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

PREREGISTRATION POSTER

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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 ASD[1] and PD[2]
- Both conditions show **differences** in **handwriting**[3, 4]
- Analysis of movement kinematics has revealed:
  - **Increased** *jerk* in both ASD[5] and PD[6]
  - **Increased** *sub-movements* in ASD[7] and PD[8]
  - **Increased** *speed* and *acceleration* in **ASD**[5]
  - **Decreased** *speed* and *acceleration* in **PD**[6, 9]

What is a shape's angular frequency?

- The number of **curvature oscillations** per unit angle of θ (where θ 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

How does angular frequency relate to movement kinematics?

- In the general population, individuals **adapt** their **speed** as a function of the **curvature** of their movement[10]
- This **gradient** of this adaptation is dependent on the shape's **angular frequency**[11]

How 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**

Why is it important to investigate similarities between ASD and PD movement?

- An **increased prevalence** of PD has been reported in ASD[12]
- **Similarities** between ASD and PD **movement** have been noted[13]
  → ASD movement may "look like" PD movement
- **PD** is often **diagnosed** based on **motor function**
  → Recent suggestions of diagnosis from handwriting analysis (~90% accuracy)[14]
- **Overlap** between ASD and PD **movement** may **explain** higher levels of **diagnosis**

What insight will this study provide?

- At present, **no studies** have **directly compared** ASD and PD movement
  → This study will implement a **matched-groups design**
- More **in-depth investigation** of movement similarity is **needed**
  → This study will investigate overlap in a range of **movement kinematic variables**, taking into account the **angular frequency spectrum**

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
→ ANOVA on model coefficients

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)
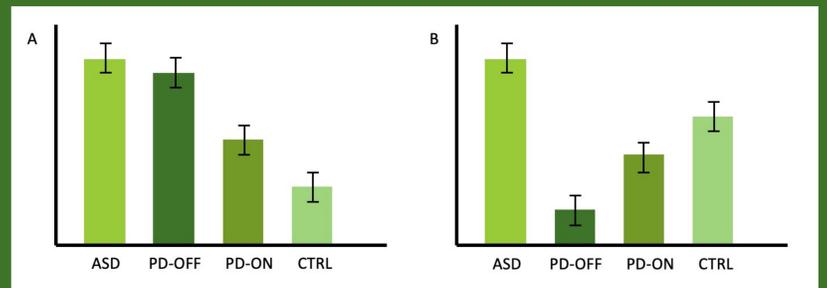
Effects of shape
→ Our analyses will reveal whether **kinematics vary** along the **angular frequency spectrum**

Interaction between shape and group
→ Our analyses will reveal whether there are **group differences** in the **relationship** between **kinematics** and **angular frequency**

Exploratory Analyses

If group differences in jerk are found…

→ Random forest analysis (or similar) 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 4)
→ Frequency analysis – assess differences in energy in angular frequency bands for each shape and group

Exploratory analysis of traits…

→ Do autistic traits, motor difficulties or alexithymic traits predict kinematic variables or mediate relationships observed?

Methods

Participants

| Autistic individuals x30 | Individuals with Parkinson's Disease (both ON and OFF dopaminergic medication) x30 | Control participants x30 | Matched on age, gender, and non-verbal reasoning |

Step 1 – Online Measures

Demographics

Age
Gender
Diagnosis
Handedness
Medications
Ethnicity

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

Approx. 30 mins; PD complete ON medication

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)

4/5   4/3   2   4
Angular Frequency
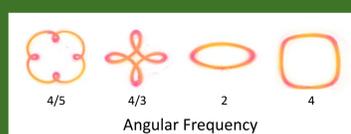
Approx. 20 mins; PD complete both ON and OFF medication

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).

Preliminary Findings

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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

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