Kinematic and Force Control Features in Autistic Adults during Curvilinear Movements

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Background

Motor challenges have been reported in 87% of autistic children (Bhat, 2021) and may persist into adulthood (Cho et al., 2022), which could underpin autistic social difficulties.

The two-thirds power law (2/3 PL) defines the relationship between moving speed and the curvature of moving path. Different adherence to 2/3 PL was observed in autistic children (Fourie et al., 2022), but not yet tested in autistic adults. Additionally, force modulation is affected in autistic individuals (Shafer et al., 2021). Force quantification during the curvilinear motion task could help further understand autistic motor regulation during the 2/3 PL task.

This study contributes to the computational characterisation of 'autism motor signature' (Anzulewicz et al., 2016), leading to a better understanding of motor challenges and required support in autism.

Methods

Nine autistic and twelve typically developing adults, age ranged 19-57 years, participated in this study. Participants used an Apple Pencil to trace and draw ellipses on an iPad Pro 11-inch tablet while timestamped on-screen trajectory and force data were recorded. An elliptical path was shown on screen for tracing while an empty canvas was provided for drawing ellipses (Figure 1).

Each participant performed 5 trials of tracing and then 5 trials of drawing activities. Each trial lasted around 15 seconds. The longest continuous movement was extracted from each trial for further analyses.

The β value representing adherence to 2/3 PL was computed using the equation below:

$$\text{Tangential Velocity} = K * \text{Radius of Curvature}^{\beta}$$

Force data were first normalised by the maximum value of the trial and then averaged, indicating the average ratio of force applied with respect to the maximum force.

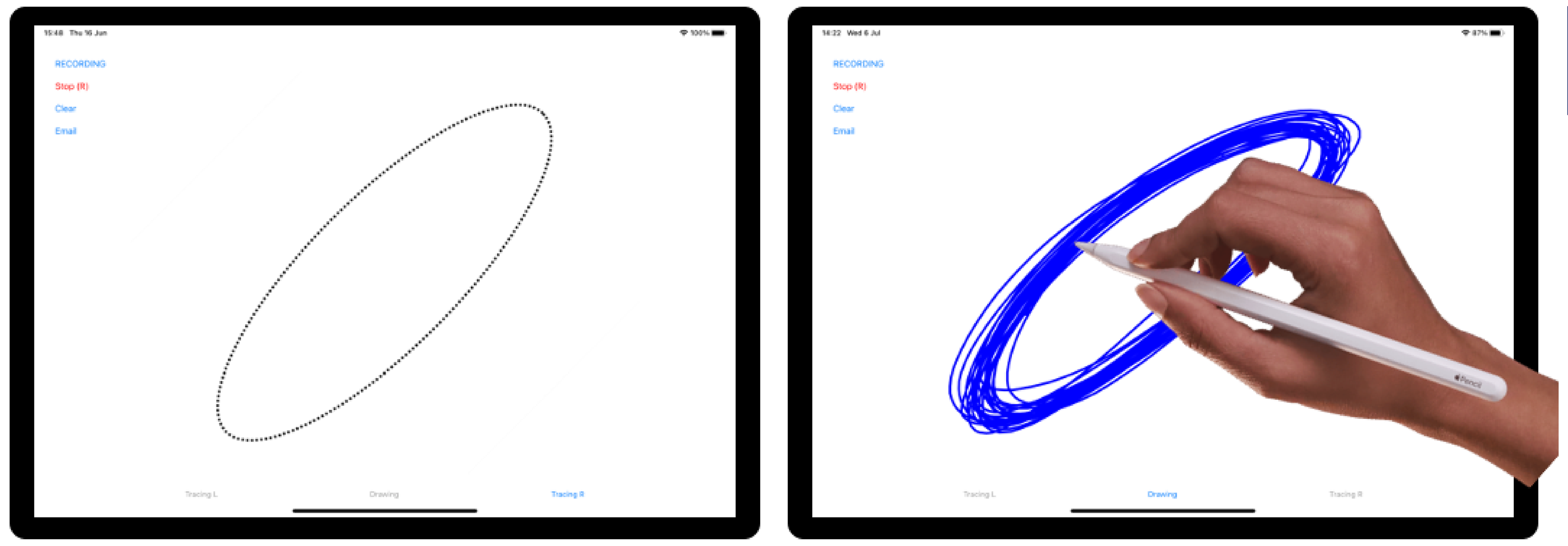

Figure 1. Participants used an Apple Pencil to first trace an elliptical trajectory on an iPad Pro 11-inch tablet and then draw ellipses on an empty canvas. Timestamped trajectories and force during tracing and drawing activities were recorded.

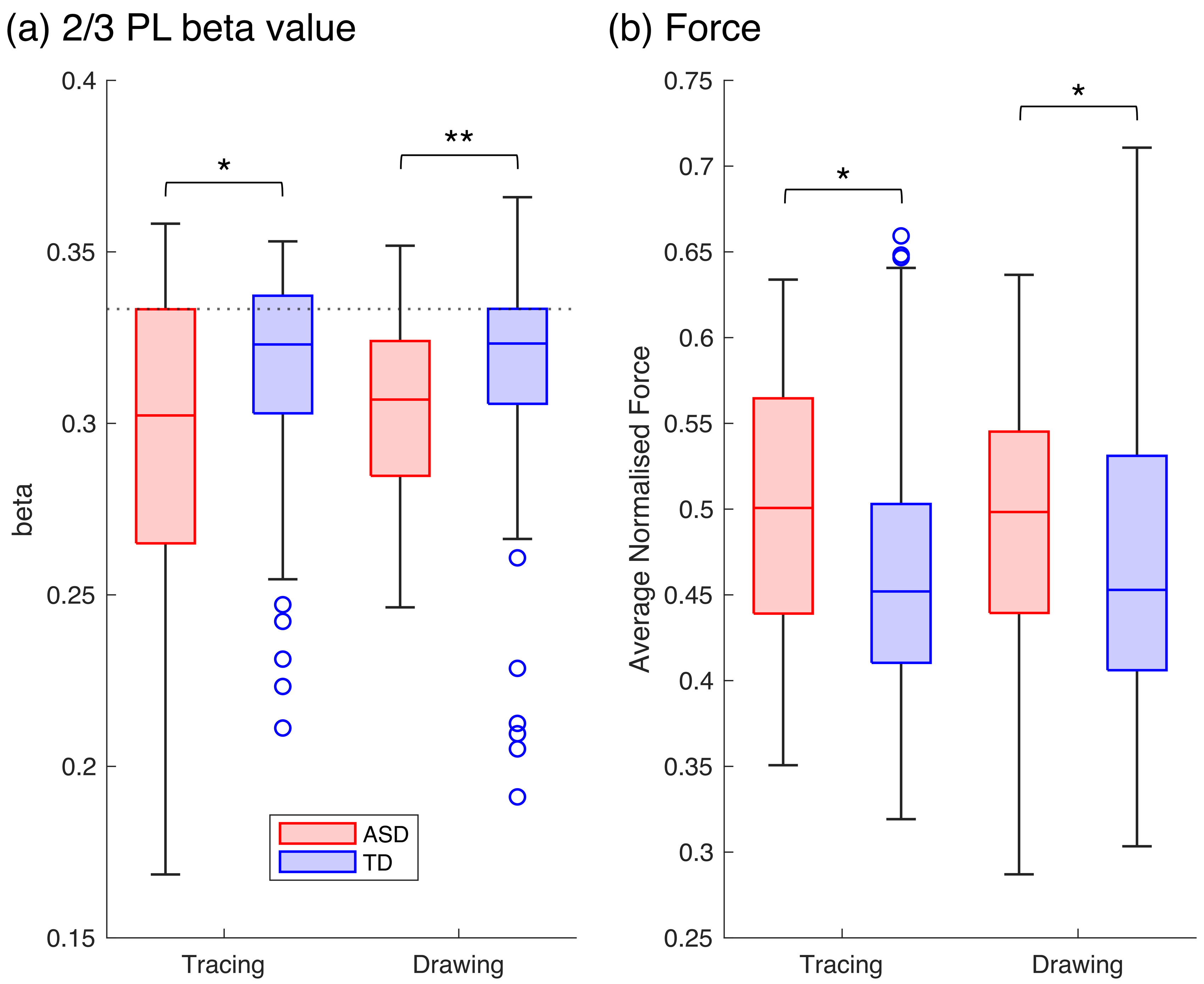

Figure 2. In comparison to typically developing adults (TD), autistic adults (ASD) demonstrated **(a)** greater deviation from the two-thirds power law (dash line, beta = 1/3) and **(b)** higher normalised force during both ellipse tracing and drawing activities (* $p < 0.05$; ** $p < 0.01$; Kolmogorov-Smirnov test).

Results

Greater deviation from the 2/3 PL in ASD

In comparison to typically developing adults, autistic adults demonstrated greater deviation from the 2/3 PL (β=.333) in both tracing (ASD Mdn=.302, TD Mdn=.323, p=.010) and drawing (ASD Mdn=.306, TD Mdn=.323, p=.002) activities (Figure 2a).

Greater normalised force in ASD

Autistic adults also applied greater normalised force in both tracing (ASD Mdn=.501, TD Mdn=.452, p=.038) and drawing (ASD Mdn=.498, TD Mdn=.453, p=.032) activities than their typically developing counterparts (Figure 2b).

Conclusions

This study revealed the kinematic and force control differences in autistic adults during ellipse tracing and drawing activities. These differences may lead to an impact on their quality of life as curvilinear movements are essential in daily life activities such as writing, ball throwing, and turning a car wheel.

Understanding the motor control differences in ASD could help develop intervention plans to overcome motor challenges and hence improve their quality of life.

Furthermore, these motor control differences may be related to their brainstem function (Delafield-Butt & Trevarthen, 2018). This research paradigm could support future investigations on the relation between motor features and brain function.

References

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