

ERPs Reveal Atypical Neural Response During Empathy for Physical and Social Pain in ASD

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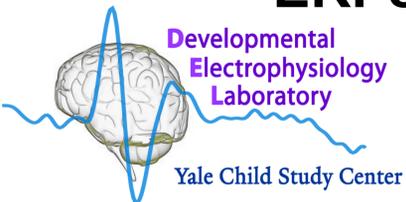
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BACKGROUND

Empathy is a core social ability affected in autism spectrum disorders (ASD) manifest in:

- Lower self-reported empathy and difficulties representing others' mental states.
- Atypical patterns of brain activation during emotion recognition and reduced embodied empathy during physical pain.

Empathy for physical and social pain recruits distinct and overlapping neural networks in typical development (TD):

- Empathy for physical pain recruits affect-encoding brain regions (e.g., anterior cingulate cortex, insula).
- Empathy for social pain recruits mentalizing networks (e.g., dorsomedial prefrontal cortex, precuneus).
- Enhanced activation in affect-encoding regions during observed physical pain is also seen in highly empathic individuals during empathy for social pain.

Our previous work in TD adults revealed that autistic traits modulated event-related potential (ERP) markers of empathic processing for both physical and social pain:

- N110: a short-latency marker of empathic distress.
- P300: an index of cognitive appraisal and stimulus categorization.

Neural markers of empathic response to social pain in ASD remain unexplored.

The current study investigates:

- The temporal dynamics of empathy for physical and social pain in ASD versus TD.
- Relations among neural responses to observed social pain, empathic traits, and social function in ASD.

METHOD

PARTICIPANTS

- 14 TD male adults (2 left-handed)
- 7 male adults with ASD (1 left-handed)

Table 1. Participant Demographics

	Age		EQ Score		SRS-A-SR Score	
	M (SD)	Range	M (SD)	Range	M (SD)	Range
ASD	22 (3)	19-28	36 (14)	15-54	67 (18)	44-91
TD	21 (2)	18-25	38 (9)	27-56	--	--

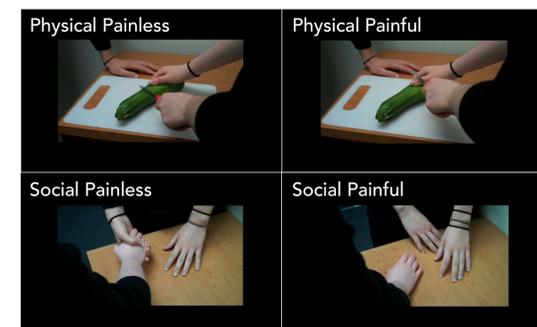
SELF-REPORT BEHAVIORAL MEASURES

- The Social Responsiveness Scale; Adult Self-Report (SRS-A-SR)
- 65-item measure of social functioning in adults.
- The Empathy Quotient (EQ)
- 40-item measure of cognitive empathy, emotional reactivity, and social skills.

STIMULUS SET

- 60 dynamic videos and 60 static images depicting hands in painful/painless scenarios (15 per condition).

Figure 1. Example static stimuli. Static stimuli depict the last frame of the preceding video.



METHOD

EXPERIMENTAL DESIGN

- Three experimental manipulations:
 - **Type** of stimuli (Social/Physical)
 - **Pain** depicted in stimuli (Painful/Painless)
 - **Task** (Count/Rate)
- **Task** manipulated attention:
 - **Count** the bracelets on actors' wrists (1-4)
 - **Rate** distress to observed pain (1-4)
- Four blocks, counterbalanced for sequence
- 60 trials per block (30 painful, 30 painless trials randomized within block)
- Each trial included a video and a static image depicting the video's final frame.

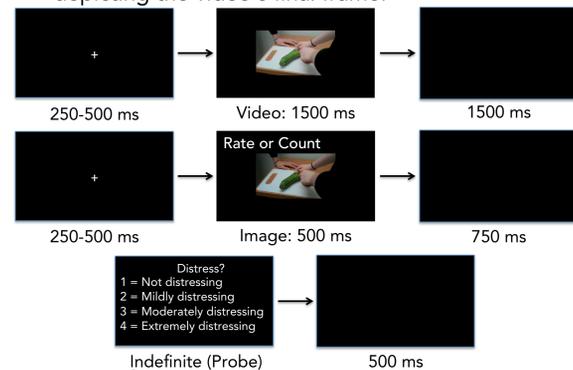
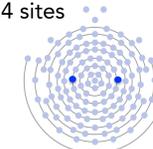


Figure 2. Trial structure

DATA ACQUISITION AND EXTRACTION

- EEG recorded continuously at 250 Hz
- Hydrocel Geodesic Sensor Net 128
- Data segmented to static image (100 ms pre-stimulus baseline, 550 ms post-stimulus) and average-referenced
- Peak amplitude and latency for the N110 (90-170 ms) and P300 (300-550 ms) extracted at C3 and C4 sites

Figure 3. C3 and C4 recording sites



STATISTICAL ANALYSIS

- Peak amplitude and latency were analyzed using multivariate repeated measures ANOVA.
- 4 within-subjects factors
 - **Type** (Social/Physical)
 - **Task** (Count/Rate)
 - **Pain** (Painful/Painless)
 - **Hemisphere** (Left/Right)
- Between-subjects factor
 - **Diagnosis** (ASD/TD)
- Bivariate correlations were computed among amplitude and latency difference scores and behavioral scores.

RESULTS: FIGURES

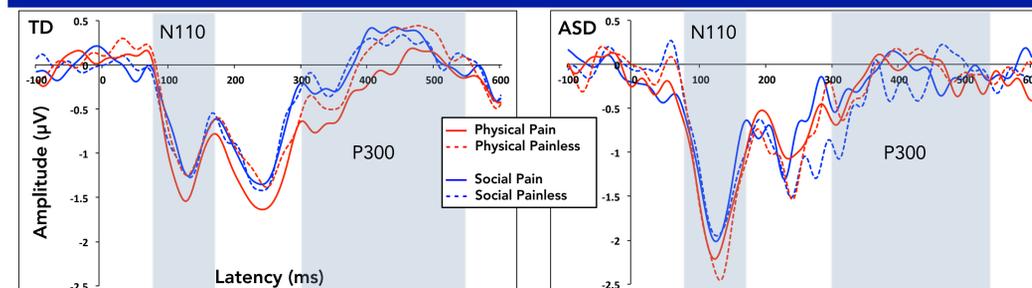


Figure 4a. Waveforms to observed physical and social scenarios (painful and painless) in TD.

Figure 4b. Waveforms to observed physical and social scenarios (painful and painless) in ASD.

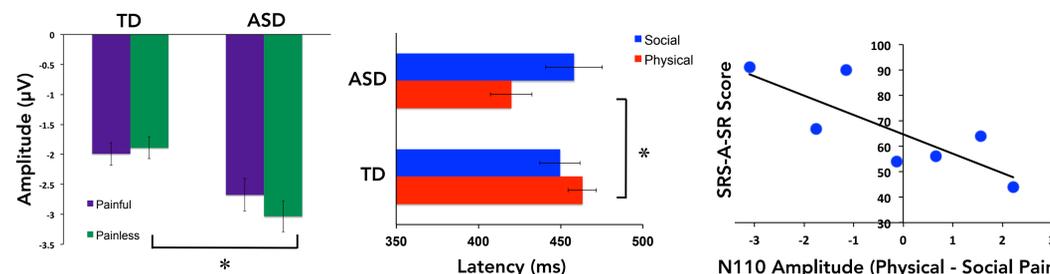


Figure 5. N110 amplitude to observed painful and painless scenarios in TD v. ASD (across hemispheres).

Figure 6. P300 latency to physical and social scenarios in TD v. ASD (right hemisphere).

Figure 7. Correlation of SRS-A-SR scores with a neural index of social pain sensitivity at the N110 in ASD (left hemisphere).

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RESULTS: SUMMARY

ERP RESULTS

- **N110 Amplitude:** Interaction between Diagnosis and Pain [$F(1,19)=5.941, p=.025$]:
 - N110 amplitude to painless scenarios in ASD>TD [$t(19)=4.038, p=.001$].
- **P300 Latency:** Interaction of Diagnosis, Type, and Hemisphere [$F(1,39)=9.425, p=.006$]:
 - P300 latency to social scenarios longer than to physical scenarios in ASD [$t(6)=2.327, p=.059$] but not in TD [$t(13)=, p=.188$] in the right hemisphere.
 - Right-hemisphere P300 latency to physical actions in TD>ASD [$t(19)=2.791, p=.012$].

ERP-BEHAVIORAL CORRELATIONS

- EQ scores correlate with the difference in P300 amplitude between observed physical and social pain in the right hemisphere across diagnostic categories [$r=-.641, p=.002$]:
 - Higher trait empathy is associated with greater amplitude to social versus physical pain.
- EQ scores correlate with the difference in P300 amplitude between observed socially painful and painless scenarios in the right hemisphere across diagnostic categories [$r=.573, p=.007$]:
 - Higher trait empathy is associated with greater amplitude to socially painful versus painless scenarios.
- SRS-A-SR scores in ASD correlate with N110 amplitude differentiation between observed physical and social pain during the rating task [$r=-.801, p=.030$]:
 - Higher social function in ASD is associated with greater amplitude to social relative to non-social pain in the left hemisphere.

CONCLUSIONS

- ERPs revealed disruption of brain mechanisms regulating affective response to observed pain/lack of pain, as indexed by the N110 component, in ASD.
- During affective stages of empathic processing, enhanced sensitivity to social pain at the N110 was associated with greater overall social functioning in ASD.
- ERPs indicated delayed neural processing of social actions and faster processing of physical actions, as indexed by the P300 component, at cognitive stages of empathic processing in ASD.
- During cognitive stages of empathic processing, self-reported empathy was associated with greater sensitivity to social pain at the P300 component in TD and ASD.

IMPLICATIONS

- The neural response to observed social pain is closely associated with empathic functioning in both typical and atypical development.
- Early emotional response to others' pain may serve as an indicator for treatment selection and a metric of outcome for social skills interventions in ASD.
- Research in progress in our lab explores the modifiability of this response in children and adults with ASD.

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