Neural Mechanisms of Empathy for Physical and Social Pain and Their Relation to Autistic Traits

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BACKGROUND

Empathy is critical to effective communication and social relationships.

- Individuals with autism demonstrate atypical empathic responses to others' distress and reduced drive to empathize, contributing to social impairment.
- Autistic personality traits predict empathic drive in the typical population as well as in ASD. Autistic traits are associated with attenuated drive to empathize.

Functional neuroimaging studies have identified distinct neural networks supporting empathy for others' social and physical pain.

- Empathy for others' physical pain primarily recruits affect-encoding brain regions (anterior cingulate cortex and anterior insula).
- Empathy for others' social pain correlates with greater activity in mentalizing brain regions (e.g., medial prefrontal cortex).
- Individuals with autism demonstrate atypical patterns of hemodynamic response in these critical neural networks during empathizing and mentalizing tasks.
- This suggests a possible neural basis for reduced empathic drive in ASD.

Recently, electroencephalography (EEG) has been applied to study the temporal dynamics of empathic processing.

- Event-related potential (ERP) studies in typically developing populations reveal a distinct early, attention-independent response and a late, attention-dependent response to other's physical pain.
- No studies have yet explored the temporal dynamics of empathy for social pain, in spite of its relevance to social understanding.

This study investigates for the first time:

- The time course of neural response to observed social pain.
- The relationship between autistic traits and observed neural response to physical and social pain at temporal components indexing the early and late stages of empathic processing.

METHOD

PARTICIPANTS

- 30 typical adults (18-23 years) pre-screened for autistic traits and empathic drive.
- Assigned to "high" and "low" autistic trait groups based upon a cutoff score of 20 on the Autism Quotient.

BEHAVIORAL MEASURES

- Autism Quotient (AQ)
- Empathy Quotient (EQ)

STIMULI

- 60 video primes and 60 static images depicting hands in painful/ painless scenarios.
  - 15 physically painful
  - 15 physically painless
  - 15 socially painful
  - 15 socially painless

Table 1: **Participants**

Group	AQ	Sex	Handedness
High AQ (n = 12)	Mean = 24 Range = 21 - 26	Male: 6 Female: 6	Right: 11 Left: 1
Low AQ (n = 18)	Mean = 14 Range = 4 - 20	Male: 7 Female: 11	Right: 16 Left: 2

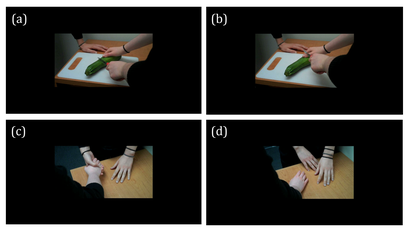

Figure 1. **Example static images.** Sample stimuli showing (a) a painless physical scenario, (b) a painful physical scenario, (c) a painless social scenario, and (d) a painful social scenario. Static images depicted the last frame of the preceding video.

METHOD

EXPERIMENTAL DESIGN

- Attention manipulation at static image:
  - **Rate** how distressing the observed pain is (1-4)
  - **Count** the number of bracelets on the actors' wrists (1-4)
- Four blocks, counterbalanced for sequence
- Two experimental manipulations:
  - Type (Physical, Social)
  - Task (Rate, Count)
- 60 trials per block (30 painful, 30 painless)

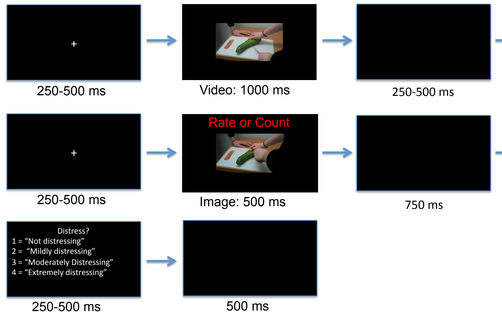

Figure 2. **Trial Structure.** Schematic diagram of a trial.

DATA ACQUISITION AND EXTRACTION

- ERP recorded continuously at 250 Hz
- Electrical Geodesics 128 Hydrocel sensor net
- Peak amplitude and latency for the N110 (90-135 ms) extracted from frontal and central sites
- Peak amplitude and latency for the LPP (720-1000 ms) extracted from frontal sites

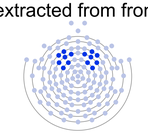

Figure 3. **Frontal electrode sites**

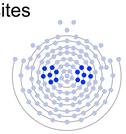

Figure 4. **Central electrode sites**

STATISTICAL ANALYSIS

- N110 and LPP amplitude and latencies to peak analyzed using separate univariate repeated measures ANOVA
  - Four within-subjects factors with two levels each:
    - Type (Social/Physical)
    - Task (Count/Rate)
    - Pain (Painful/Painless)
    - Hemisphere (Left/Right)
  - Between-subjects factor: AQ group (High/Low)
- Bivariate correlation computed for AQ and EQ scores

RESULTS

BEHAVIORAL RESULTS

- High levels of autistic traits correlated negatively with empathic drive ($r(28) = -.60$, $p = .001$).

ERP RESULTS

- Similar morphology and topography of the neural empathic response to social and physical scenarios.

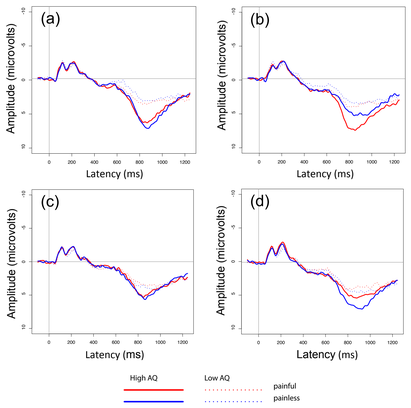

Figure 5. **Electrophysiological Response in High and Low AQ group over frontal scalp.** Plot of amplitude versus latency for (a) Physical Scenarios in Counting Task, (b) Physical Scenarios in Rating Task, (c) Social Scenarios in Counting Task, and (d) Social Scenarios in Rating Task.

ERP RESULTS (continued)

Early processing: N110 (central scalp)

- Overall, longer latency to painful stimuli when attending to distress (rating) versus counting (*Fig. 6*).
- High AQ group showed longer latency to painful stimuli only when attending to distress (rating); low AQ group did not differentiate (*Fig. 7*).

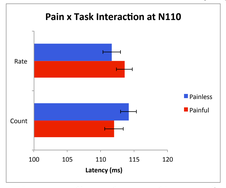

Figure 6. **Interaction of pain by task** ($F(1,28) = 11.31$, $p = .002$)

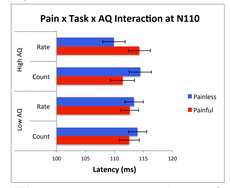

Figure 7. **Interaction of pain by task by AQ** ($F(1,28) = 7.71$, $p = .010$)

Late processing: LPP (frontal scalp)

- Overall, longer latency to social pain than to physical pain (*Fig. 8*).
- Low AQ group showed longer latency to social stimuli at the LPP; high AQ group did not differentiate (*Fig. 9*).

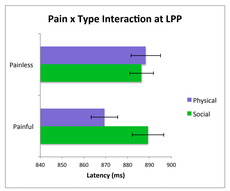

Figure 8. **Interaction of pain by type** ($F(1,28) = 8.102$, $p = .008$)

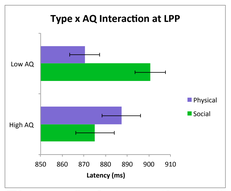

Figure 9. **Interaction of type by AQ** ($F(1,28) = 7.71$, $p = .010$)

CONCLUSIONS

We report for the first time the influence of subclinical autistic traits on the temporal dynamics of empathy for physical and social pain.

Replicating prior behavioral studies, we found that high levels of autistic traits are associated with diminished empathic drive in typically developing individuals.

Participants demonstrated similar morphology and timing of the electrophysiological empathic response to physical and social pain, indicating parallel neural mechanisms.

Consistent with prior ERP studies of the temporal dynamics of empathy for physical pain, we identified an early temporal component (N110) peaking approximately 115 ms after viewing a stimulus.

- At this early stage of empathic processing, participants demonstrated slower neural response to painful compared to painless social and physical scenarios in the rating task, which directed attention to affective dimensions of the stimuli.
  - Attention modulates initial stages of empathic processing.
  - Longer latency for painful stimuli reflects greater cognitive appraisal.
- Individuals high in autistic traits differentiated painful and painless situations when attending to distress, while individuals low in autistic traits showed equivalent appraisal independently of attention or pain content.
  - Low levels of autistic traits may be associated with broad sensitivity to others' experience, independently of pain.

We also identified a long latency positive potential (LPP) over the frontal scalp, peaking approximately 883 ms after viewing a stimulus.

- Neural response to social pain was slower than to physical pain.
  - Processing of social pain requires more extensive appraisal of the context and intentions of social agents.
- Individuals low in autistic traits demonstrate more extensive appraisal for social scenarios. Individuals high in autistic traits trend toward greater appraisal for physical scenarios.
  - Individuals high in autistic traits are more likely to empathically evaluate physical scenarios, reflecting attenuated social empathic drive.

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