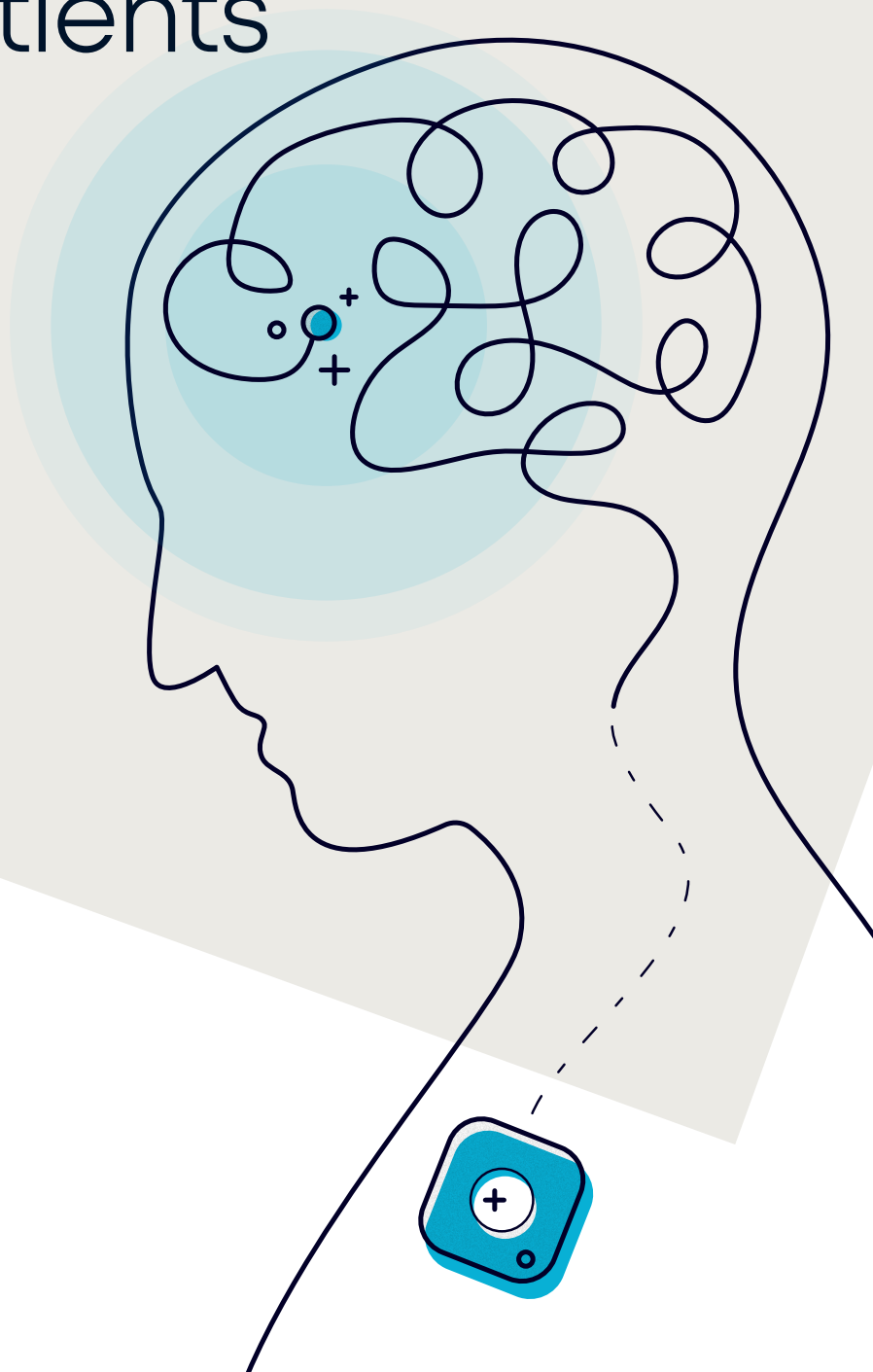
Innovation briefing

Revolutionising DBS aftercare for Parkinson's disease patients



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CC in three
your key notes to take away

1. The vital aftercare of deep brain stimulation (DBS) provides long-term benefits for Parkinson's disease sufferers, but it is not currently well suited to patient lifestyles and clinician needs

2. Understanding and tackling the challenges that patients and clinicians face is the key to increasing the quality of aftercare and improving patient outcomes

3. A multidisciplinary CC team has identified ways for technology to capture non-motor symptoms for improved DBS aftercare – and created a concept system called Sen to illustrate its progress

Introduction – the problem of Parkinson's

Parkinson's disease affects six million people worldwide. It is a progressive and lifelong neurological disorder caused by a loss of nerve cells in the part of the brain called the substantia nigra. Symptoms can be different for everyone. It brings about a wide range of conditions which can be grouped into two: motor and non-motor related symptoms.

Deep brain stimulation (DBS) is widely used as a treatment option for Parkinson's. An FDA-approved surgical procedure, it helps patients regain control and independence over their life. DBS is primarily intended to ease motor symptoms and decrease the medication needs of the patient. It has been shown that Young-Onset Parkinson's disease has higher rates of DBS candidacy and surgery, as well as positive motor response after surgery.

Although DBS is mainly used to treat motor symptoms, its efficacy for depression is currently being investigated. Several clinical studies have shown that it can be used safely and effectively. Extending the use of DBS in this way would certainly greatly benefit Parkinson's patients.

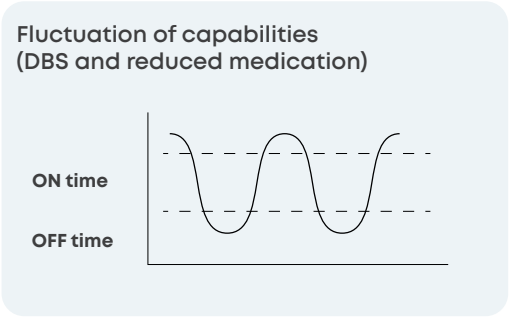
DBS long term aftercare requires a multidisciplinary team

After the surgery, the process to optimise the DBS stimulation is a long one. Customising DBS therapy can take up to six months and include several sessions to programme the stimulator to unique needs, titrate medication and monitor changes in symptoms.

Managing the disease requires a multidisciplinary care team (including nurses, neurologist, occupational therapist, physiotherapist and speech-language pathologists, among others) to improve a patient's functional capacity, wellbeing and quality of life.

Figure 1: DBS aftercare process

Tune implant



Function optimised

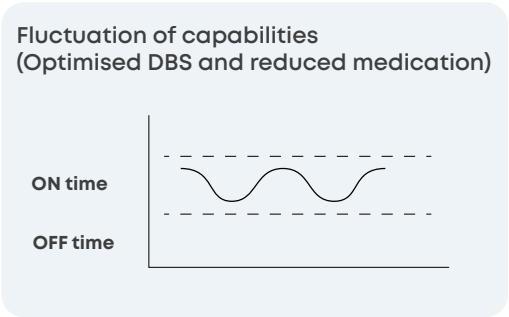


Figure 2: Optimising DBS enables greater stability of capability

Optimising the function of your DBS implant to improve the quality of life

A more personalised, comprehensive and objective monitoring approach to Parkinson's disease is warranted due to the challenges and limitations of current scaling methods.

Key challenges for clinicians

1. Clinicians may experience limitations working with the United Parkinson's disease Rating Scale (UPDRS) and little technology is available to support this assessment process.
2. Clinicians may not be able to capture accurate disease progression data of the patient being treated by DBS over time, especially the dependency of motor and non-motor symptoms.
3. Healthcare professionals dedicate a lot of time to patients over the course of DBS aftercare; when such time is limited, patient quality of life may be impacted.

Key challenges for patients

- Some DBS patients do not feel in control of their own aftercare
- DBS patients may feel emotionally burdened by the progressive nature of the disease, and the long-term aftercare required
- DBS aftercare can hinder patients' ability to truly regain control and independence over their life

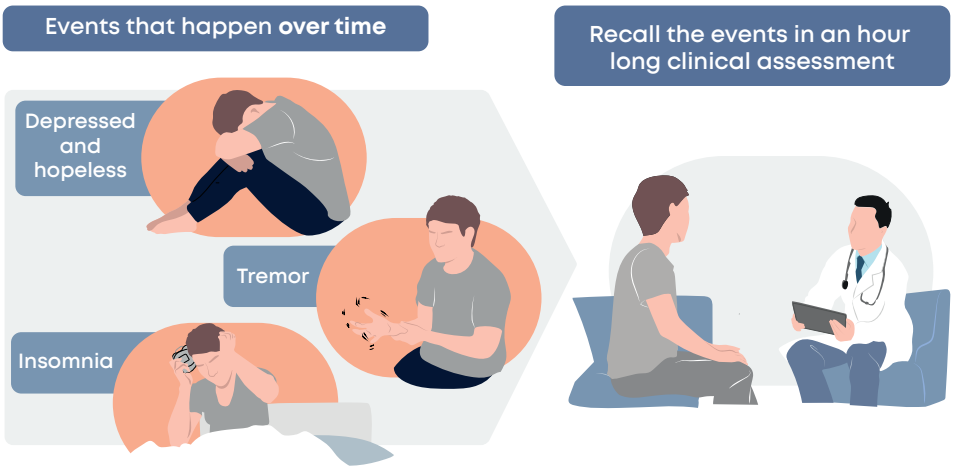


Figure 3: Clinical assessments aim to distil many weeks of activity history

Stakeholder insight can unlock more suitable technology

It is clear from literature reviews that a more personalised, comprehensive and objective monitoring approach to Parkinson's disease is warranted. There are many challenges and limitations around scaling current monitoring tools to capture a holistic profile for improved treatment.

How do we help clinicians access more accurate patient information?

To fulfil this objective, we need to understand several factors. For example, what type of information is useful for decision-making to support effective diagnosis? How does the data map into the UPDRS grading system? How can we identify patients' condition patterns based on the extracted data?

And how do we provide clinicians with filtered, relevant insights from the data?

How do we help patients feel empowered and in control of their treatment?

For this, we need to understand patient needs and personalise a solution accordingly. We also need to work out how to seamlessly collect information regularly without interrupting someone's lifestyle. Patient age and level of motivation are also important considerations when it comes to technology application. For example, older users can find technology daunting and difficult to use effectively.

It is also vital to provide just the right level of information to patients. We need to strike the right balance, so they understand their condition and the status of their implant without being overwhelmed. Patients also need to be supported in recording information by removing the burden of self-recorded data and recall.

Current motor symptom monitoring technology

Several studies have demonstrated that remote monitoring systems and virtual visits improve the quality of care while minimising direct and indirect healthcare costs. There are currently many wearable monitoring systems on the market which produce varying data. This can be interpreted by the user or clinician to monitor tremors and other symptoms associated with the motor system.

A multitude of tech-based measures have been developed within the last decade. However, tech developers are duplicating solutions and not all are driven by the clinical field. This is creating solutions that seem repetitive and are yet to reach their full capacity.

Currently, patient and caregiver engagement with wearable and mobile technology is modest, as shown by a recent study demonstrating that 32% of users stop using wearables after six months, and 50% after just over a year. This stems from devices being deemed to be too much effort, and often not delivering enough benefit to ensure compliance.

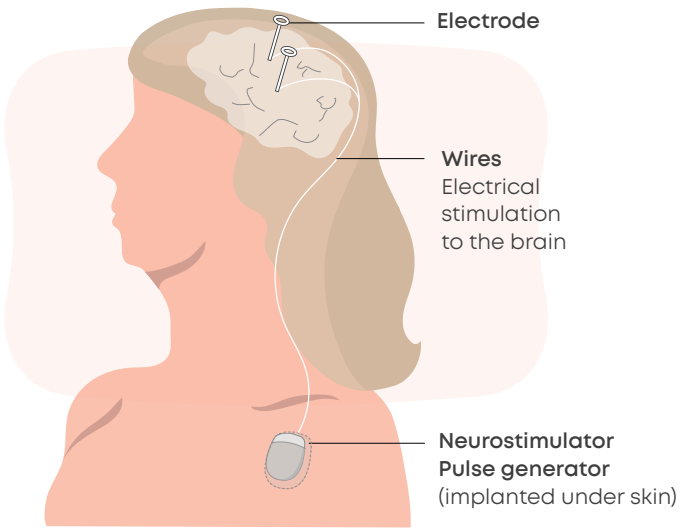


Figure 4: Typical DBS implant set-up with the Sen wearable sensor

Monitoring psychological and emotional aspects

There has been increasing awareness of non-motor symptoms caused by Parkinson's. The gradual increase of such symptoms has been shown to significantly lower a patient's quality of life. Non-motor symptoms can play an important role in treatment, diagnosis and monitoring disease progression.

Technologies and techniques to address psychological symptoms in the context of Parkinson's disease are currently under-explored. The hardest challenge of monitoring non-motor symptoms is understanding and capturing the psychological symptoms associated with Parkinson's:

5 categories of psychological symptoms associated with Parkinson's

Figure 5: The five categories of psychological symptoms associated with Parkinson's

To understand how clinicians assess these symptoms, the CC team interviewed a consultant psychiatrist specialising in elderly care. She revealed that her general approach during the clinic appointment involves a combination of a patient self-report, carer report, and a doctor-led discussion.

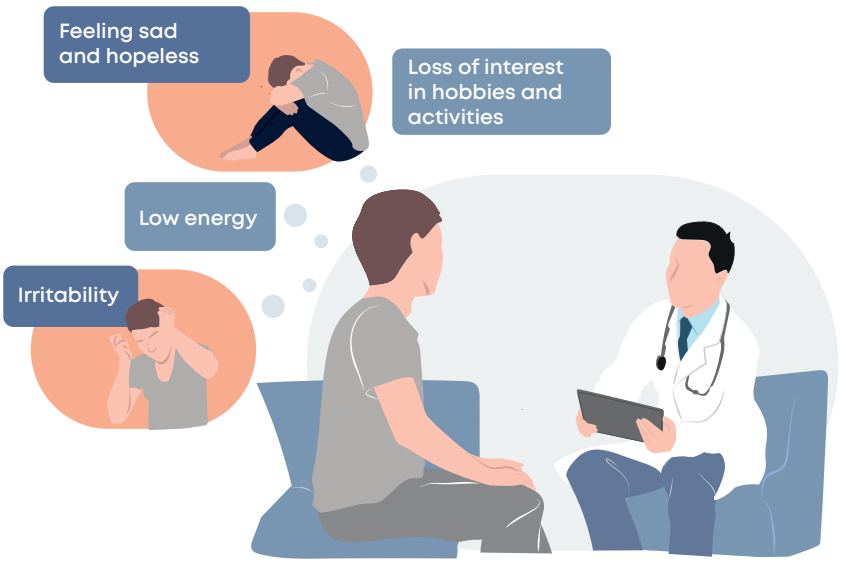


Figure 6: Examples of psychological symptoms which can affect quality of life

While AI shows promise, there are no specific solutions for Parkinson's

There are two clusters of AI that have the potential to help Parkinson's patients through unobtrusive measurement of non-motor symptoms:

- Disease assessment – using traditional and novel biomarkers to track symptom progression
- Digital phenotypes – bringing together multimodal streams of data to build a pattern and achieve a deeper understanding of the patient

Despite the increasing emergence of AI-powered solutions for various aspects of Parkinson's, there's still no holistic solution which has been proven to detect the range of psychological symptoms specific to the disease. This is due to the natural complexities and many-to-many relationships between everyday life factors, introspective thoughts, behaviours and psychological symptoms.

Measuring psychological and emotional symptoms through behavioural metrics

Within the realm of both disease assessments and digital phenotypes, behavioural metrics play a role in non-motor symptoms detection and management. Non-motor symptoms can be broken down into:

1. **cognitive**;
2. **emotional**;
3. **physiological** (outside of Parkinson's already defined motor symptoms);
4. **postural**, and
5. **behavioural symptoms**.

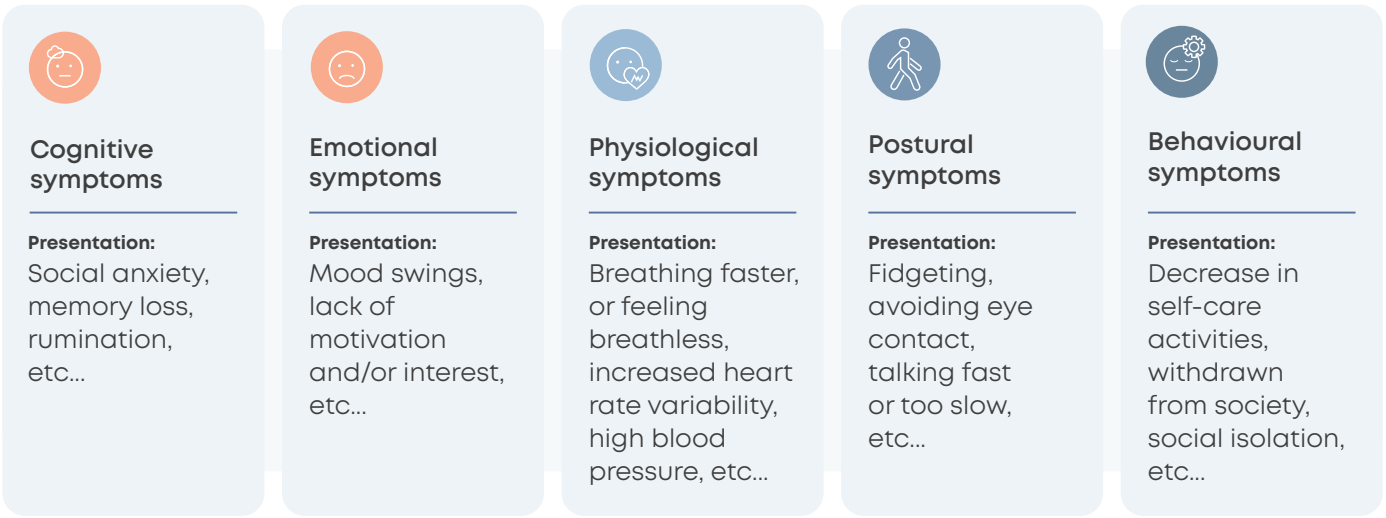


Figure 7: Psychological symptoms can present in measurable behaviours, allowing us to capture a window of insight into the patient's inner state

To tailor measurements to a specific patient, it is important to establish the patient's baseline. In each of these five categories, technology-driven solutions powered by AI have shown the potential to monitor these in greater spatial and temporal detail – and output more actionable insights.

Case study – the 'Sen' aftercare solution

Seamlessly integrating technology into a patient's lifestyle

Understanding the pain points and needs of both Parkinson's patients and clinicians was crucial for the next step of the CC team's journey. As was our investigation into the potential of motor and non-motor monitoring systems. This preparatory work enabled us to design a concept aftercare solution for Parkinson's patients with implanted DBS therapy devices. We call it Sen. It is a flexible, rechargeable continuous monitoring system designed to give patients their normal lives back.

The holistic wearable medical device concept puts the underserved needs of Parkinson's patients at the heart of its user-centric design.

Sen incorporates:

- A wearable sensor and charger
- An adhesive power coil
- A wrist strap
- A docking mat doubling as a discreet wallet
- An app-based aftercare support system

The wearable tracks the characteristic symptoms of freeze, tremor, twitch, walking pattern, postural stability and sleep patterns. The companion app monitors non-motor symptoms including speech, writing, mood and pain levels. Although the concept is yet to incorporate comprehensive monitoring of psychological aspects, there is plenty of potential for more development.

Wearable Sensor
Monitors patient's condition, snaps magnetically to charger.

Wearable Charger
Wearable battery pack to charge the implant under the skin. 30 minutes per day or 2 hours each week will keep the implant fully charged.

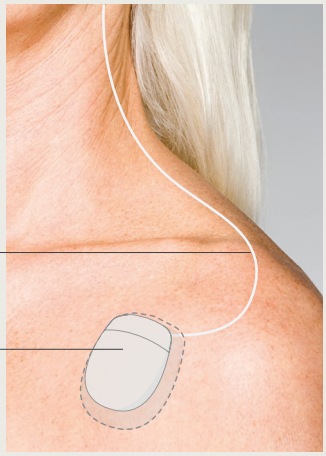
Adhesive power coil
Implant charging coil embedded in wipeable and reusable adhesive patch to stick onto the skin.

Neurostimulator implant
(under the skin - not part of Sen)

Neurostimulator implant overview:

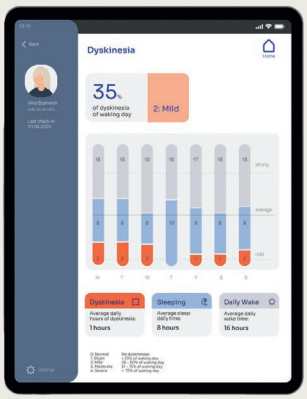
Wire carrying electrical stimulation to the brain

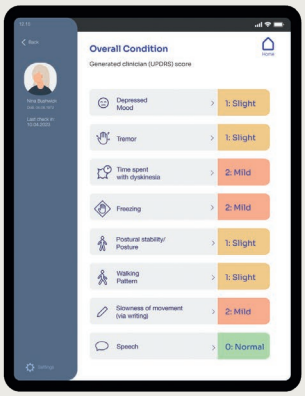
Neurostimulator implant under the skin with rechargeable battery



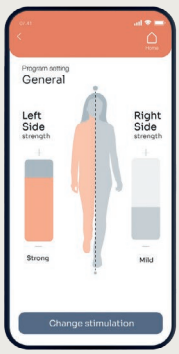
Objective and unbiased assessment

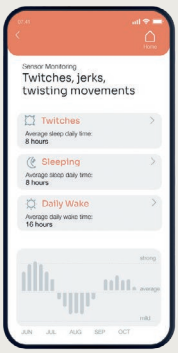
Sen collects real-time data of the patient's symptom characteristics continuously to support clinicians with objective assessment of disease progression. This significantly improves on conventional scoring tools by eliminating patient cognitive bias during clinical assessment. It also increases the efficiency of hospital visits. Continuous monitoring enables a shortened DBS tuning phase.



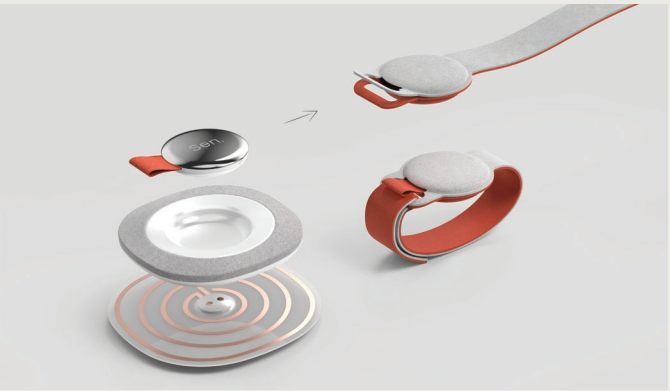


Clinician





Patient



Patients feel empowered

Sen reassures patients and empowers them to lead a less worrisome life at what is a complex and emotional time. The key to this is the treatment information that is provided through the app. Patients can check the condition and performance of their implant, configure stimulation settings and monitor data. The app also captures past episodes and symptoms, which removes the burden of manually logging or remembering these events.

The system delivers impact

Accurate baselining and assessment is essential for effective management of Parkinson's disease symptoms. Sen supports better treatment through continuous monitoring and vastly improved data availability for clinicians. It enables more effective inpatient appointments, as well as freeing up clinical staff availability by cutting the time and complexity needed for traditional assessment methods. So, by combining widely adopted technologies in this way, substantial time savings can be achieved that benefit the healthcare system at large.

Summarising Sen

- Considering human needs is important to address challenges and make tech work better
- Parkinson's aftercare still has room for improvement – especially in the non-motor symptom domain
- Based on our research, we see the potential for further growth and development in psychological monitoring for medical technology

The commercial context

A business perspective from John Genova, Senior VP, Global Medical Technology, Cambridge Consultants:

"This CC Innovation Briefing explores the current limitations of implanted deep brain stimulation (DBS) aftercare for Parkinson's patients. But it also tells the story of our unique approach to medical technology development. The Sen concept for an aftercare solution for Parkinson's patients with DBS devices was conceived after the team identified a clear gap in the market."

"The project that unfolded put unmet user needs at the heart of design development – and is indicative of the way my colleagues are able to signpost industry advancement for ambitious innovators. CC is characterised by a rare mix of academic expertise, technology knowledge and deep market understanding. This is a powerful combination, especially at a time when patients are increasingly becoming consumers. Novel, patient-centric solutions like this, that empower lives and lead to better outcomes, represent differentiating commercial opportunity."

The multidisciplinary CC team

The Sen concept aftercare solution for Parkinson's patients with implanted DBS therapy devices is a case study in multidisciplinary innovation. The initiative characterises CC's instinct to challenge conventional thinking and help clients propel their ambitions. The concept was conceived and developed by a team of designers, human factors engineers and human behaviour scientists who are passionate about harnessing technology to improve patients' lives.

Emma Hughson,
Affective Computing Engineer

Dawn Tang,
Designer

Hajni Salazar-Velekey,
Human Factors Engineer

Sam Odell,
Human Factors Engineer

Michelle Lim,
Human Behavioural Scientist

Why CC?

Cambridge Consultants (CC), part of Capgemini Invent, is a global team of 800 bright, talented people – united by the ambition to turn brilliant and radical ideas into technologies, products and services that are new to the world. We expand the boundaries of technology innovation by tackling the tough, high-risk challenges that bring sustained competitive advantage and market leadership for clients. We are trusted by some of the world's biggest brands and most ambitious start-ups to realise their critical technology-based aspirations – and we've been doing it for 60 years.

Let's continue the conversation

If you'd like to discover more about the project, or would like help with any aspect of medical innovation, do please get in touch with John Genova, Senior Vice President – Global Head Smart Implants, MedTech.

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