## Elevator Pitch - 97% human

In a quiet room in Naperville Mr. Zhou, a 82 year old stroke survivor, cries because he cannot say “I love you” to his grandson. He's not alone. 7.5 million Americans with speech disorders face the same silence. Their brains’ function, but their failing muscles trap them in the prison of their bodies [1]. Current solutions fail them. AAC tablets cost $10,500, forcing users to type at a miserable 10-15 wpm [2][3]. That’s 10 times slower than natural speech [4]. Brain Implants? $50000-$100000, requires high risk neurosurgery, and excludes 99% of patients [5][6]. Our non-invasive, LLM powered headset decodes attempted speech directly from facial muscle signals (EMG), converting silence into audible voice, real time. By leveraging economies of scale, we aim to deliver medical grade speech restoration for ~$2500, 75% cheaper than market standards. Our goal isn’t ‘just’ to restore speech, it’s to restore people’s fundamental right to be heard.

## Team: 144 words, 100% human

VOCL formed as we visited James's house over the summer and met his grandfather, who we affectionately called Ye-Ye. He was 82 and battling ALS. Every visit that summer we'd tell him about our day. He'd listen, silently tracking us with his eyes. His problem was the same as millions of others: his brain worked, but his muscles didn't.

When Ye-Ye passed away late summer, we were devastated. Early fall, we read about researchers at Stanford decoding inner speech with 74% accuracy. However, it required invasive implants - tens of thousands in costs. We realized that if they could decode thoughts invasively, why couldn't we decode attempted speech non-invasively?

Idhant engineers our signal acquisition hardware while Atharva develops the ML models. Craig handles ergonomic testing and MVP refinement. Jayden validates our ideas with clinicians and researchers while James coordinates market research with experts/families for feedback.

## Opportunity: 281 words, 93% human, 5% mixed, 2% AI

VOCL seeks to decode attempted speech from facial muscles. We're non-invasive, hands-free, and bridge the gap between devices that don't work and expensive, dangerous surgeries.

Speech is a fundamental part of life, yet 7.5 million Americans live without it [1]. The status quo of solutions is unacceptable. AAC tablets like the Tobii Dynavox I-Series cost ~$10,500 [2] and the PRC-Saltillo is ~$7,895-$8,395 [7]. Medicare barely covers these [8], leaving families paying exorbitant prices out of pocket. Despite their price, these devices are hardly effective. Patients are forced to type at 10-15 wpm [3] - a speed so slow that 30-50% abandon the devices entirely [9]. Imagine a life where you need 2 minutes to type "I need the bathroom." Brain implants like Neuralink and Synchron hit 97%

accuracy but cost between $50,000-$100,000 [5][6], not to mention invasive drilling into your skull. The gap between cheap solutions that don't work and unaffordable invasive solutions leaves millions voiceless.

Speech loss is widely considered as the driving force for depression in 64% of stroke survivors [10]. Beyond that- without communication employment slips away. Unemployment for severe speech disability is already at 70% [11]. VOCL aims to target the "Missing Middle": the 3 million with Dysarthria [12], 2 million with Aphasia [13], and 30,000 with ALS [14]. These are all patients who retain residual control of their facial muscles but cannot vocalize. EMG signals from attempted speech are 3-5× stronger than imagined speech [15], rendering brain surgery obsolete while still delivering natural, non-invasive communication. VOCL goes past just this device. It's a grandfather saying "I love you" to his grandson again, a teacher returning to the classroom, a parent reading bedtime stories. It's millions reclaiming their voices.

## Market:

People with speech disorders, namely dysarthria, aphasia, ALS, and stroke-related paralysis, are VOCL's primary individual consumers. Secondary consumers include medical institutions: rehabilitation centers, VA hospitals, SLP clinics, and nursing homes seeking solutions covered by Medicare.

Speech-impaired individuals share three core values: restoration, affordability, and naturalness. Current solutions include $10,500 AAC tablets or $50,000-$100,000 brain implants. Implants not only require invasive surgery but are also incredibly expensive, making it nearly impossible for a regular family to afford. Although AAC tablets are non-invasive, they're still expensive and force patients to type at an agonizing 10-15 WPM. VOCL is able to exceed all of the criteria these solutions fail on by delivering medical-grade performance at $2,500 while enabling natural speech at 30-50 WPM, making this product clearly stand out in the market.

Our market strategy is two-pronged: B2C and B2B. Families are able to bypass insurance delays entirely and pay out-of-pocket to restore members' voices. Families truly appreciate the ease and speed VOCL provides due to the uncertainty of involved disorders. On the other hand, institutional buyers can take advantage of Medicare Part B reimbursement [45][46], where VOCL's price qualifies, making approval uncomplicated. With this model, institutions profit from reduced hospital stays and readmission rates. [43][44].

Our total addressable market is a $270M speech-generating devices industry [40] that will reach approximately $939M by 2037. For our Serviceable Obtainable Market, VOCL aims to capture 5.3% market share ($49.4M/$939M) and targets 19,720 units ($49.4M in revenue) in ten years, positioning us as a significant player in this market. Our serviceable addressable market includes 5 million who cannot use AAC—specifically dysarthria patients (3M) [12], aphasia patients (2M) [13], and ALS/MS populations [14]—and 7.5 million speech-impaired Americans [1].

## Innovation:

VOCL is a non-invasive EMG headset that restores the crucial function of speech for the millions of individuals who have lost their voice. It acts as a direct pipeline from intention to speak to expression, allowing for nearly seamless communication without the need for surgery, screens, or millions of dollars.

Our prototype weighs in at around ___g and features three main components. The chassis is custom 3D-printed out of PETG, ensuring both flexibility and strength for a robust fit. The shape and flexibility of the chassis ensures each electrode maintains constant pressure, preventing signal loss in noisy environments. Eight gold cup electrodes in total fit into the chassis and measure signals across the user's face as they attempt to speak. Finally, the headset houses the 8-channel OpenBCI Cyton board along with four 3.7V 500mAh Lithium ion batteries. The board samples at 250Hz and amplifies the electrode signals [17], creating a continuous stream of high gain, low noise EMG data to be analyzed by our software.

Users begin by pairing the headset to their personal device via Bluetooth, which runs calibration software and displays real-time feedback on signal quality. Users complete a 10-minute personalization sequence where they attempt to say 20 common phonemes. Our adaptive algorithms learn the user's unique muscle activation patterns, accounting for variations in anatomy and condition from person to person. For example, spastic vs flaccid paralysis creates completely opposite signal profiles and tremors from ALS create high-frequency noise that needs to be filtered at 30Hz instead of 45Hz [79]. The app provides visual feedback during calibration with a green light when signal quality is strong, yellow when moderate, and red when the headset needs to be readjusted.

After calibration, the headset is ready to go and transform lives. When a user attempts to say "hello," even without actually making any sound, voltage drops as subtle as 5 microvolts run across several facial muscles [16][25]. Electrodes measure these voltage drops across the orbicularis oris superior, orbicularis oris inferior, and depressor labii inferioris. Additionally, reference and bias electrodes sit on the platysma to establish a stable ground plane, critical for rejecting 60Hz noise that would otherwise drown the intended signals we're measuring. Electrode data is sent to the OpenBCI Cyton board for preprocessing and finally analyzed by our LLM.

Our ML pipeline applies a 0.5-45Hz bandpass filter [18], using Independent Component Analysis (ICA) to remove artifacts like eye blinks, jaw clenches, and other extraneous movements. Principal Component Analysis (PCA) combined with Linear Discriminant Analysis (LDA) compresses dimensionality [21], focusing on the most important signals and ultimately reducing complexity. The algorithm recognizes each individual phoneme (most basic unit of speech) that is subvocalized and predicts the most likely word made up of those phonemes. In the "hello" example, the phonemes /h/, /ə/, /l/, and /oʊ/ are recognized in order at a __% confidence level, combining to successfully output "hello" as audio from the user device. Within 300ms, our users can hear their own words, some for the first time in years.

VOCL is the first system to combine attempted speech EMG data with LLM post-processing for context-aware speech formation. Phoneme sequences alone create ambiguity; for example, /b/, /æ/, and /t/

could be “bat”, “bad”, or “back”, so we integrated our LLM layer to predict the most likely words based on context. Predictions use the current window plus a few seconds of prior context to simulate conversational flow, distinguishing “I need water” from “I need Walter” based on whether the previous sentence was related to thirst or a person. Recent research using similar LLMs achieved a 12.2% word error rate, down from 28% [27], which falls below the 15% threshold for practical use [28]. The LLM essentially acts as an autocorrect for speech, leveraging grammatical context to piece together phrases even if some phonemes remain obscure.

Our proprietary pipeline will be protected through several layers. We will pursue a utility patent to cover our EMG to phoneme to LLM architecture (no existing system combines all three) and use trade secrets to safeguard our training dataset of over 4,000 EMG samples collected over the past few months and our neural network weights/biases. Additionally, our system becomes more and more distinguished as our dataset grows further.

VOCL is the first affordable and non-invasive speech restoration technology. Sold for $2,500, it will replace unrealistic alternatives such as Neuralink [5] and Dynavox [2] and serve millions of people by reviving voices and restoring connections through real time communication.

Fundraising Question

Assuming the company grows at the speech-generating devices industry's 10% CAGR [40], we project that 1,240 units will be sold in 2028, year one, and 19,720 over a decade (19.72% of our SOM). First-year expenses are $1.46 million: $800,420 for manufacturing ($645.50/unit), $107,880 for marketing [58], $100,000 for AI development [59], $75,000 for clinical trials [60], $50,000 for tooling [61,62], $10,000 for lab space [63], $50,000 for regulatory consulting, and $7,000 for patents [64]. Illinois LLC fees total $274 [65,66].

For fundraising, we are pursuing NIH SBIR Phase I grants and ALS Association Research Grants that target medical device R&D for communication disorders [67], venture capital funds, such as SOSV/HAX and 1517 Fund that specialize in early-stage hardware, with HAX focusing on medical devices, and crowdfunding campaigns on Kickstarter and Indiegogo [68].

Through multiple prototype iterations, we gained a better understanding of our costs and identified opportunities to make VOCL affordable. Most of our costs are attributed to hardware, marketing, and assembly. Under mass production, the cost breakdown per unit includes an OpenBCI 8-channel board

($555.50) [69], Ag/AgCl cup electrodes 8-pack ($14) [31], 5000mAh LiPo battery ($5) [70], 3D-printed PLA/TPU housing ($38.75) [71], wiring and connectors ($3), and miscellaneous materials such as solder and adhesive ($2). Assembly and packaging costs will average $27.25 per unit [72], bringing the total production cost to around $645.50 per unit.

Assuming a 15% cost reduction through economies of scale and supplier negotiations [73,74], a conservative estimate in the medical device industry, the cost per unit drops to $549. We will price the product at $2,500, yielding a 78% gross profit margin [75]. This margin funds FDA 510(k) compliance, continuous ML model improvements, patient onboarding support, and warranty coverage.

Because of our specialized market with few competitors, we are targeting a $87 customer acquisition cost (CAC) [58], which is average within the healthcare device industry. Our marketing strategy focuses on partnerships with speech and language pathology clinics, targeted campaigns in ALS/stroke patient communities, and social media advertising campaigns.

Revenue streams include hardware sales ($2,500 per unit), optional premium subscriptions ($29/month for voice cloning features using pre-injury voice recordings), and anonymized EMG dataset licensing to research institutions. We target a Customer Lifetime Value (LTV) of $3,200 over 5 years, yielding an LTV:CAC ratio of 10.7:1 [76].

Through this business model, we deliver top-tier speech restoration at a fraction of the price.

## GO-TO Market - 96% Human:

To expand reach and ensure affordability, VOCL will leverage B2C and B2B direct sales, partnerships with disability-focused organizations, Medicare reimbursement, and distribution through our B2C e-commerce platform and medical supply retailers such as Numotion.

To draw in customers, we will hold live demonstrations at paralysis support groups, speak at industry conferences such as AHSA, and run webinars to educate clinics about Medicare HCPCS Code E2510 qualification [45][46]. These efforts will encourage the adoption of VOCL through reimbursable purchases.

Our initial customers will consist of 50 early-stage ALS and post-stroke dysarthria patients at Northwestern Medicine and Shirley Ryan AbilityLab [49]. These patients urgently require non-invasive, affordable solutions. A survey showed that 92% of speech-language pathologists recognize a significant unmet need. Furthermore, our pilot program benefits both parties, as VOCL can collect the clinical data needed for FDA 510(k) filing as a Class II medical device [50].

## **7. Competition - Atharva, Craig:** What competes with your innovation, and how does your innovation compare? What are the

advantages and disadvantages of your innovation? What is your positioning?

Although some solutions exist, VOCL faces little direct competition in the speech restoration market. Alternatives are either low-cost but not effective or very expensive and involve invasive procedures. VOCL will be one of the first to offer clinical-grade performance at consumer prices, and it will be the only option providing affordable, non-invasive speech restoration aimed at attempted speech.

Non-invasive solutions are traditional AAC tablets like the Tobii Dynavox I-Series [2] and PRC-Saltillo devices [7], which range from $7,000 to $15,000 but force users to speak at 10 to 15 words per minute [3]. This speed is so slow that 30 to 50% of users give up on them entirely [9].

The invasive solutions Neuralink and Synchron [5][6] have undergone the most testing but require neurosurgery, are inaccessible, costing between $50,000 and $100,000, have infection risks, and may face signal issues as scar tissue builds up around the electrodes [8]. Moreover, these devices need to pass FDA Class III approval, which takes years of clinical trials. Meanwhile, MIT's AlterEgo [35] targets healthy users for silent smartphone control, addressing the wrong issue.

By recognizing these gaps, we found an opportunity to change the standard. VOCL, unlike any product currently available or in development, targets attempted speech by generating EMG signals 3 to 5 times stronger than imagined speech [15], offers a communication speed of 30 to 50 words per minute [34], and remains affordable at $2,500. VOCL is set to enter a market with few solutions and competitors with one goal: to give accessible, non-invasive voices to those who need them.

However, VOCL may encounter reliability issues since our CNN-LSTM cannot guarantee 100% accuracy [41]. Success will rely on ongoing iterations through pilot programs and input from patients.

## Question 5: Validation/Progress (450 words)

Our innovation has been thoroughly validated through through our intensive engineering process, expert consultations across neuroscience and speech pathology, prototype testing and surveys with 127 patients families and clinicians

We used OnShape and Fusion 360 and iterative prototyping to develop our wearable through 7 redesigns. V1-V3, we used a cap-based design with scalp electrodes requiring conductive gel. It was bulky and uncomfortable (505 g) and suffered from a terrible signal to noise ratio since brain signals have a weak correlation with attempted facial speech. V4, we pivoted to a mask based design built specifically for facial muscles. It had  a reduced weight of 467g but there were issues with electrode contact during head movement. V5 added a more adjustable set up for more consistent electrode pressure. It achieved 8 channel EMG capture but was still uncomfortable after 20 minutes of wear. V6 had a more ergonomic, head shaped design inspired by professional headphone design. However, this complicated assembly with over 27 components. V7, we brought down to 12 components, weighing ~420g and is comfortable for long term wear and easy to reproduce.

Our software pipeline was developed on 440 phoneme utterances (44 phonemes x 10 repetitions) from one subject (to ensure consistency) that led to 3220 training samples after sliding window segmentation. Initially, our CNN-LSTM machine learning architecture had inconsistent results without proper dimensionality reduction. Following a meeting with Dr. Nicholas Hatsopoulos from the University of Chicago where he recommended adding autoencoders & principle component analysis, we implemented PCA-LDA dimensionality reduction compressing 256 features into 45 discriminative dimensions [20]. This change led to 82% single subject phoneme classification accuracy! Dr. Hatsopoulos emphasized to us that "'the bar is incredibly low for noninvasive ALS speech solutions so a product like ours if done properly would be revolutionary". His specialization in motor cortex BCI's was invaluable in helping us identify the muscle activation patterns and their ability to transfer across vocalization conditions.

We continued to test our functional prototype over 35 testing sessions (6 months), successfully decoding 1847 attempted words with 68% accuracy in continuous speech. Our LLM integrated architecture had < 300 ms latency and maintained signal quality across 2 hour sessions- a factor that is important for real world testing.

Additionally, we consulted with 8 leading researchers who validated our technical approach and market need. Dr. Howard Nusbaum (UChicago Psychology) confirmed that while EMG signals are inherently variable, our machine learning approach can effectively overcome context-dependent challenges in speech mapping [37][38]. Dr. Sergey Stavisky (UC Davis Neuroprosthetics, 2023 International BCI Award winner [39]) called our approach 'unique and very interesting', further noting that noninvasive signals can definitely serve early stage ALS patients and those that still retain residual movement ability. Dr. Dina Simkin (Northwestern) also confirmed that the viable motor neurons in affected subjects make our training approach highly effective and even referred us to more clinical contacts. **Davis moses, harshavardhan, include them**

We also validated market need through 2 anonymous surveys. Among 68 patients and family members (ALS, stroke survivors, dysarthria), 91% confirmed current solutions were inadequate, 87% would consider purchasing VOCL at $2500 and 94% preferred noninvasive options instead of surgical. Among 59 clinicians, 93% recognized the unfulfilled need for affordable speech restoration, 98% believed VOCI addressed a critical gap and 86% would recommend it to patients if FDA approved.

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**Word count: 450 words exa,ctly ✓**