Towards Designing Assistive Software Applications for Discrete Trial Training

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ABSTRACT
Discrete Trial Training (DTT) is one of the most effective training methods for children diagnosed with Autism. Traditional DTT suffers from limitations of inconsistencies on account of human error, disruptions due to in-session data collection by trainers, and difficulties of producing physical within-stimulus prompts. Current software solutions either support sole child usage thereby eliminating the social interaction benefits of DTT or lack automated data collection. Designed by an inter-disciplinary team of software engineers, HCI, and psychology experts and certified behaviour analysts for a touch-tabletop, DTTAce is an assistive-software that provides digital consistency and integrity and supports customization of trials, automated data collection, and within-stimulus prompts while preserving natural interactions and the social nature of DTT. It is an important step towards designing effective assistive software for Discrete Trial Training.

Categories and Subject Descriptors
K.3.1 [Computer Uses in Education]: Computer-assisted instruction (CAI)

General Terms
Design, Human Factors

Keywords
Discrete Trial Training (DTT), Autism Spectrum Disorder (ASD), Assistive Technology, Software Application Design, Touch-tables, Children, Learning, Education

1. INTRODUCTION
f the several methods available for teaching children with Autism Spectrum Disorder (ASD), Discrete Trial Training (DTT) has been found to be particularly effective [6]. DTT is an intervention-based teaching procedure, based on the science of Applied Behavior Analysis (ABA) used to teach academic and valuable life skills to children with neuro-developmental disorders [6]. DTT consists of four distinct activities: the trainer's (behaviour analyst) presentation of the stimuli (e.g. differently coloured squares), the child's response (may be prompted, e.g. identification of the requested colour), the consequence (e.g. trainer's reinforcement), and a short interval leading to the next trial. DTT is traditionally performed using physical artefacts (e.g. cubes, card-board) with the trainer and child sitting across a physical table. *Within-stimulus prompts*, which involve making the correct answer subtly more obvious by transforming its implicit property (e.g. by increasing its size, proximity to the child, illuminating it etc.) are more effective than less subtle verbal or gestural prompts [5]. Currently, DTT is exposed to three critical limitations which can potentially undermine its quality and effectiveness: (a) natural variations in human (trainer) behavior and performance can lead to errors and inconsistency in the trial; (b) in-session data recording and analysis by the trainer can be inaccurate and disruptive to the primary activities; and (c) manual creation of customized within-stimulus prompts (e.g. an usually large teacup) for individual trials is time-consuming and cumbersome.

Our research involves the design of assistive software to address these issues. Latest touch-based technology (e.g. iPads) supports direct and more natural manipulation of digital objects on the screen as opposed to the gratuitous complexity of using mouse and keyboard and affords an increased appeal for the younger demographic that have emerged as digital natives [4]. Touch-based table-tops are particularly suitable due to their physical table-like appearance, large screen real-estate, multi-touch functionality to support collaborative work recognizing simultaneous trainer and child gestures, and object-recognition technology which allows physical objects to be used digitally. Our inter-disciplinary team of experts contributed to the design and development of *DTTAce* on the Samsung SUR40, a large touch-tabletop (40") with 50 simultaneous touch points and all of the above functionalities for teaching basic colours to children diagnosed with ASD.

2. CURRENT SOLUTIONS
Current solutions include: mTrial, a program developed to allow therapists to record, store, and report discrete trial data on a personal data assistant [7]. The study found that traditional data collection using pen and paper was approximately equal in accuracy to mTrial but surprising was faster than the digital alternative. DT Trainer, a PC based software application featured automated stimulus presentation, response recording, and immediate data collection [3]. A major concern here was that the sole use of a computer by the child learner could further isolate the child and hinder any potential of social growth, which might otherwise be gained from traditional DTT. Other solutions such as Artoni (Android app) [1] and Colour/Word SLapPs (iPhone app)

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suffered from reduced screen size on smartphones and tablets while Dr. Brown's applications were found to be unnecessarily complex in terms of user interface and layout [2]. Overall, none of the current solutions succeeded in preserving the social nature of DTT on a large surface area while supporting customized trials and automated trial-data collection.

Figure 1. DTTAce Main Screen with Train and Track Options

3. DTTAce: A PROPOSED SOLUTION

DTTAce application was developed using the Microsoft Surface 2.0 SDK and the .NET framework. SQL compact edition server database, compatible with the Visual Studio 2010 IDE, was used for data storage. We employed Participatory Design and Agile software development methods to develop and refine the application in an iterative and incremental manner based on feedback from psychology and ABA experts. Balsamiq Mockups were used to develop lo-fidelity prototypes. Nielsen's usability heuristics were used as the guideline for each screen's user interface, for example error checking and validation were included throughout the application, providing helpful system status messages to the trainer. Key features include:

- *Customized DTT Session*: allows the trainer to customize the session beforehand by setting the number of discrete trials per session, number of colour options per trial, colours to be tested (e.g. a Red circle as the correct answer), other colours to serve as (incorrect) options, and within-stimulus prompts (e.g. location, proximity, or illumination of correct colour.)
- *Automated Data Collection*: collects data such as date and time of each DTT session, accuracy of learner responses for each session, latency in learner responses for each trial and session, and overall session duration.
- *Learner Progress Tracking*: uses the data collected automatically by the software to generate graphs of percentage correct learner response, learner latency per session, session duration, and filter any of the above within a specified time period.
- *Learner Profile Management*: allows the trainer to login, view learner profiles, add/edit/delete learners, and select a particular learner to begin a trial session (Fig.1)
- *Token Economy*: uses the tabletop's object recognition technology to identify physical tokens given by the trainer for every correct response.

4. DESIGN CHALLENGES & FUTURE DIRECTIONS

Using a Participatory Design approach involves users and experts throughout the design process. As such we collaborated closely with behavior analysts and psychology experts throughout the design process. However, since our target end-users are children diagnosed with Autism it has been a challenge to include them in the design phase. For example, our collaborating behavior analysts strongly cautioned that the software needed to be complete and thoroughly tested before exposing it to our users as unfinished software can potentially damage the children's learning schemas and cognitive abilities. Therefore, we conducted a preliminary usability evaluation with 10 university students leading to corrections of some important usability issues prior to the next phase of evaluations with children.

Human ethics approval and a *special school* participation consent are now in place. Our next steps are to conduct a longitudinal evaluation of *DTTAce* with child learners and behavior analysts, focusing on both aspects of usability and efficacy. We're exploring ways to effectively capture user opinions during evaluations in addition to capturing automatically collected (quantitative) trial data and the trainer's (qualitative) experiences to assess usability and efficacy of our application.

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