External Fine Motor Markers of Neurodivergence: Pilot Results of the TangiBall

W J Farr[1], S McGrevey[2], P Breedon[3], Y Wei[4], L Siena[5], J Starkey[6], I Male[7]

[1]Faculty of Education, University of Cambridge, Hills Road, Cambridge, UK

[1,2,7]Sussex Community NHS Foundation Trust, Brighton, UK

[1,7]Brighton and Sussex Medical School, Brighton, UK

[3-5]Nottingham Trent University, Nottingham, UK

[6]University of Sussex, Falmer, Brighton, UK

[2]University of Surrey, Guildford, UK

[1]wjf33@cam.ac.uk

ABSTRACT

At two previous ICDVRAT conferences (2018, 2022) the authors reported on the concept, and then development phase of a tangible toy that could be used to assist in the diagnosis of autism in pre-school children. Here, results of the first round of testing on the intended user group are reported. Results show variation between pre-school neurodivergent and neurotypical populations as predicted in terms of speed and accuracy of movement. Fine motor movement can be a potential biomarker for autism that would be less dependent on observational data, and more objective.

1. INTRODUCTION

Autism is a challenging diagnosis to make in children, especially those who are primary school age and those who are pre-school with an unclear cluster of symptoms. Children who receive diagnoses quickly are generally either severe and with intellectual disability, or extremely clear in presentation (Abrahamson et al., 2021). Original diagnostic descriptors that pre-date both the World Health Organisations International Classification of Disease (ICD), and the United States Diagnostic and Statistical manual of Disorders (DSM) of Grunya Sukhererva in the Soviet Union in the late 1920s suggest that children with autism have additional disorders in motor function as well as in social communication (Sher & Gibson, 2021). These additional areas currently manifest in the manuals as interoceptive, sensory impairment, and even as emotional regulation problems rather than as disorders with origins in divergent proprioceptive and receptor activity (Torres et al., 2018; Torres et al., 2013; Torres & Denisova, 2016). The single biggest problem with autism diagnosis is in the agreement on presentation, and the majority of diagnostic tools have either relatively poor sensitivity or specificity, resulting in a national screening programme in the United Kingdom being repeatedly dismissed (UK National Screening Committee, 2022) . Subjective Observational Inventories (SOIs) e.g., Autism Diagnostic Observation Schedule, result in there being no single clear biomarker for autism (Bokadia, Rai and Torres, 2020) .

2. METHOD

2.1. TangiBall

The TangiBall is an attempt to look at a singular external marker - fine motor activity - to see if this aligns with variation between neurodivergent populations and neurotypical presentation. Fine motor activity in this feasibility pilot study was detected through the insertion and removal of a jack into a hole which is locked into place with a shape indentation (see figure 1). TangiBall is a hub toy of 12 faceplates (see diagrams 1 below). Speed and accuracy of insertion were measured with LEDs, sensors, an SD card, and a microcontroller. Sensor faceplates have a unique shape point on the surface, and correct shape insertion elicits the hub to light-up and then a “reward” sound is played. Accuracy is determined by how easily a child can find the correct insertion faceplate, and speed refers to how fast the peg is inserted into the faceplate once the correct shape is identified. Each input peg provides movement time in milliseconds in real time, and an analogue to digital convert number (ADC) which can be

converted into voltage for data processing. Data was stored in basic .txt format in the SD card within the hub housing. When raw data of time versus voltage is graphed, this produces gradient curves showing insertion, removal actions of the child, as well as activity whilst just holding and turning over the hub.

2.2. Participants

The study was given NHS Research Ethics clearance in February 2022. Children with a diagnosis of autism, or suspected autism were recruited from one single NHS trust in the South of England, after an approach by a known clinician. Information was then passed to the research team to recruit and consent. Five children with autism and five children who have never had any contact with child development services were recruited to the study. Children played with the TangiBall between June 2022 and March 2023 when the project closed. All children played with the TangiBall long enough for there to be a registered result. On average 5 minutes of interactive play produced around 10,000 lines of data.

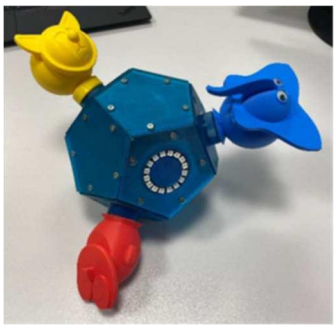

Figure 1 *TangiBall prototype*

3. RESULTS

3.1. Quantitative Findings

Five children with autism and five controls played with the TangiBall between June 2022 and March 2023. Mean age in both groups was Autism, 41.24 months, and Controls, 49 months. Average insertions and removals by children with autism indicated less control than the control group (average voltage Autism, 518v). A child's ability to smoothly insert and extract the tangible peg into the correct hole showed that the autism group were less controlled than the neurotypical group (voltage Autism, 077v, and Control, 0.12v, SD). This is consistent with previous literature. Children with autism also played with the object for a shorter amount of time than control peers overall (width ms average, autism, 5348 milliseconds, SD 8532ms, control 6755ms, SD 6429ms). Autistic children were showing less smooth insertion, and also playing for less time overall. Overall Lempel-Ziv complexity of baseline scores showed variance even when children were just playing with hub and not inserting or removing insertion pieces (autism 0.71, SD, Control 0.69). Even when the hub was not fully engaged with utilising insertion pieces, autistic children showed interest in the hub marginally more than control group children.

4. CONCLUSION

This work aimed to explore the viability, integration and acceptability of data gathered during interactions that are ecologically sound e.g., for children that would most likely be with objects such as toys or during play situations and are potentially clinically useful. Data collected in a smooth and uninterrupted manner whilst engaging with professionals is paramount. Currently, data that could be gathered from children as they interact naturally is only harnessed through recall and observation. The ultimate problem is with subjective observation, and this was an attempt to begin to automate the process. With the rise of the neurodiversity civil rights movement, there is also a clear delineation required between those who are neurodivergent – that is that have a condition that impairs social functioning and requires clinical diagnosis or support, and the neurodiverse, those within the normal distribution in a population.

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