Examining movement kinematic differences in Autism Spectrum Disorder and Parkinson’s Disease: a matched-groups comparison study

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Background

What do we know about movement in Autism Spectrum Disorder (ASD) and Parkinson’s Disease (PD)?
• Differences in motor function are apparent in both ASD¹ and PD².
• Both conditions show differences in handwriting³,⁴
• Analysis of movement kinematics has revealed: ⁵
  - Increased jerk in both ASD and PD⁵
  - Increased sub-movements in ASD³ and PD³
  - Increased speed and acceleration in ASD³
  - Decreased speed and acceleration in PD³

Frequency analysis
• The number of curvature oscillations per unit angle of movement is one full 360°/2π (radians rotation)
• E.g., a square has an angular frequency of four as there are four peaks in the curvature of the trajectory when tracing the perimeter

What is a shape’s angular frequency?
• In the general population, individuals adapt their speed as a function of the curvature of their movement⁶
• This gradient of this adaptation is dependent on the shape’s angular frequency⁶

What does this relate to ASD and PD?
• Problems with handwriting may be explained by inappropriate modulation of speed as a function of curvature
• To date, studies of ASD and PD have not looked at kinematic variables along the angular frequency spectrum

Exploratory Analyses

Participants
Autistic individuals x30
Individuals with Parkinson’s Disease (both ON and OFF dopaminergic medication) x30
Control participants x30

Step 1 – Online Measures:

Demographics
Age
Gender
Diagnosis
Handedness
Medications

Questionnaires
Autistic traits → The Autism Quotient
Movement difficulties → The Adult DCD/Dyspraxia Checklist (section 2: current functioning)
Alexithymic traits → The Toronto Alexithymia Scale

Non-Verbal Reasoning
The Matrix Reasoning Item Bank
• Each trial: select the appropriate shape to fill the empty cell of a 3 x 3 matrix

Step 2 – Shape Tracing Task
Participants will trace shapes on a touchscreen device.
• 4 blocks of 12 trials
• Each block: different shape, presented in a random order
• The four shapes cover a range of different angular frequencies
• Movement trajectories will be recorded (x and y coordinates over time)

Kinematic Variables
Velocity, acceleration and jerk
• First, second- and third order non-null derivatives of the raw positional data

Sub-movements
• % of frames which comprise an acceleration sign change (i.e., a flip from accelerating to decelerating)

Beta values
• How participants modulate their speed as a function of each shapes’ curvature (i.e., the gradient between speed and curvature)

Methods

Analysis Plan

Group matching
• Age and non-verbal reasoning (between-groups ANOVAs), gender (chi-squared)

Group differences
• Autistic traits, motor difficulties and alexithymic traits (between-groups ANOVAs)

Linear mixed models
• Separate analyses for each kinematic variable
• Fixed effects: group, shape, group*shape
• Random effects: trial number, participant number

Expected Results

Significant effects of group
We anticipate increased jerk and sub movements for both the ASD and PD-OFF groups relative to the PD-ON and CTRL groups (Graph A)
However, we expect increased and decreased velocity, acceleration and beta values for the ASD and PD-OFF groups respectively, relative to PD-ON and CTRL (Graph B)

Exploratory Analyses

If group differences in jerk are found...
• Random forest analysis for each group to determine importance of velocity, sub-movements and beta values in predicting jerk

If group differences in beta values are found...
• Participants may not be appropriately modulating their speed for given shapes
• We can decompose movement data into a spectrum of energy in the angular frequencies that make up the movement (e.g., we would expect square movements to have high energy around 1)
• Frequency analysis – assess differences in energy in angular frequency bands for each shape and group

Preliminary Findings

ASD pilot study
• Increased speed, jerk, sub-movements and beta values in ASD compared to controls
• Bigger difference between groups at higher angular frequencies

Dopamine D2 receptor antagonist haloperidol study
• Decreased velocity, acceleration, jerk and beta-values in drug compared to placebo

References