Evidence-based technology design and commercialisation: Recommendations derived from research in education and autism

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Abstract

The proliferation of mobile technologies and apps raises questions for researchers in the field of educational technology. Many apps are marketed as having impact on learning or therapeutic outcome in populations with additional support needs. This paper briefly outlines three possible academic responses to the rise of therapeutic technologies for vulnerable populations. These are: reviewing existing scientific evidence to inform design; knowledge exchange with consumers and commercial partners; and rigorous evaluation of technologies in an academic context. The examples are drawn from autism research, but have implications for the evaluation of technologies generally, and for provision of guidance to various user communities. Better communication and closer working between developers, researchers and consumers is necessary to ensure relevant research outcomes and evidence-based practice in educational technology. The paper concludes with concrete recommendations for researchers in Education, Psychology, or Computer Science in carrying out work relevant to commercial enterprise and consumers.
Keywords: autism spectrum disorder; education; intervention; knowledge exchange; participatory design; technology

Introduction

Autism spectrum disorder is a single diagnostic category encompassing a variable population including those who would formerly have been diagnosed with autism, or Asperger's syndrome (APA, 2013). Hereafter, for simplicity, the term 'autism' will be used to describe people with a range of specific diagnoses under the heading of autism spectrum disorder. The core behaviours observed in autism are difficulties in social interaction and communication, and the presence of restricted interests and repetitive behaviours. Autism is present in about 1% of the UK population and persists across the lifespan (Baird et al., 2006). Individuals may have normal and above-average intelligence, but it is associated with learning disability in at least 50% of cases (Elsabbagh et al., 2012). Thus behaviours in each core domain manifest differently dependent on general level of ability: repetitive behaviours in someone with a learning disability may include rocking, hand-flapping, lining things up, or repetitive speech. In a person with normal intelligence, instead we might see a restricted interest in a very specific topic (e.g. vacuum cleaner design), or highly repetitive and rigid daily routines. Likewise examples of social interaction and communication difficulties

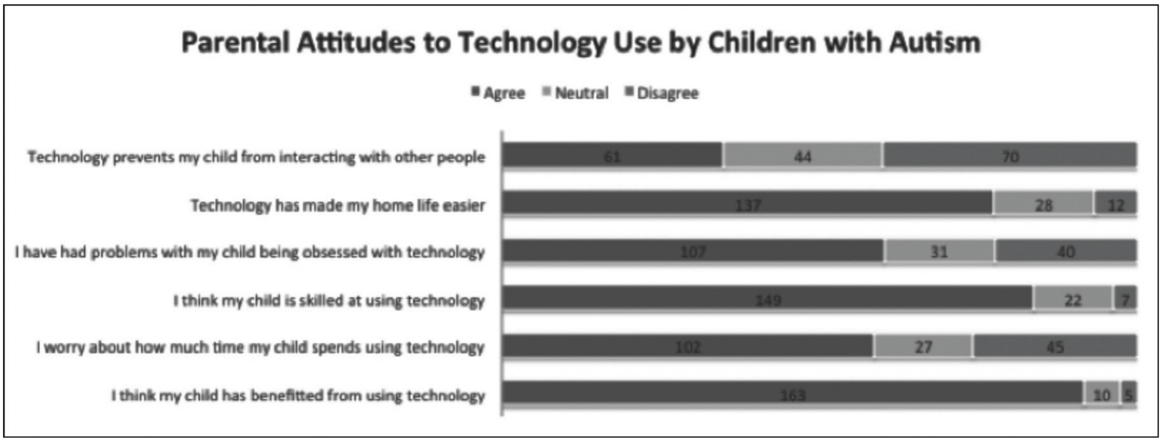

Figure 1.

range from individuals who are totally non-verbal, to people who are confused by sarcasm, metaphor, or the social rules of conversation.

The heterogeneity of autism means that people with autism are a challenging population to work with both as a practitioner and a researcher. Nevertheless, one can fairly confidently state that working with technology represents an area of both skill and preference for a large majority of people with autism. People with autism choose to spend a high proportion of their leisure time using technology (Mazurek & Wenstrup, 2012; Orsmond & Kuo, 2011; Shane & Albert, 2008). Moreover, there is significant evidence from a range of recently-published meta-analytic reviews for the benefits of technology-based learning and therapeutic support for this population (Grynszpan, Weiss, Perez-Diaz & Gal, 2013; Pennington, 2010; Ramdoss et al., 2011a; Ramdoss, Machalicek, Rispoli, Lang & O'Reilly, 2012; Ramdoss et al., 2011b). As a result of the known advantages of technology in application to the difficulties associated with autism, there has been a recent explosion in both research on technology and autism (see Figure 1, from Grynszpan et al., 2014) and commercially available technologies for this community (see Figure 2, from Fletcher-Watson & Durkin, 2015).

This explosion in autism-targeted technology presents challenges to technology developers, consumers, practitioners and researchers in the field. These challenges represent an extreme case of issues experienced across research on

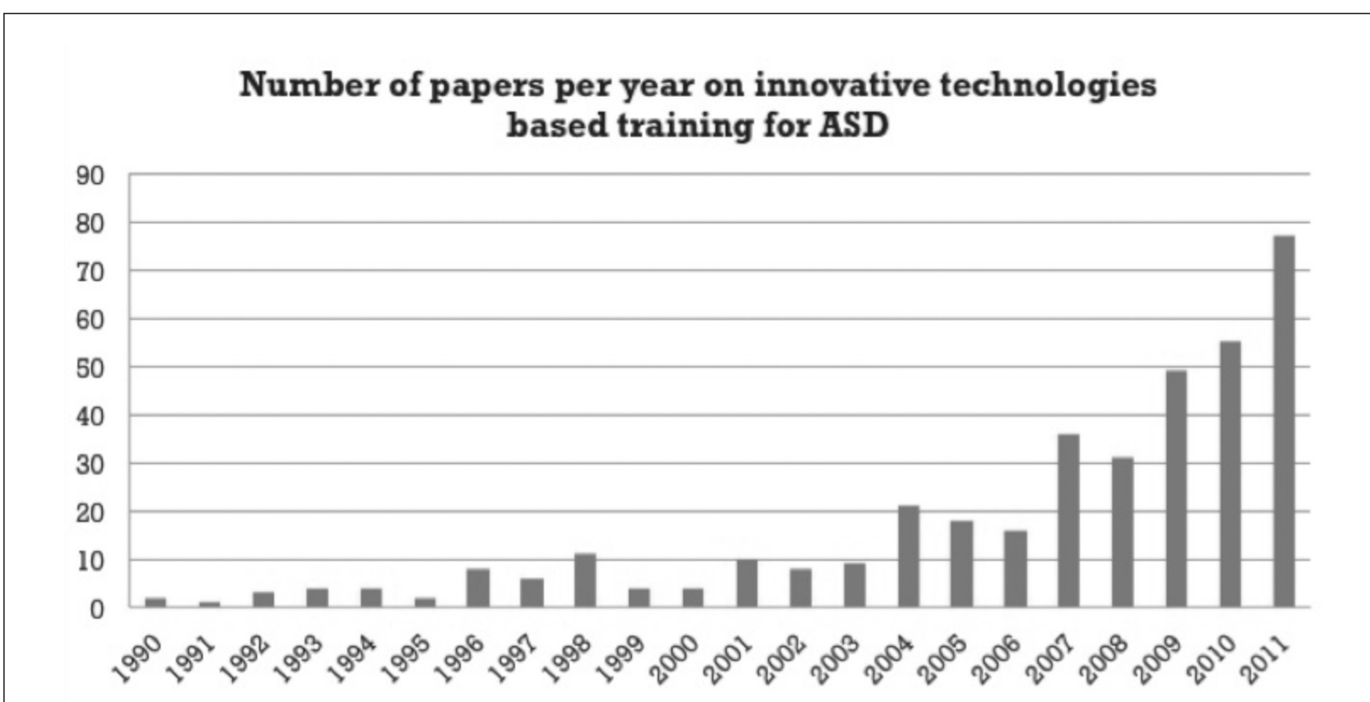

Figure 2.

the interface of the academic disciplines of Computer Science, Education and Medicine, such as digital education and telehealth. Such concerns include:

- How should practitioners balance the apparent therapeutic value of technology with warnings against excessive screentime, especially when working with a young or vulnerable population?
- How can researchers provide an evidence base which keeps pace with the rapid rate of development of commercial technologies?
- How should practitioners respond to the independent adoption of therapeutic technologies by patients?
- What are the differences between high-quality and useful technologies and those which offer mere bells and whistles?

While a randomised controlled trial is the gold standard in evaluating any new therapeutic approach, the differing timelines of academic progress and technology development make this impossible to achieve. Comparing two different educational or therapeutic technologies presents even greater obstacles. In this paper I briefly outline three possible ways in which research expertise can be brought to bear on the questions of how to evaluate commercial technologies and provide evidence-based guidance to consumers and practitioners.

Reviewing Scientific Evidence to Inform Design

Theoretical models and empirical findings can be combined to provide a solid foundation for the development of new technologies. Recently a colleague and I reviewed studies from eye-tracking specifically, with a view to identifying the findings which could have relevance for the design and implementation of aided and augmented communication (AAC) systems for users with autism (Gillespie-Smith & Fletcher-Watson, 2014). The original studies had not been designed to provide an evidence-base for AAC users or practitioners, but we felt that there was enough relevant content to validate the approach. For example, because of the social interaction difficulties associated with autism, many studies have investigated how people with autism look at faces, and respond to social cues such as where someone else is looking (Nation & Penny, 2008). AAC pictograms often use faces as part of the content or to direct attention to important details, but the autism eye-tracking studies suggest this method may be less effective for a user with autism.

This approach can also be used in the opposite direction, by reverse engineering a technology to explore its theoretical or empirical basis (Rajendran, 2013). For example, research on the use of mobile phone functions by people with autism has been interpreted using theoretical models of social impairment (Durkin, Whitehouse, Jaquet, Ziatas & Walker, 2010). This theory-based interpretation could then be used to inform the design of mobile phones more suited to the needs of the autism community. This approach is harder to achieve, and less scientifically rigorous. Nonetheless, it is my contention that software or hardware which can be demonstrated to address a known area of need, correspond with an established theory, or otherwise be grounded in knowledge accrued from research will have a greater chance of achieving its educational or therapeutic goals. Taking this approach further, researchers could attempt to retrospectively taxonomise commercially available products in order to impose an evidence-based structure which could aid practitioner and consumer selection of the appropriate technology for their, or their client's, needs. Attempts have been made in this direction in the disability research field (Lahm, 1996).

Knowledge Exchange with Consumers and Commercial Partners

One principle of using research to evaluate technology is that research provides an opportunity to go beyond the individual's experience and generate general statements about quality or efficacy. However pursuing this rigour in its purest form risks losing the nuance and complexity of individual experience. For example, experimental studies may select only a single technology, or perhaps a pair of technologies, for investigation, and without consultation with users the research team may be oblivious to the fact that these are not the technologies actually in use in the community.

During the recently completed ECHOES project, in which a virtual environment with a touchscreen interface for children with autism was developed, the research team worked closely with users with autism, their parents and practitioners to design the environment and the associated evaluation which followed (Porayska-Pomsta et al., 2011). They used participatory design activities, questionnaires, individual interviews and focus groups to define everything from the skills being targeted to the instructions provided to teachers (Frauenberger, Good &

Keay-Bright, 2011). Elsewhere I have contended that this engaged design approach leads to higher quality product (Fletcher-Watson, 2013), and although this has not been evaluated, this is the principle which guides participatory design (Guha, Druin & Fails, 2012). In particular, if design processes can be published or otherwise shared this information can influence technology development in the future.

In a separate, but similar, app design project, (Fletcher-Watson, Pain, Hammond, Humphry & McConachie, 2014) the research team further collaborated in knowledge exchange activities with the app developer who licensed the finished product and released it to the market. A key element of this enlightening process was the discussions around which features the developers wanted to change in order to make the app consumer-ready and which we felt it was not possible to change without impairing its therapeutic potential. For example, changing the menu design to create a better interface for parent users was fine, but adapting the reward animations to fit with the house style of the developer was not.

Rigorous Evaluation of Technologies in an Academic Context

A third option is to adopt the gold standard approach and engage in a full randomised controlled trial (RCT) of a specific technology. Although this is normally unrealistic, nevertheless this approach adds value and can contribute to understanding of technologies in general as well. In the first place, the use of a rigorous design like the RCT can represent a coming-of-age of a research field. While we might not expect every app to have RCT evidence, the existence of this kind of published evidence demonstrates that we do not accept that technology based approaches should be consistently permitted a lower evidence-level than other therapeutic or educational methods. If we never aim for these high methodological standards we devalue the potential impact of technology in the classroom or in development.

RCTs can also add useful feasibility data which apply across technologies. For example, in our case (Fletcher-Watson et al., 2014b) we found, contrary to expectation, that there was a very low rate of damage to iPads distributed to young children with autism. The RCT also forced us to consider the appropriate outcome measures which should be adopted in studies of technology, and the ways in which the technology itself could contribute to our analysis – for example by recording in-app data on usage. These principles can carry over into other related technologies and be employed in different research designs such as single case studies or uncontrolled classroom evaluations.

Discussion

This paper has drawn on examples from the literature on technology and its application to autism to demonstrate ways in which researchers can respond to the need for a evidence base to guide consumers, practitioners in selection of technologies, and developers in their creation. These were: reviewing existing evidence with a view to provide insights into design of new technologies; working with consumers, practitioners and commercial operators to ensure collaborative design and evaluation; meeting high standards in rigorous evaluation studies, formulated to have impact beyond the specific technology involved.

The appropriate response will depend on the stated goals of the technology and its potential uses. Some AAC apps being marketed at parents of non-verbal or minimally-verbal children with autism claim to "help your child with autism learn to talk". It is reasonable to expect such technologies to provide a rigorous evidence base to support such a bold therapeutic claim. On the other hand games which provide enjoyable activities to supplement classroom learning of, for example, algebra or spelling might not require such formal evaluation. In these cases, consumers are much more in need of ways to distinguish between software (or hardware) options which superficially seem to do the same thing. The focus here must be on providing rapidly-available and widely-accessible information of relevance to the user community. Here the importance of dissemination via blogs, online reports and reviews, and public talks is apparent.

Drawing on the experience of researchers in technology and autism, I make the following recommendations to researchers wishing to use their expertise to provide evidence and guidance of relevance to the community:

- Publish outside your discipline, and outside academic journals in order to faciliate interdisciplinary exchange and collaboration
- Consider the longevity of your results – if investing in an involved project, design it so that you can draw conclusions which extend beyond a specific technology
- Work with, not just for, consumers and commercial operators from the outset of a new project
- Be creative in linking evidence and theory to practice

The challenges of evaluating educational technology should not mean we abandon attempts to provide an evidence base. By innovating in methods and working closely with stakeholders we can bring research expertise to bear on questions of real world significance.

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