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Neuromarketing in space deep tech: leveraging emotional and cognitive responses to accelerate tech adoption

Michele Rosari*[a], Alessia Gloder [a], Giordano Fagiolo, Patrizia Cherubino [b], Alessia Vozzi [b], Stefano Menicocci [c], Valentina Scaramozzino [c], Gianluca Borghini [d], Giada Russo [e], Federica Angeletti [f], Francesco Ventre [g]

[a] *Somaspace S.r.l, Via San Filippo Neri 39, 00041 Albano Laziale, Rome, Italy*
[b] *Brainsigns S.r.l, Via Tirso 14, 00198 Rome, Italy*
[c] *Dept. Of Psychology, Sapienza University of Rome, Via dei Marsi, 78, 00185, Rome, Italy*
[d] *Dept. of Molecular Medicine, Sapienza University of Rome, Piazzale Aldo Moro, 5, 00185, Rome, Italy*
[e] *Aiko S.r.l, Via Dei Mille 22, 10123 Torino, Italy*
[f] *School of Aerospace Engineering, University of Rome "La Sapienza", 00138 Rome, Italy*
[g] *Space Generation Advisory Council, Schwarzenbergplatz 16, TOP 1 1010 Vienna, Austria*
* Corresponding Author

Abstract

This study investigated the application of neuromarketing principles within the space industry, aiming to optimize communication and stakeholder involvement.
It analyzed the effectiveness of emotionally driven narratives and simplified messaging in boosting the persuasive appeal of space technologies. It employed methods such as questionnaires, EEG, GSR, HR, and eye tracking, the research contrasts the impact of technical communication with emotional approaches.
Ultimately, the objective was to create actionable guidelines for space startups and SMEs to overcome communication barriers, secure funding, forge partnerships, and successfully enter markets.
This is achieved by utilizing neuroscience to decipher emotional and cognitive responses to different communication styles. A key finding is the importance of humanizing space technologies to enhance their understanding and acceptance within a democratizing space sector, thus ensuring broader public engagement and comprehension.

Keywords: Neuromarketing, Storytelling, Communication, Business Strategy.

Acronyms/Abbreviations

EEG – Electroencephalogram
GSR – Galvanic Skin Response
HR – Hearth Rate
PPG – Photo-Plethysmography
AW – Approach Withdrawal
WLD – Workload
ME – Mental Engagement
HR – Heart Rate
EI – Emotional Index
M – Male
F – Female
BVP – Blood Volume Pulse
AOI – Area Of Interest
%F – Percentage of Fixations Count
TV – Time Viewed
EB – Eyeball
TTFF – Time To First Fixation
MDPI – Multidisciplinary Digital Publishing Institute

1. Introduction

The deep-tech sector, including the growing space industry, often struggles to translate highly technical innovations into compelling value propositions for investors and customers. While the technological merits are often clear, their complexity creates barriers to adoption [1–3]. Neuromarketing, which measures physiological and neural signals capable of capturing unconscious drivers of decision-making, offers a means to address this challenge [4–6]. By analysing people's real-time cognitive and emotional responses, it is possible to scientifically test and refine communication strategies, allowing complex technologies to be communicated more effectively and accessibly [5–8].
The study presented in this paper compares and evaluates the impact, in terms of audience engagement, of two versions of a company's pre-recorded sales pitch: one based on storytelling and another adopting a standard, fact-based approach. We hypothesize that the storytelling approach will result in measurably higher mental engagement and more positive emotional responses, thereby supporting its use as a tool to accelerate deep-tech adoption.

1.1 Companies involved and role

The study involved three Italian organizations:

1) Aiko S.r.l. - a deep-tech startup developing AI-driven solutions for satellite autonomy and operations [9]. Aiko provided the sales pitch material used in the study, namely the original version of its GIFTED GENE sales pitch, which served as the stimulus for neuromarketing analysis. The company also collaborated with Somspace Sr.l. to develop the storytelling-based version of the pitch and recorded both versions in video format. The pitch focused on the company's product GIFTED GENE, a user-friendly software platform designed to detect and anticipate satellite anomalies through a hybrid rule-based and machine learning engine.
2) Somaspace s.r.l. - a strategic communication and business development agency specialized in the space and deep tech sectors [10]. Somaspace contributed by framing the research problem, focusing on how deep-tech companies can improve their stakeholder communication through scientifically validated methods. In addition, it collaborated with AIKO in adjusting the storytelling version of the sales pitch, adapting it as much as possible to make the presenter feel comfortable.
3) BrainSigns S.r.l. – an innovative SME of the Sapienza University of Rome specialized in Industrial Neuroscience applications [11]. Its core expertise is neurophysiological data collection and analysis for human's mental states assessment. In marketing applications, BrainSigns measures cognitive and emotional reactions to improve advertising, company's communication, products, website, customer experience and services. BrainSigns conducted the neuromarketing experiment, measured participants' real-time neurophysiological reactions and compared the effectiveness of the two communication approaches.

2. Material and methods

The study was conducted in Italy at the Industrial Neuroscience Labs at Sapienza University and involved 10 healthy participants (mean age: 44.9 ± 10,7; 4 male and 6 female).

The experiment adhered to the ethical principles outlined in the Declaration of Helsinki (1975, revised in 2014) [12]).

Each participant was shown two different versions of Aiko's sales pitch. The first, serving as the control variable, was the company's standard presentation, characterized by a technical, mainly data-driven and company-focused approach. The second, representing the experimental variable, was a revised version of the first pitch that incorporated a narrative-based and storytelling structure.

Prior to data collection, participants were fully informed about the study and provided written informed consent. Each video lasted approximately five minutes, and their order of presentation was randomized.

2.1 Experimental protocol

Participants were seated in a comfortable chair in front of a 24-inch computer screen and received an explanation of the experimental procedure. Ater signing the informed consent, neuromarketing devices were applied by an experimenter on the participant to record neurophysiological data throughout the video presentations. Before the experimental session, two preliminary recording sessions were performed: a 60-second resting state with closed eyes and a 60-second resting state with open eyes. These conditions were employed during signal processing to define each participant's individual alpha frequency [13] and to support blink artifact recognition [14]. Subsequently, a 60-second baseline was recorded while participants observed a deep-space galaxy. The signals gathered during this baseline video served to estimate each participant's personal activity for the Electroencephalogram (EEG), photo-plethysmography (PPG) and Galvanic Skin Response (GSR) variables used in the analysis. The signals acquired during the baseline were used in the processing phase to assess modifications in participants' internal state during exposure to the target videos, relative to the baseline condition.

Finally, in the experimental session, participants were shown the two sales pitch videos. Each session lasted approximately 15 minutes.

By convention, in this paper the original pitch (before expert revisions) is referred to as "Video PRE", while the revised storytelling version is referred to as "Video POST".

During the experiment, participants were not given specific instructions, other than to pay attention to what they would watch.

At the end of the experimental session, they completed a questionnaire assessing aspects such as spontaneous recall, liking, and the level of interest elicited by the videos.

2.2 Stimuli and storytelling

The experimental material consisted of two sales-pitch videos provided by AIKO s.r.l. The Video PRE followed a technical, fact-oriented structure, introducing the company first and then describing product features along with a case study. The Video POST was re-designed and reviewed together with a representative from AIKO's sales team, who also recorded the video versions of the two pitches. Storytelling and positioning principles were applied to reorganize the content into a coherent narrative arc. The revised storyline followed these steps:

1. **Emotional hook and context**: the pitch opened with an evocative statement aimed at capturing attention

and situating the broader context of space autonomy, positioning the product within this environment.

2. **Problem framing**: instead of listing generic technical challenges, the problem was presented from the company's perspective, drawing on insights gathered from field experience and feedback from stakeholders, clients, and potential customers. This translation of operational insights into a clear problem description grounded the story in authenticity.
3. **Category introduction**: a brief framing statement positioned the solution within a distinct product category, differentiating it from existing alternatives.
4. **Solution reveal**: the product (Gifted_GENE) was introduced with its main features, complemented by quantitative data highlighting its technical value.
5. **Evidence through case study**: a concrete example illustrated a successful product application, reinforcing the company's proven expertise and heritage.
6. **Demonstration:** a short video segment showed the software in operation, offering a direct visualization of its interface and functionalities.
7. **Closure**: the pitch concluded by highlighting engagement opportunities (e.g., demos requests or collaborations) and a concise company overview to strengthen credibility.

This restructured sequence shifted the emphasis from *"who we are"* to *"why this matters and how it works.*

2.3 Neurophysiological data collection and analysis

During all experimental tasks, the participants' brain activity was recorded using the Mindtooth Touch EEG wearable system (produced by Brain Products GmbH. Gilching, Germany - BrainSigns srl Rome, Italy). This EEG system, developed within the Horizon 2020 European Fast-Track-to-Innovation project Mindtooth [15] [16], has been already successfully validated and employed in previous studies [17].

The Blood Volume Pulse (BVP) and Galvanic Skin Response (GSR), two peripheral physiological signals, were recorded with the Shimmer System (by Shimmer Sensing, Ireland) at a sampling rate of 64 Hz. Specifically, GSR signal was acquired via two electrodes placed on the palmar side of the middle phalanges of the second and third fingers on the non-dominant hand of the participant, in line with published procedures [18].

BVP was simultaneously measured using a photoplethysmography sensor positioned on the thumb of the same hand. The heart rate (HR) signal was subsequently derived from BVP recordings using the Pan-Tompkins algorithm [19].

These neurophysiological signals were recorded to derive the indices of interest to characterize the participants cognitive and emotional response across the two experimental conditions (Video PRE, Video POST)

2.4 Eye tracking data collection and analysis

Eye tracking data were acquired using a Tobii Pro Spark screen-based eye tracker with a sampling frequency of 60 Hz, to capture eye fixations and generate heat maps of participants' visual behaviour while viewing the proposed stimuli. Heat maps provide a visual representation of where a participants, or a group of participants, fixations or gaze data samples were distributed on a still image or video frame [20]. Tobii Pro Spark system was used in combination with the Tobii Pro Lab software.

This setup allowed the collection of quantitative metrics describing how users visually engage with the videos.

The videos were divided into segments based on the topic, and three Areas of Interest (AOIs) were defined: the screen, the speakers' face and her hands. Analyses focused on these AIOs to assess user experience, based on different metrics.

From the eye-tracking data, the following parameters were extracted:

- Percentage of Fixations Count (%F): number of total fixations withing an AOI. The greater the percentage of fixations, the higher the attention of the user.
- Time Viewed (TV): average time participants spent looking at a specific AOI.
- EyeBall (EB): percentage of participants who fixated on a given AOI. This metric describes which AOI, on average, attracts the most attention from the experimental group.
- Time To First Fixation (TTFF): average latency from stimulus onset to the first fixation within an AOI, reflecting its overall attractiveness.

Following the neurophysiological recordings, participants completed a written interview designed to collect qualitative data on spontaneous recall, liking and others subjective evaluations of the videos.

3. Theory and calculation

3.1 Signal processing

Neurophysiological data were processed in accordance with best practices reported in the scientific literature. All signals underwent standard pre-processing, including artefact removal; further methodological details can be found in MDPI Journal [21]. The global field power was computed on the EEG signals, in alpha, theta and beta bands. From these data, three validated cognitive-emotional indices, normalized according to the baseline condition (as described in [22]), were derived: Approach Withdrawal (AW) [23]; Workload (WLD) [24]; and Mental Engagement (ME) [25]. Analysis of the PPG recordings allowed the derivation of the HR, while the combination of HR and GSR was used to compute the Emotional Index (EI) [26].

3.2 Statistical analyses

The statistical analysis was conducted to assess differences between the neurophysiological and the eye-tracking indices. Data normality was firstly verified using the Shapiro-Wilk test. Since the data were normally distributed, a paired t-test was performed to compare indices across Video PRE and Video POST. An additional analysis was performed on specific segments of the videos, identified with conceptual phases. Specifically, four macro phases were identified in Video PRE and eight in Video POST. Figure 1 shows the identified phases:

Phase	Video pre	Video post
I	COMPANY & CONTEXT	CONTEXT & TARGET
II	GIFTED GENE	PROBLEM INTRODUCTION
III	CASE STUDY	CATEGORY FRAMING
IV	DEBRIEFING & CONCLUSION	GIFTED GENE
V		CASE STUDY
VI		PRODUCT DEMO PRESENTATION
VII		OPERATIONAL APPROACH
VIII		COMPANY

Figure 1: Video PRE and Video POST conceptual phases.

Three of these phases, highlighted in yellow in Figure 1, were conceptually equivalent between the two videos, and a t-test was performed on the phases, identified in Video PRE and Video POST: phase 1 (PRE) and phase 8 (POST), phase 2 (PRE) and phase 4 (POST), phase 3 (PRE) and phase 5 (POST).

4. Results

4.1 Neurophysiological results

As Figure 2 shows, the Video POST generated significantly higher levels of mental engagement compared to the Video PRE (p=0.023, t=-2.72, d= -0.86).

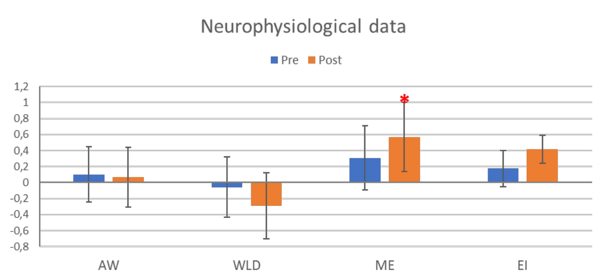

Figure 2: Neurophysiological data.

As for the other indicators:

- Both videos generated a positive level of interest.
- While no statistically significant differences emerged, results indicated a trend suggesting that the Video POST required less cognitive effort and generated a higher level of emotional engagement than the Video PRE.

Further analysis of the conceptual phases revealed significant differences (see Figure 3). In phases related to the description of *Gifted_GENE* (phase 2 Video PRE vs. phase 4 POST), significant effects emerged in nearly all neurometric indicators except AW:

- ME: p = 0.005, t = -0.73, d = -1.28;
- WKLD: p = 0.029, t = 2.66, d = 0.88;
- EI: p = 0.54, t = -2.22, d = -0.7.

Additionally, significant differences in the workload value were observed when comparing the phases presenting the company (phase 1 PRE vs. phase 8 POST):

- WKLD: p = 0.009, t = -3.41, d = -1.14).

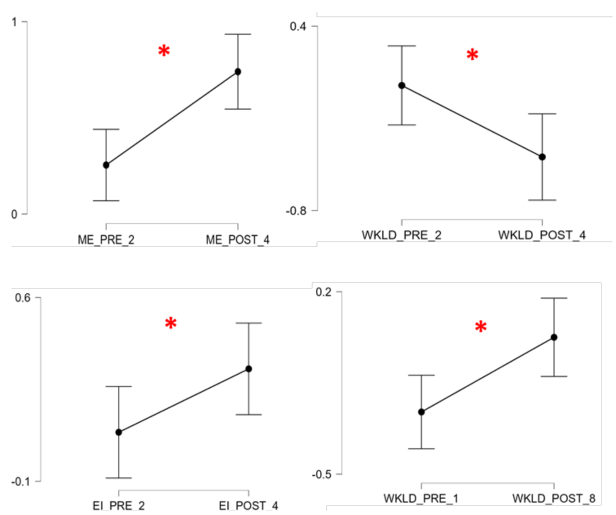

Figure 3: Neurometric indicators.

Eye-tracking data were analyzed to compare participants' visual attention while watching the two videos. We focused on the specific AOIs, and the slides presented on the screen (Screen), comparing the percentage of fixations recorded within the AOIs. The Screen attracted the highest number of fixations, with participants spending more time on it than on the presenter's face or hands.

Importantly, the Video POST generated significantly more visual attention to the Screen than the Video PRE, both in terms of fixations (p=0.002, t=-4.468, d=-1.413) and the time participants spent observing the AOIs (Time Viewed) (p=0.001, t=-8.407, d=-2,659). These comparisons are reported in Figure 4.

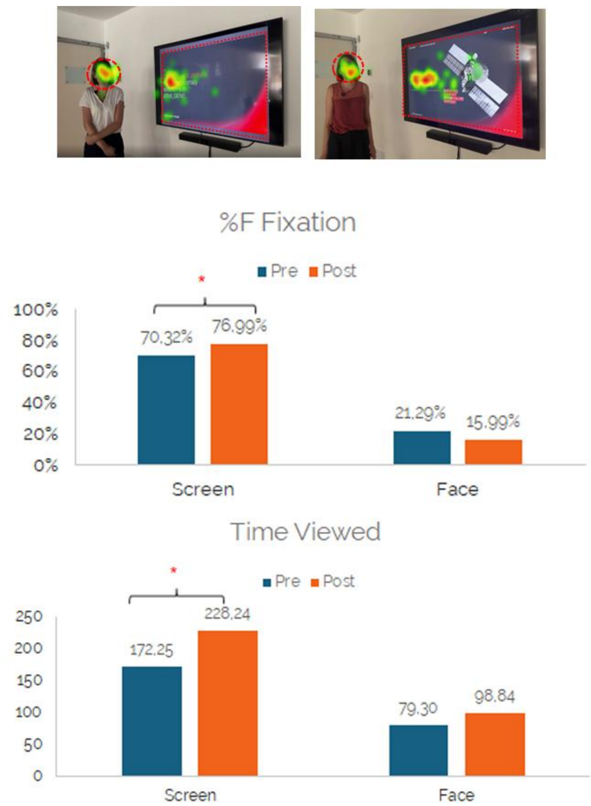

Figure 4: Eye tracking data, visual behaviour, Fixation Percentage, Time Viewed.

4.2 Behavioural results

At the end of the study, the participants were asked to complete a short questionnaire evaluating the two test videos. As shown in Figure 5, although less visually appealing, the Video POST was rated as more interesting. We compared participants' responses regarding the Video PRE and Video POST. A significant difference emerged between the videos for the question "how visually appealing is it?" ($p=0.006$, $t=3.577$, $d=1.131$).

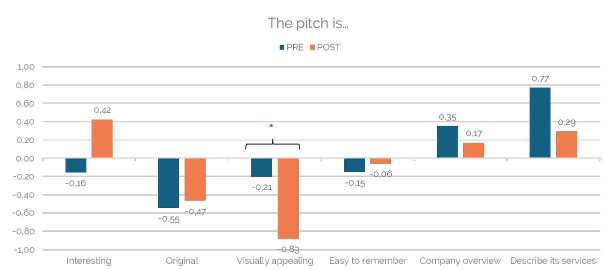

Figure 5: Pitch appealing.

The Video PRE inspired more confidence in the service and raised awareness of the technology (Figure 6). While the Video POST captured more attention, it clearly conveyed the product's benefits and was the preferred version. Participants expressed a stronger intention to purchase after watching the Video POST (Figure 7).

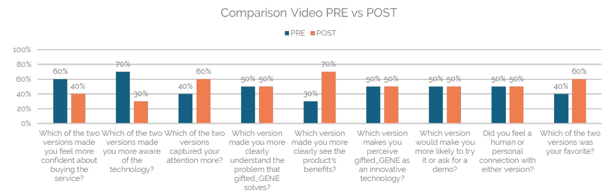

Figure 6: Technology awareness.

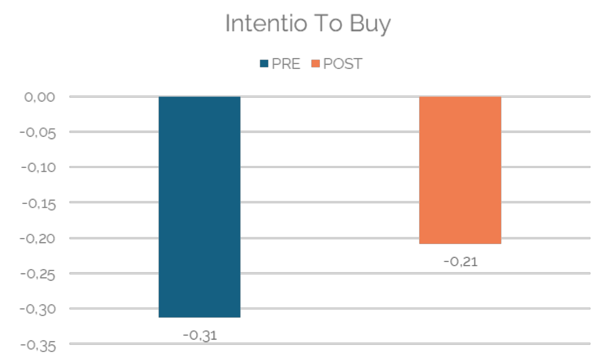

Figure 7: Intention to purchase.

5. Discussion and Conclusions

The study provides empirical evidence that storytelling-based communication strategies are more effective than purely technical pitches in enhancing engagement with space-related deep-tech solutions. While both approaches conveyed the necessary information, the narrative-driven version demonstrated a superior capacity to lower cognitive workload, increase emotional involvement, and direct attention toward key information elements. The results suggest that, even in highly technical fields, effective communication is not merely about accuracy and completeness, but also about resonance and accessibility.

By integrating neurophysiological and eye-tracking measures, the study captured unconscious drivers of attention and emotion that are often overlooked in traditional assessments of communication. These findings align with and extend prior literature, reinforcing the idea that emotional framing and narrative structures improve memorability, foster trust, and increase the intention to engage with innovative products. From a methodological standpoint, this research demonstrates the feasibility of applying neuromarketing tools, such as EEG, GSR, and eye-tracking, in the context of space entrepreneurship. Traditionally confined to consumer markets, these tools here provide a rigorous framework to test and refine communication strategies in a B2B and high-tech environment. This cross-domain application represents an innovation in itself, suggesting that neuroscience-based evaluation methods can be systematically employed to reduce the gap between complex innovation and market adoption.

Nevertheless, the study presents some limitations. The sample size, while sufficient for an exploratory analysis, remains small, and future work should involve larger and more diverse participant groups to validate generalizability. Additionally, the experiment focused on a single case study, and further research is needed to test whether the observed effects hold across different products, technologies, and cultural contexts. It would also be valuable to analyze longitudinal impacts, for instance whether narrative-driven communication leads to sustained recall and preference weeks or months after exposure.

In conclusion, this work supports the integration of neuromarketing insights into strategic communication for space and deep-tech companies. Storytelling, when grounded in authenticity and supported by quantitative evidence, not only improves immediate audience engagement but also strengthens the perceived value of technology. For startups and SMEs in emerging markets, this approach can become a differentiating factor in building partnerships, securing funding, and ultimately accelerating adoption of disruptive solutions. As the space sector continues to democratize and expand, embedding human-centric communication practices will be essential to ensure that groundbreaking technologies are not only developed but also understood, embraced, and supported by stakeholders at every level.

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