  - Linear weights, thresholds for edges, sensitivity of orientation filters, etc.
- Optimization problem
  - Find the parameter set that produces the most similar behavior to a particular individual
- Comparisons
  - Performance comparison (model vs. data)
  - Functional comparison (model vs. model)

Similarity Metrics



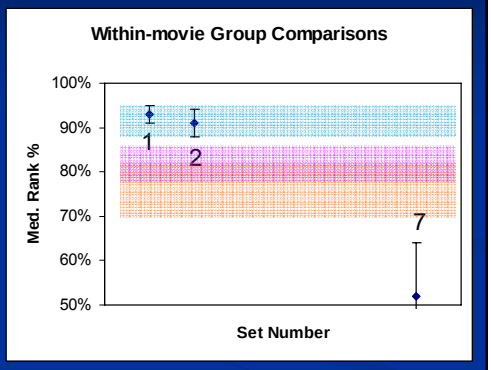
- Euclidean distance is a horrible measure
- Must account for underlying image properties
- Rank-order image locations based on featural similarities between those underlying image patches

Comparisons



Evaluation of Optimized Attention Systems

	Name	Model	Data	Rank
1	Control on Self	C_i	C_i	93%
2	Autistic on Self	A_i	A_i	91%
7	Random on human	R_i	C_j , A_k	52%



- Strata of common strategies
  - Good transfer within control group
  - Some transfer within autistic group
  - Some transfer between groups
- All better than random

(Shic & Scassellati, 2005)

Top-Down or Bottom-Up?

- Multiple explanations for strategy differences
  - Top-down
    - Social context processing
  - Bottom-up
    - Differences in processing low-level visual features
- Solution
  - Manipulate high-level social context while maintaining the same low-level visual features

Scene Inversion

Thompson, P. (1980).

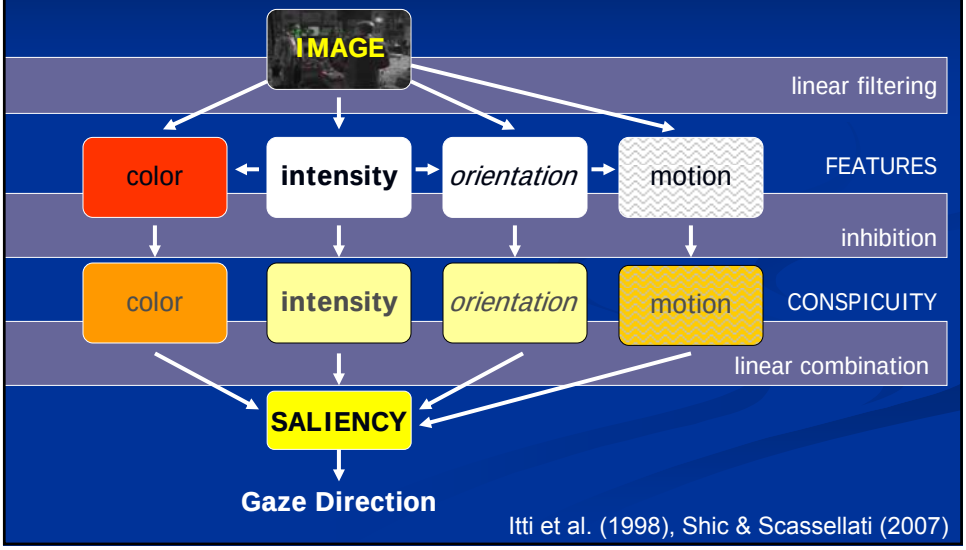
Stimuli for Manipulating Social Context

	Mute	Sound
Inverted		
Upright		

Subjects

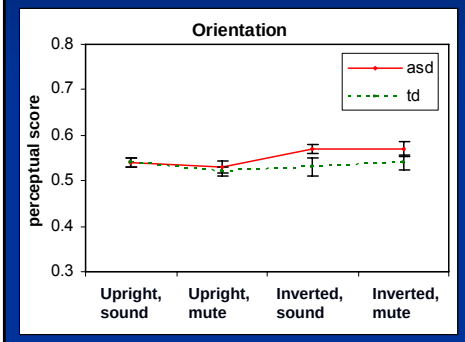
	ASD	TD
N (M:F)	31 (26:5)	15 (13:2)
Age (mo)	42.2 (12.1)	39.2 (16.5)
$N_{sessions}$	49	24
$N_{viewings}$	157	88

Computational (Robotic) Models of Attention



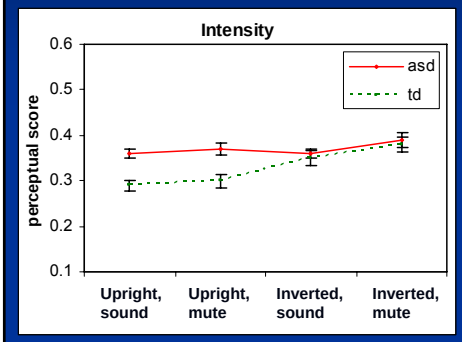
Itti et al. (1998), Shic & Scassellati (2007)

Results (1)



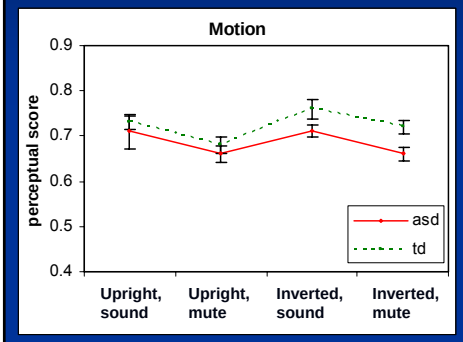
- **Color and Orientation:**
  - No effects for Diagnosis, Scene Inversion, or sound

Results (2)



- **Intensity:**
  - Diagnosis* *(ASD>TD)*
  - Scene Inversion** *(inverted>upright)*
  - Diagnosis x Inversion** *ASD: inverted = upright; TD: inverted > upright; inverted: ASD = TD; upright: ASD > TD*
- Consistent with perceptual work
  - McCleery et al. (2007); Bertone et al. (2005)
  - Tantam et al. (1989)

Results (3)

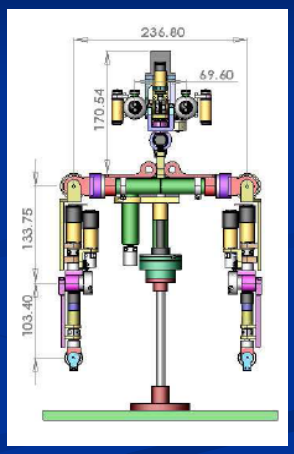


- **Motion:**
  - Diagnosis* (ASD<TD)
  - Scene Inversion* *(inverted>upright)*
  - Sound** *(sound>mute)*
- Consistent with previous work:
  - Frith (1989), Milne et al. (2002), Blake et al. (2003), Spencer et. al. (2000)
  - Sekuler R. et al. (1997).

Conclusions

- Results consistent with perceptual literature:
  - ASD individuals use more contrast, less motion
  - ASD individuals less affected by scene inversion
  - Motion & sound interaction
- Previous perceptual work focuses on older individuals
  - Our work shows that these results might be applicable even at an earlier age
  - Extendable to the naturalistic world

Back to Robots…



Acknowledgements

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