TangiBall: Development of a Prototype Tangible User Interface for Detection of Speed and Accuracy Variation in Pre-School Autistic Children

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1. Abstract

- **The creation of digital tools to assist in diagnostic pathways for children at-risk of autism is a priority due to increased prevalence.**
- **This project reports on the development of a tangible user interface as an ecologically valid option for children at-play in clinic**
- **The toy aims to assist in useful data capture for pre-school populations.**

2. Introduction

- The National Health Service in England has undergone significant transformation in the last two years, not least because of the international pandemic, but because of the impact of implications of the NHS Long term plan (NHS England, 2019).
- A crux point for this plan involves future care and services provided for Autistic children, Autistic adults, and children yet to be diagnosed - against a backdrop of increased prevalence worldwide (Aronson et al., 2021).
- One aspect now vital is the creation of digital tools to assist diagnostic pathways, and the creation of digital pathways
- This team reported on the pilot of a graphical user interface (GUI) toy (Farr & Male, 2021; Jordan et al., 2017)
- This tangible user interface (TUI) works as an additional option to the GUI to assist data capture of useful clinical data in the pre-school - rather than school-aged - population, building on prior rationale (Farr & Male, 2018).

2. Motor Function in Autistic Children

- Data on children's motor function shows that children with neurodevelopmental disorders occupy a qualitatively different developmental trajectory (Mari et al., 2003; Torres et al., 2013, 2013).
- Early stochastic experiences are initially shaped by levels of parental interaction and from there development diverges (Torres et al 2013)
- Prospective motor control in autism is different between ASD/TD children in time and speed of movement, and only increases with age (Chua et al, 2021)
- By the teenage years, atypical development has led to a vast array of compensatory strategies which reflect divergent development and hard-wired responses (Torres et al., 2013).
- Any delay in identification leads to optimal windows of therapeutic and interventional care being hampered, severely impacting future quality of life (Abrahamson et al., 2021).

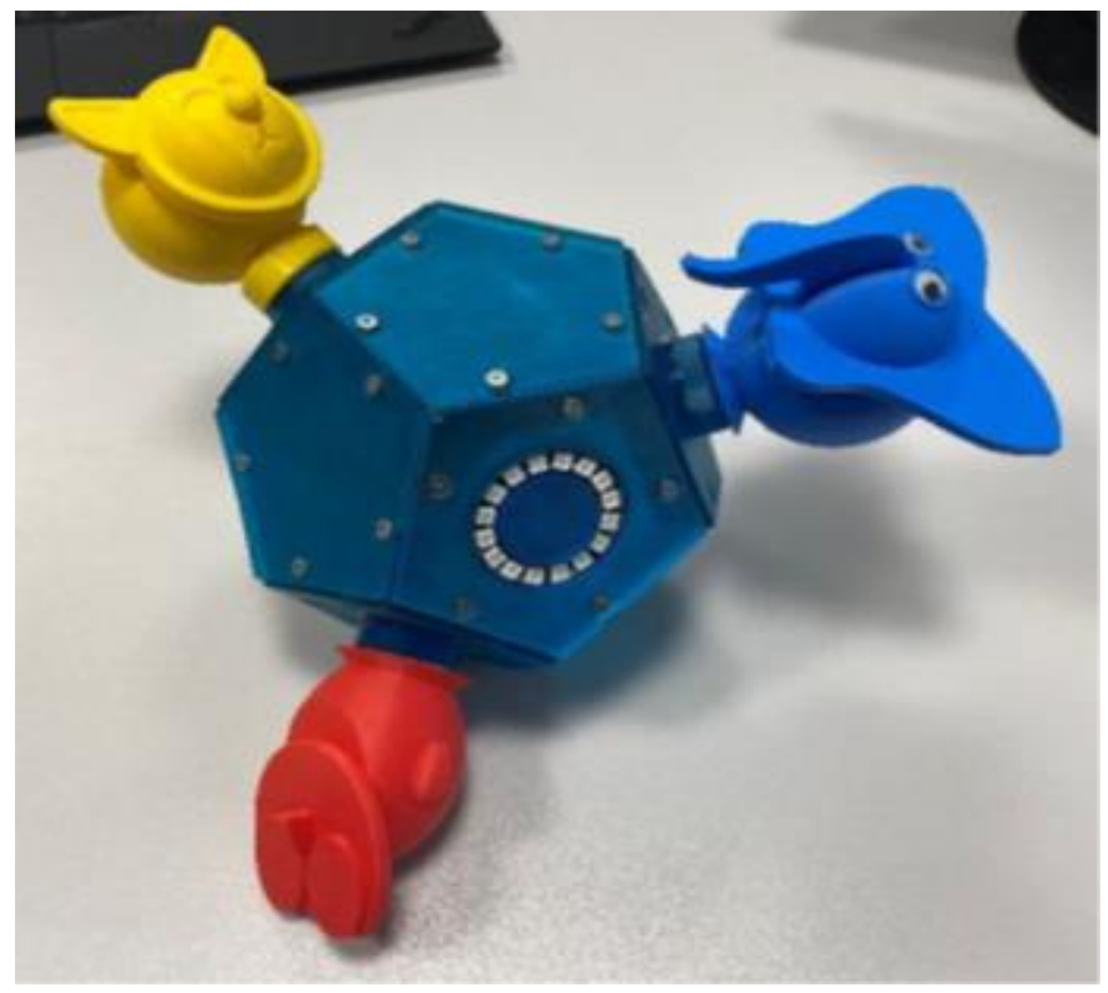

Figure 2. Tangiball tool showing insertion jacks and main hub

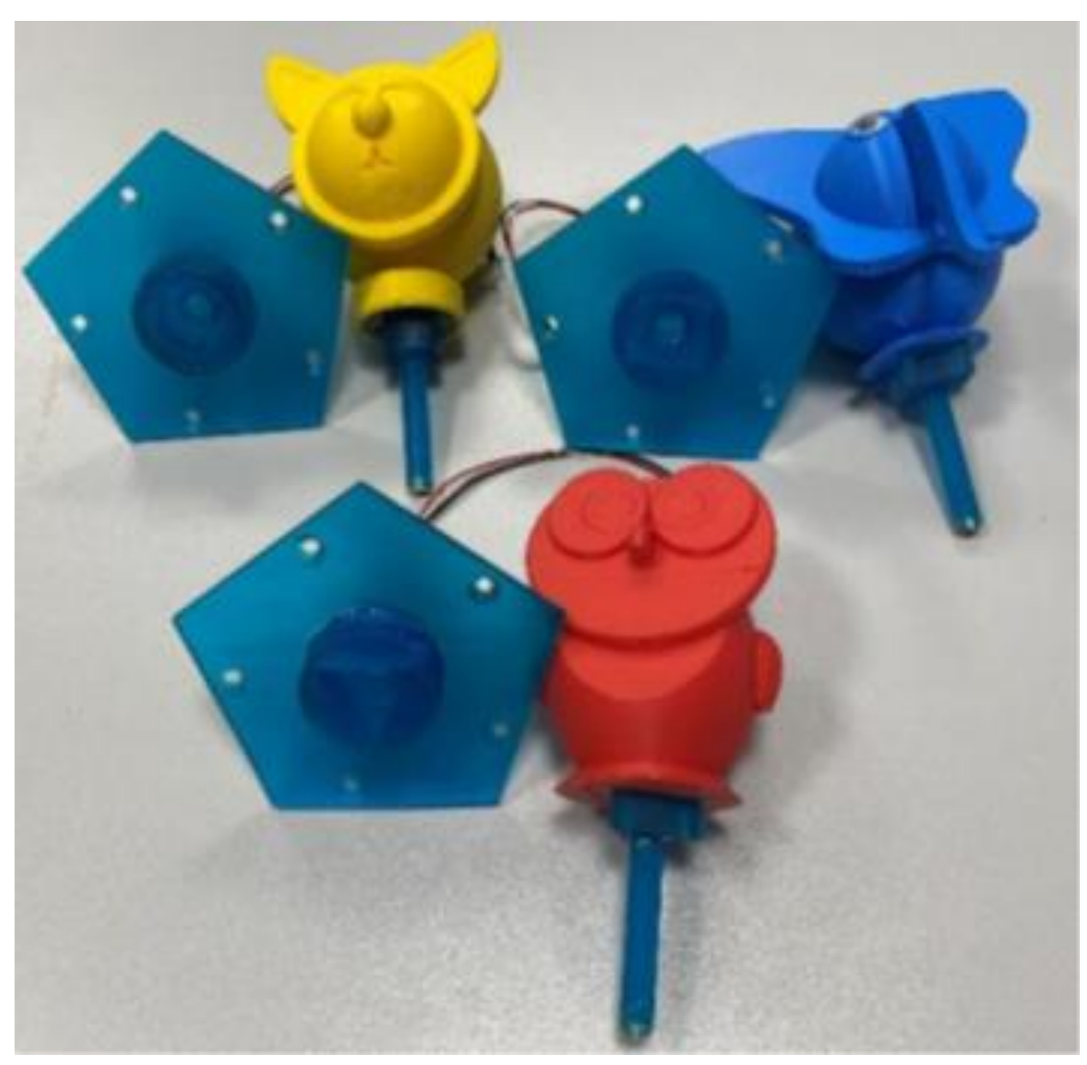

Figure 3. *Tangiball jacks separate from the main hub, showing sensor plates*

What has been achieved?

A prototypes, with many trade-offs along the way. This working prototype is important for proof of concept

What I have learnt?

New digital datasets come with new problems: storing, moving, & analysing of raw data where there is little prior investigation

What is exciting about this research?

Beginning to visualise meaningful novel clinical data around motor function in neurodisability

3. Tangiball Development

- TangiBall tool was developed through a process of public engagement, child and YP PPI groups have inputted on the direction of development– including a call out for assistance at an international conference for project partners in 2018
- The breadth of potential toy types that could be applied has been reported before (Farr & Male, 2018)
- Specific housing types followed major research groups in Italy and Spain (Campolo et al., 2007, 2010; Gutiérrez García et al., 2017).
- This project aimed to build a low-cost, engaging toy with additional clinical value. targeting the 24–60 month age group and requiring fine motor skills of placing objects in holes (Örnkloo & von Hofsten, 2007).
- Tangiball has 12 faceplates (see figures 1-3) , including one LED plate, three sensor plates, one SD card plate, one microcontroller plate, one battery plate and five blank plates (which will be utilised after this pilot).
- Sensor faceplates have a unique shape on the surface which allows a particular toy to be fully inserted.
- When the correct shape (circle, square or triangle) is placed in the correct hole, the hub lights up and "reward" sound is activated.
- The LED and sound continue until the toy is removed.
- If an incorrect toy is inserted, both LED and sound will not be activated in the current prototype.
- The data from the sensor faceplates is recorded continuously and stored on an 16GB SD card in .txt format that can record more than 24h worth of continuous data. Only movement data will be anonymously recorded.
- Pilot data will be collected on 30 children (15 typically developing, 15 with a prior diagnosis of autism) to isolate variation in movement patterns from March to August 2022.

4. Analysis

- Raw data from the input pegs will provide movement time in milliseconds time (ms) and an analogue to digital convert number number (ADC). The ADC number is then converted to voltage based on the following equation:

$$\frac{ADC\ resolution}{System\ voltage} = \frac{ADC\ reading}{Voltage\ measured}$$

- ADC resolution: 10 bits
- System voltage: 3.3V
- ADC reading: this is the raw ADC number
- Voltage measured: actual voltage measured.
- Once data is all raw graph into a "Time vs Voltage" format, the gradient of each rising curve will represent the insertion action of the child.

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