Cognitive Intervention in Autism using Multimedia Stimulus

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ABSTRACT

We demonstrate an open multimedia-based system for delivering early intervention therapy for autism. Using flexible multi-touch interfaces together with principled ways to access rich content and tasks, we show how a syllabus can be translated into stimulus sets for early intervention. Media stimuli are able to be presented agnostic to language and media modality due to a semantic network of concepts and relations that are fundamental to language and cognitive development, which enable stimulus complexity to be adjusted to child performance. Being open, the system is able to assemble enough media stimuli to avoid children overlearning, and is able to be customised to a specific child which aids with engagement. Computer-based delivery enables automation of session logging and reporting, a fundamental and time-consuming part of therapy.

Categories and Subject Descriptors

K.3.1 [**Computer Uses in Education**]; K.4.2 [**Social Issues, Assistive Technologies**]

General Terms

Algorithms, Experimentation, Human Factors

Keywords

Autism, assistive technology, therapy, multimedia stimulus

1. INTRODUCTION

Autism is a neurological disorder that disrupts early development in cognition and communication, leading to impairment in cognitive and social functions, and difficulty acquiring new adaptive behaviours. A staggering 1 in 150 children are diagnosed with Autism Spectrum Disorder (ASD). The cost of remediation is estimated at $3.2 million over the lifespan of someone with ASD;[1] the emotional cost to sufferers and carers in anxiety and depression is immeasurable.

Outcomes can be significantly improved if intervention is undertaken with children as young as two years. One such intervention is Applied Behavioural Therapy (ABA) [3], which aims to improve cognitive functions such as object labelling and categorisation. ABA involves the delivery of stimuli according to a program created by a therapist. A child will typically have 30 hours of therapy a week, often delivered by the parent, and requiring a similar additional amount of time in lesson preparation. For every lesson, media additional to that provided by the therapist must be manually sourced by the parent, printed and laminated for use as flashcards. This burden is exacerbated by lengthening waitlists for therapy, which leave parents conscious of the passing days in what is a crucial window of time for their children, but lacking the expertise and guidance to know how to help. In addition, paper-based delivery suffers from limited stimuli, which can lead to the child over learning, and being unable to generalise, and an inability to convey dynamic concepts such as verbs.

Commercial software exists to support early intervention, such as *Teachtown*, but their content is proprietary, and they lack flexibility. A host of iPad-based applications address specific skill shortages. Research has targeted affect recognition for ASD sufferers [1], and tools for early detection [2], but no attempt has been made to address automated early intervention.

In response, in collaboration with ASD experts, we have designed and implemented a web-based system to deliver early intervention therapy. It uses a database of media annotated with semantic concepts relevant to early language development to deliver therapy that adapts to the child's performance. Concepts are encoded in a language-agnostic way, so that therapy can be delivered in many languages, and across media types, making it modality-agnostic. Importantly, media resources can be extended via moderated community contributions. Our open data model avoids overlearning, and allows stimuli to be personalized (e.g., an image of concept "father" can be the child's father), which is an important feature for ASD sufferers. To our knowledge, this is the first framework created for the automatic and adaptive delivery of early intervention therapy for ASD.

2. MULTIMEDIA FOR AUTISM THERAPY

The framework has two parts: first, a database populated with multimedia content, which can grow with moderated, user-contributed content; second, metadata and logic for constructing a stimulus set to follow a syllabus, and a means to present the stimulus set to a child, record responses, and automatically adapt stimuli based on performance.

Intervention can begin with children as young as two years, so the delivery platform must support natural interactions,

[1] http://www.nationalautismcenter.org/

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such as pointing and touching. Ideally, it must also be cheap, robust, and portable, so that it is not tied to specific locations. Our therapy client, termed *Playpad*, is implemented in Javascript and HTML5 and runs in a webkit-enabled browser. A specialized version runs on the iPad and is deployed as a native application, allowing media and data to be cached locally on the device so that it can be used offline.

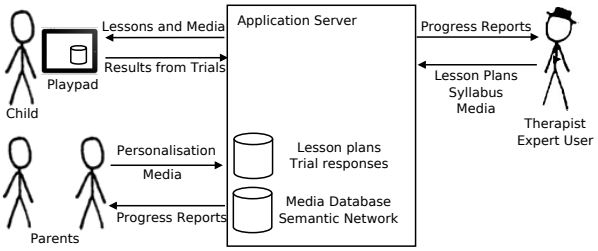

Figure 1: System Architecture

The Playpad client is served by a web application that hosts a database of media annotated with concepts that are fundamental to language development within and across cultures. Crucial concepts necessary for linguistic and congnitive development are: nouns, verbs, adjectives, functions, categories, prepositions and directions, pronouns, time and causation. Concepts include objects (e.g., spoon, dog, car), attributes (e.g., color, red, small), and actions (e.g., walking, eating). The database also contains semantic relations between these concepts, including taxonomical relationships (e.g., dog "is_a" animal), and functional relationships (e.g., spoon "used_for" eating). Together, concepts and relations comprise a semantic network that can be leveraged to assemble media stimuli of specified content and complexity.

The system can be used by a non-expert (parent) to deliver basic therapy. The curriculum includes activities that can be performed by the child using Playpad, either solo (eg. sensory matching) or with a partner (eg. two-person games, expressive language tasks). The system also includes activities done without the Playpad, which the parent can incorporate in the daily routine. These are presented in the daily lesson plan via instructional videos.

Therapists construct lessons by specifying sets of stimulus concepts (e.g., for color, [*green*, *red*]), and sets of dimensions of variation. The learner is shown how to attend to relevant aspects and ignore irrelevant aspects of the stimulus. Variation in *irrelevant dimensions* produces *variants* within a target concept; variations in *relevant dimensions* produce *distractors,* which are outside the target concept. Usually, few *variants* are introduced until the child has mastered the simpler stages. Multiple concepts may be taught simultaneously, in which case one stimulus concept serves as a *distractor* for another in the same set. Using the encoded semantic concepts and relationships, the system is able to automatically adjust stimulus complexity.

The curriculum includes a variety of matching tasks. E.g., *Symbolic Processing, Distinction of Categories*–where three exemplars of one category are presented along with one from another category. The system uses closeness in the semantic network to measure similarity. E.g., cat and dog are close because they are both sub-types of animal. Categories that are semantically closer are deemed to be more natural comparisons, but are correspondingly more difficult to discriminate. See Figure 2.

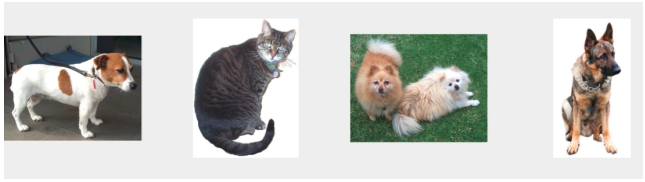

Figure 2: Example of symbolic processing task. The subject must identify which object (cat) is different from the others (dogs).

Other matching tasks include Visual or Auditory Sensory Matching, Symbolic Processing; Receptive Labelling (where the cue is a word rather than an image); Receptive Auditory, Visual Matching Sound; and Functional Matching–e.g., a broom (not a pencil or fork) is used for sweeping–which can be generalised to any semantic relation represented in the network, e.g., "found in location", and "is part of".

The ability to cue targets and exemplars in multimedia, using media potentially personalised to that child's affinities (e.g., matching colour using a favourite object, such as a train), or context (e.g., using audio spoken by the child's family or friends), increases the child's engagement with the therapy. The same platform can also provide rewards, such as games, for completing a target number of sessions. In addition, prompting and reinforcing the correct answer is an integral part of therapy, and again multimedia-based delivery accords an advantage over paper-based methods.

Computer-delivered therapy makes trivial logging and reporting, a fundamental and labour-intensive part of ABA. All of a given child's sessions are stored, which eases integration of therapy across locations (e.g., home to clinic), and when Playpad is deployed in the role of a wait-list program, enables the child to transition to professional therapy with a known performance history.

3. EVALUATION

Trials of the system using matching tasks have proved it effective at training both adults and autistic children. We are continuing to extend the curriculum by adding new tasks and concepts. Our framework for stimulus delivery can easily adapt to both the therapists goals and the child's needs.

4. REFERENCES

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