

Emerging Use of Behavior Imaging for Autism and Beyond

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Abstract Commercially available “behavior imaging” technology is effectively assisting the diagnosis and management of children with neurodevelopmental disorders, including autism. This technology offers a unique way of capturing behavior data in natural environments on video clips, and is complemented by a comprehensive information storage and retrieval platform. Uses to date include providing families living in remote areas with improved access to health care services. The flexibility and versatility inherent in this new platform allow for future expansion, which may include a variety of wireless physiologic sensors. The benefits offered by this new technology have been recognized internationally and the use of this new technology may expand from behavioral healthcare and special education to fields such as psychotherapy, therapy supervision, and a host of research applications.

Introduction

In response to the increasing demand by healthcare professionals internationally to include behavior information more systematically in the diagnosis and management of neurological disorders, academic and industry partners developed a new imaging technology which is now capable of providing comprehensive documentation of relevant patient behaviors. Behavior Imaging®¹ now has the potential of transforming the healthcare industry in a manner similar to the impact observed when medical imaging was introduced (e.g. X-rays, MRIs, CT scans). “Behavior imaging” refers to the capture and secure sharing of patient behavior information using video and other digital electronic means. The behavior information is ideally collected within a patient’s natural environment such as their home or a child’s classroom, where it can be securely shared by patients and providers independent of geographic location. The available data can be utilized for

¹ Behavior Imaging is a registered trademark of Caring Technologies, Inc. (aka Behavior Imaging Solutions) – Boise, ID USA

diagnostic purposes, improving treatment protocols, training new healthcare professionals, and other purposes.

If any data ought ever be considered an essential clinical tool, it is video data, because it can capture important visual manifestations of symptoms associated with neurological disorders such as autism, Traumatic Brain Injury (TBI), Neuropsychiatric disorders, Alzheimer's and other conditions. This is important precisely because these conditions are defined, wholly or in part, by behavioral characteristics.

To be fully adopted, a behavior imaging technology platform must meet the security, privacy, and control requirements associated with the multifaceted legal landscape of healthcare industry.

Commercial Examples

Behavior Imaging systems currently available on the market feature novel video capture, clinical annotation tools, and a personal health record platform to capture, store, and securely share behavior data between and among caregivers and healthcare providers.

Behavior Capture[™]: This system was developed at the Georgia Institute of Technology's College of Computing. It consists of a novel video capture technology which can be used in a home or institutional environment and features a unique video buffering capability that documents relevant events that occur before, during, and after a behavior. This "going back in time" feature can provide insight into causes or triggers of certain behaviors.

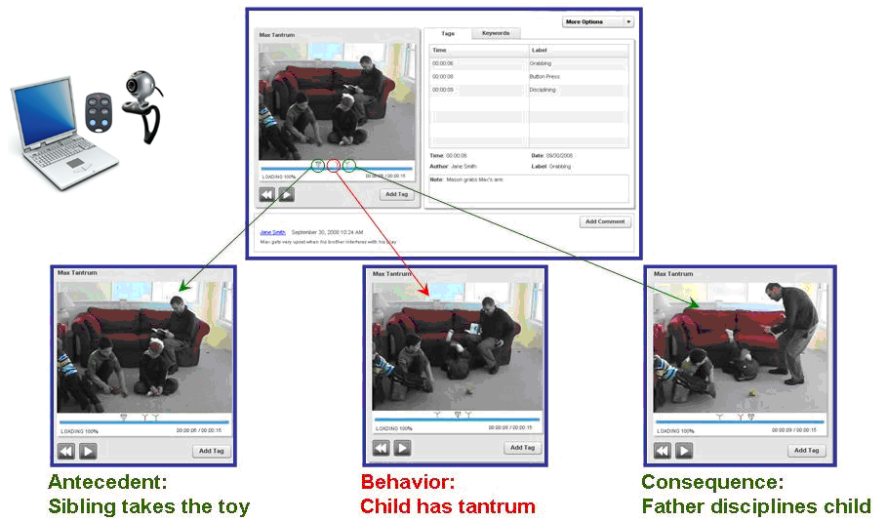


Fig. 1 With software applied to any personal computer, Behavior Capture™ enables a caregiver in a natural environment to capture a video clip of what happens before (antecedent), during (behavior), or after (consequence) with a small remote control device. That resultant video clip can tag aspects along the video clip that either the caregiver or the health professional can annotate for collaboration or data mining purposes. [1]

Behavior Connect™: This is a data and records management platform which allows users to organize, analyze, and share videos as well as other types of images such as x-rays and pertinent documents, among and between patients, caregivers, health providers, therapists, etc. It is a secure, HIPAA-compliant web-based application and complies with the healthcare industry's current health record technical standards. It facilitates the non-disruptive integration with other database systems. The product also provides a proprietary fax transmission tool, special file uploader which can securely transmit large files even from low-bandwidth connections (as in rural areas), and a secure messaging system to enable electronic consultations. Field applications have shown that the technology is simple to use and can provide caregivers with important support during times of crisis or when asked to provide more contextual information.

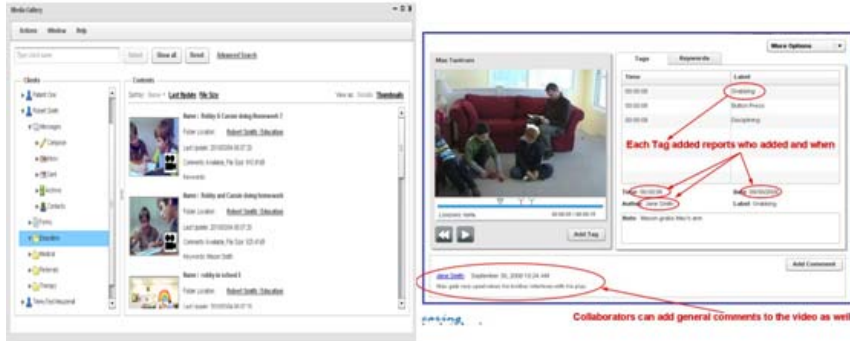


Fig. 2. Behavior Connect™ allows clinicians to search file data of their patients (left), as well as uniquely tag and collaborate on any video or other data file (right).

Behavior imaging is available as a full solution to organizations or practitioners, or as a complementary plug-in to existing health and special education databases.

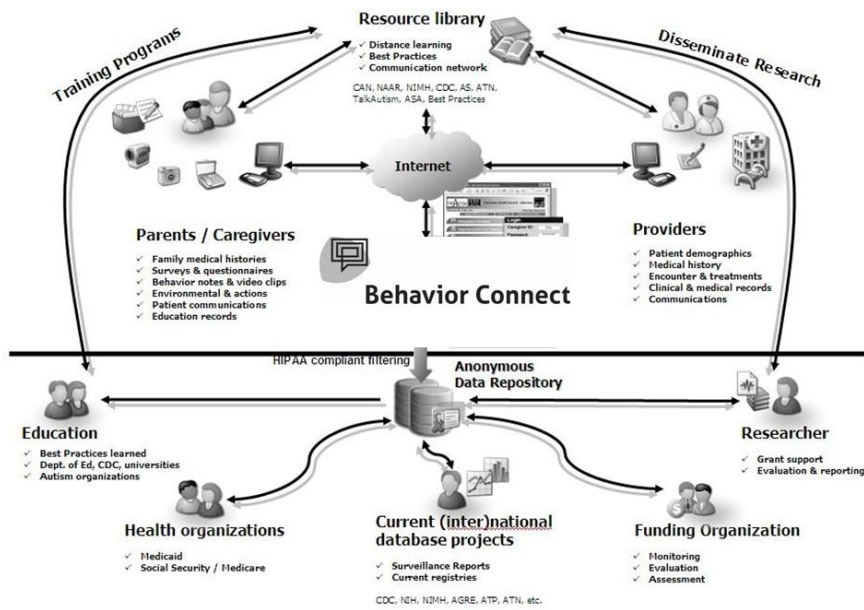


Fig. 3. Illustration shows how Behavior Connect™ platform can connect caregivers from anywhere to their healthcare providers, and collect important data that can effectively treat the patient, but also provide researchers, health organizations, and others more understanding more about autism spectrum disorders. [1]

Use Cases

The efficacy of Behavior Imaging in promoting patient access to healthcare providers and improving data integrity in the clinical decision-making process has been evaluated by a number of leading academic institutions. The outcomes demonstrate high value in a variety of settings.

Health

Diagnostic Evaluation: Studies conducted at the Southwest Autism Regional Resource Center (SARRC), a leading autism center of excellence serving 11,000 individuals annually, showed that the use of Behavior Imaging accelerated the diagnosis of autism. [2] In addition, earlier work by the University of Medicine and Dentistry of New Jersey (UMDNJ) and Princeton Autism Technology (PAT) revealed that behavior imaging could provide valid diagnostic data directly from the home of the autism families. [3] These and other projects illustrate that this new technology platform can facilitate autism diagnoses, provide more accurate and more contextual information relevant to the management of the health condition, and serve as a resource by providing the ability to archive all relevant data in a child's electronic health record.

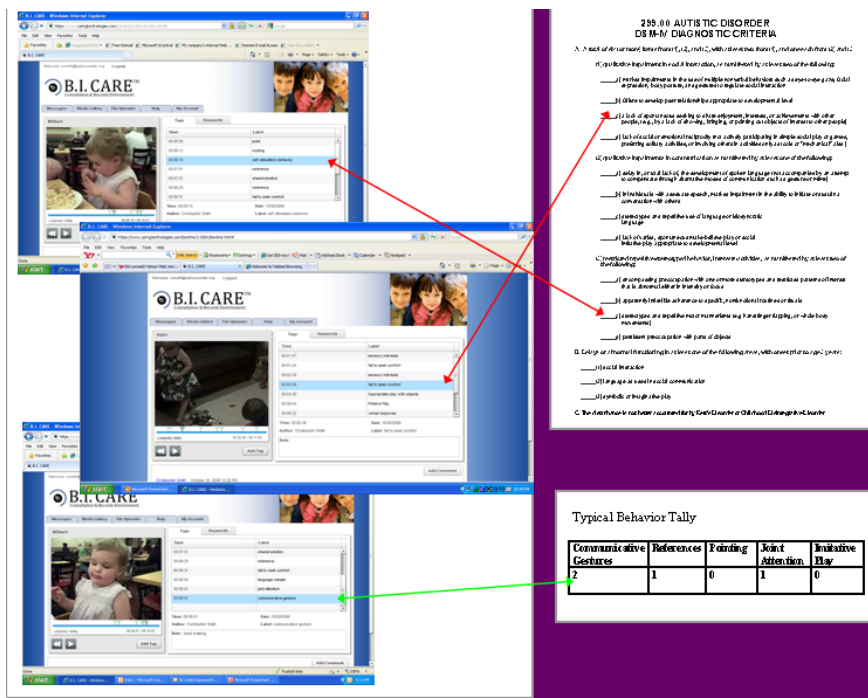


Fig. 4. Excerpt of a research poster illustrating Natural Observation Diagnostic Assessment. Illustrations show how three collected Behavior Image video clips taken from families with children with developmental delays from rural communities in Arizona, were transmitted remotely, received securely and later analyzed in Behavior Connect (formerly called “B.I. CARE”, left side). Platform allows diagnosticians annotating to follow DSM IV criteria (top right), while providing tabulated scoring (bottom right)

Functional Behavior Analysis: Research has illustrated that if teachers use behavior capture to collect functional behavior data instead of conventional paper-and-pencil data collection, they experience 43% less errors when doing data collection for a functional behavior analysis, while providing collateral benefits. Researchers at Monash University in Melbourne, Australia documented the benefits offered by Behavior Imaging in providing a technology platform suitable for performing remote Functional Behavior Analysis (FBA) and providing a data sharing system linking autism families living in the Australian outback with behavior specialists in Melbourne. [4]

Remote Consultation: Families often have difficulty communicating their children’s autistic behaviors to healthcare providers, and wait a long time to receive provider feedback. Many of these families are now using Behavior Imaging to share behavioral data and medical results in a more timely fashion. This strategy has reduced waiting times significantly when compared to parents who had to rely on in-person visits only. [5] In a telling practical example, data archived in a Behavior Imaging health record allowed one doctor to uncover a pattern of seasonal

recurrences of behavioral issues in an autistic child which would not have been discovered any other way. In another example, many families displaced by Hurricane Katrina in 2005 were able to have their children with autism re-evaluated remotely to determine their behavioral health needs. This was possible because their health and behavioral data were saved with Behavior Imaging. [6] Rural families visiting SARRC in Phoenix, AZ have been shown to benefit from improved clinical outcomes when using Behavior Imaging to implement early intervention therapies. These therapies are now delivered and monitored from home. [7] Lastly, select US military dependents are now being helped by Applied Behavior Analysis (ABA) therapists who use Behavior Imaging to provide therapy which would have otherwise not been accessible.

Medication Management: As inferred in the previous section, behavior that occurs in the natural setting may have little relationship to behavior observed in the clinical setting. Behavior in the home can be captured, even “after the fact” using the time-buffering software, uploaded to a personal health record, and securely shared with specialists for the purpose of consultation, assessment, or follow-up of care. Patients who are difficult to transport, or for whom behavior in the office setting are of limited value, can receive initial or follow up care with potentially greater efficacy or acumen. Some preliminary support for this concept has been seen in studies that have used store-and-forward telemental health approaches for providing psychiatric and cross-cultural consultation to primary care providers in rural settings. [8,9]

One potential use for this approach is to use it for monitoring the progress of medication treatment. For example, families whose children are placed on medications would not need to return to the clinic for routine follow up appointments. Rather, they can simply record behaviors at home and maintain a personal record. Child psychiatrists, child neurologists, or developmental pediatricians could follow the progress of patients using this web-based system with the hopes of providing care with a more accurate data set, make more appropriate medication changes, and avoid potentially negative medication side-effects.

Special Education

Education is currently the only accepted treatment for children with autism. Accepted treatment philosophies including early intervention has been shown to dramatically help children with autism, but experienced practitioners are in short supply and not easily accessible. Finding new ways to educate these children is a challenge.

Classroom Management: In a study funded by the National Institutes of Health (NIH), educators endorsed Behavior Imaging technology as a means of more effectively treating children with autism. Assessment surveys indicate that applica-

tion of this type of platform in classroom settings is received favorably. Of the participating 29 educators from 11 different national clinical sites, 74% agreed that Behavior Imaging saved time and money by enabling them to easily capture on video what preceded a student’s inappropriate behavior. 88% would use behavior capture to improve their teaching, and a majority of the participants reported that they will be able to serve more students than before. Application of this technology to staff training, student assessment, and supervision of students by their parents was reported as providing a significant benefit. “This would be tremendously helpful to our organization because we have 16 locations around the world and training and mentorship from central locations to the remote sites would be greatly enhanced with these capabilities”, according to one participant. Other participants commented that Behavior Imaging would address a critical need in rural schools, which often lack resident specialists. [10]

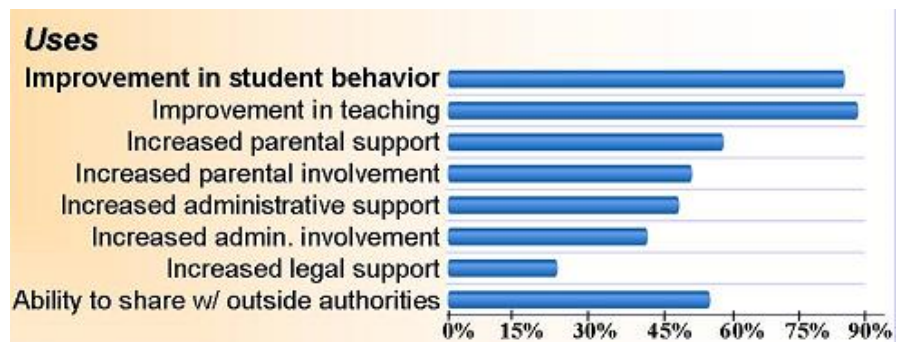


Fig. 5. Excerpt of a research poster illustrating perceived additional benefits of Behavior Imaging technology for special education classroom management.

Alternate Assessment: Special education students pose different challenges to be able to demonstrate their baseline skills, and progress they are making – due to many times not be able to take standardized tests. The Idaho State Department of Education (ISDE) is using Behavior Imaging to improve and simplify the process of creating, submitting and evaluating special education progress reports – and have this private student data available. This replaces the paper-based processes that have proven cumbersome and expensive for teachers and administrators. Now, teachers in Idaho have captured and shared more than 70,000 video case studies, faxes or scans of homework or other reports electronically with the click of a mouse. Costs are estimated to be one half of doing this progress tracking through conventional ‘paper’ processes, while providing additional benefits.

OTHER USES

The growing number of applications of the Behavior Imaging platform in the autism field has generated interest in this technology form other health fields, including:

Supervision of psychotherapy in a clinical setting

Behavior Imaging systems would allow trainees to easily capture psychotherapy sessions (with patient consent) with the equipment they probably already have in the office, a computer and web-camera. After a session is conducted, key sections of the video can be “tagged” and notes added. The video can then be uploaded to a web-based “supervision record” where a supervisor provided with the appropriate passwords can log on, quickly scroll through the video, review key sections that the trainee tagged as important, and provide feedback notes both instantaneously and regardless of location. Supervisors no longer have to be on the premises to view confidential patient videos, and given that faculty are increasingly taking on more responsibilities, often at various sites, location is no longer an obstacle to timely supervision. This kind of system could improve the ability to provide direct/active feedback in a way that is less intrusive to patient and therapist, requires no additional equipment, is easy to use, easily shares the information with the supervisor, provides a platform for sharing information between trainee and supervisor, and creates a secure system for storing videos for teaching purposes and for documenting competencies.

The U.S. Air Force is developing a web-based supervision system using this type of approach for the entire Air Force Air Education & Training Command. Such a system would allow staff psychologists and psychiatrists to provide supervision to trainees within the same clinic, but also to provide supervision and mentoring to novice or newly graduated providers located in remote military locations anywhere in the world.

The U.S. Air Force is currently using Behavior Capture™ for a variation of the web-based concept just described. This is being done to capture the sessions of newly trained therapists who have learned a new intervention, Virtual Reality Exposure (VRE) Therapy for the treatment of post-traumatic stress disorder (PTSD), a 5-year project funded by the U.S. Air Force and awarded to the fifth author and his organization, Virtually Better, Inc, based in Atlanta, Georgia. Having been trained by civilian psychologists who are among the leading experts in the fields of virtual reality and PTSD, the U.S. Air Force clinicians, in locations ranging from Anchorage, Alaska, to San Antonio, Texas, to Rheinland-Pfalz, Germany, receive continuity of training by meeting with these experts on a weekly basis, via telephone and videoconference consultations. The discussions of cases are driven by the videos that were captured and tagged via Behavior Capture™ and sent immediately to the civilian experts located in Atlanta, Georgia, and New York City.

Psychotherapy - Direct in-session applications: Behavior Imaging can be a valuable asset to the clinician in the context of psychotherapy. In its initial implementation phase, clinical psychologist Dr. Josh Spitalnick is using the Behavior Capture™ technology in a variety of unplanned and pre-planned ways, always with patient consent. The time-buffering capabilities inherent in this technology allow for the camera to be enabled and operational in “capture” mode to record unplanned critical moments in therapy (e.g., the patient has an insight several months in the making, the patient confronts a fear for the first time, or the therapist and patient experience an important therapeutic relational event). To do so, the clinician clicks the wireless remote, activating the software, which can “look back in time” up to 45 minutes to capture the powerful moment even though it has already passed. This video capture is then played back to the patient so he/she can experience it again and hear back the important revelation. This serves as a powerful experience in therapy whereby the patient gets to see him/herself in the same manner as the therapist and the world see them.

This use case of Behavior Imaging technology highlights the value of having video capture capability within psychotherapy treatment to allow the patient to hear his or her own words exactly as they were shared, and the additional capability of capturing time-buffered video. To capture unanticipated events even after they have occurred can provide a powerful and transformative moment in therapy. This technology also makes it possible to store this and any videos in the patient's personal health record (PHR), which is housed on a secure server and can easily be accessed, or store it in a clinical electronic health record for future review with the patient (if appropriate consent is given).

Clinicians can also use planned video-capturing in a variety of ways, including role-plays and capturing trauma narratives with patients engaged in imaginal exposure. Such videos can also be used, with patient consent, for training purposes by sharing them with other clinicians who can watch these video from more seasoned clinicians and witness techniques that foster a therapeutic relationship as well as observe the implementation of therapeutic interventions. For role-plays with patients, having video capture capabilities provides the clinician a valuable tool to share with the patient, by playing the role-play back, in session, so the patient can see how he/she comes across in the designed interaction. This allows the patient to more readily learn how they come across as effective or ineffective in a given scenario, and it provides the patient the opportunity to see the dynamic between two people, to learn what methods of communication are more or less effective.

Clinician Training: As many clinicians also serve as clinical mentors and supervisors to residents and graduate students, as is the case with several of the authors, one quickly begins to realize, one quickly begins to realize an added value to the capturing of unplanned and planned clinical interactions: a library of real training videos begins to take shape. Of course, anytime a clinician considers sharing patient data, written or digital, with anyone other than the patient, full informed consent must be addressed. The use of such technology can create a won-

derful and rich set of training videos that are easy to view, share, and keep secure even when sharing. Behavior Imaging allows for a method of secure sharing of videos with trainees, experts, or supervisors, with the creator of the video being able to choose the level of security, from the recipient simply being able to view the video without downloading it, to being able to download, to being able to download it and provide digital feedback within the video. These and other uses have become an increasingly common practice among those who are comfortable introducing various forms of technology into the therapy process.

International Behavioral Research: A final exciting potential of this technology is in the collection of specific data regarding complex behaviors that can be compared across countries and across cultures. This data could be compared with and analyzed against other data sets such as environmental exposures, family histories, and genotype. This could potentially facilitate cross-cultural, large scale, neurobehavioral research that lends itself to culturally-informed evidence-based interventions. This system could facilitate nationally or internationally based multi-site research study in which medical, psychological, or behaviorally-oriented assessment or treatment research is conducted and require behavioral data to be evaluated, coded, and analyzed. Behavioral data could be related to the standardized implementation of the actual treatment protocol or the behavior of the actual research participant.

Future

With clinical and research benefit already, it is anticipated that the Behavior Connect technology platform will expand in several important ways. Complementary technologies such as the integration of wireless physiologic monitors that track blood pressure, EEG and EMG output, etc. can expand the type of information clinicians will have ready access to – to make more informed decisions.

In the not-too-distant future, emerging technologies for unobtrusively measuring behavior wirelessly in natural environments [11] could be fruitfully combined with Behavior Connect. For instance, recent developments in ambulatory and non-contact autonomic nervous system monitors [12,13,14,15]), wireless accelerometers [16], and automated facial expression detection systems [17] could be used to explore physiological arousal [18], physical activity monitoring [19] and automated facial expression [20], respectively. Integrating these sensing modalities with time-locked, *in-situ* video and audio collected by Behavior Connect would enable a rich, multi-level assessment of the environment and an individual's overt behavior and covert biology over time and across settings.

Furthermore, we anticipate in the coming years that real-time data mining and pattern recognition algorithms will enable automated extraction of important behavioral and developmental events that researchers, caregivers, and service providers can use to assess, understand, and support clinical populations from a dis-

tance. For example, imagine the value a clinician or researcher could glean if his 500 patients each having 100 behavior images captured can do. With today's information technology capabilities, one could use the Behavior Connect platform to pull up any examples where a patient articulated an intelligible word over years of data, or show if a patient ever had real eye-contact with another to demonstrate social abilities, or to pull up anytime his body made an unnatural behavior (based on norms that it can be compared to).

These may help make the review of complex behavior data as helpful, or even more helpful, than X-Ray images or MRI images. Availability of Behavior Imaging offers great potentials for education, healthcare and research. The technology along with judicious clinical experience will bring never-before-available benefits to a wide variety of populations.

The authors wish to recognize the late Dr. Swamy Laxminaryan for pioneering the conceptual framework of Behavior Imaging, which now is helping to achieve his dreams for improved health care through technology.

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