



iMotions Research Report 2024

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Looking back at 2024

iMotions is a trailblazing research software that has enriched the academic world with hundreds of publications over the last two decades. We're excited to share with you an inspiring overview of the groundbreaking research accomplished with the help of iMotions in 2023.

This past year has once again shown the productivity of our clients, who have published an impressive array of articles, book chapters, conference papers, and posters. These contributions span a diverse range of fields, including clinical and educational research, user experience, human factors, communication psychology, traffic psychology, sensory research, and across many more fields.

A notable trend in 2024 was the integration of multimodal research methods, **with 45% of the articles published leveraging more than one biosensor** to gain deeper insights. Compared to the previous year, **20% more publications highlighted the value of combining biosensors** to understand the multifaceted nature of the research questions being studied.

Eye tracking emerged as the most popular modality with over half the publications employing it to obtain valuable data on where and how individuals direct their attention. This was often paired with sensors designed to capture additional dimensions of the experience, such as facial expression analysis and galvanic skin response (GSR) data, enriching the findings with valence and arousal data.

Additionally, the use of electroencephelography (EEG) and electrocardiography (ECG) for behavioral research gained significant momentum. The research field also saw an increase in remote data collection, with an increase in publications using webcam based eye-tracking.

First, lets look at a few key highlights ...

45% of the articles published
leveraged *more than one biosensor*.



The most commonly used modalities were *eye tracking*, *facial expression analysis* and *galvanic skin response*.

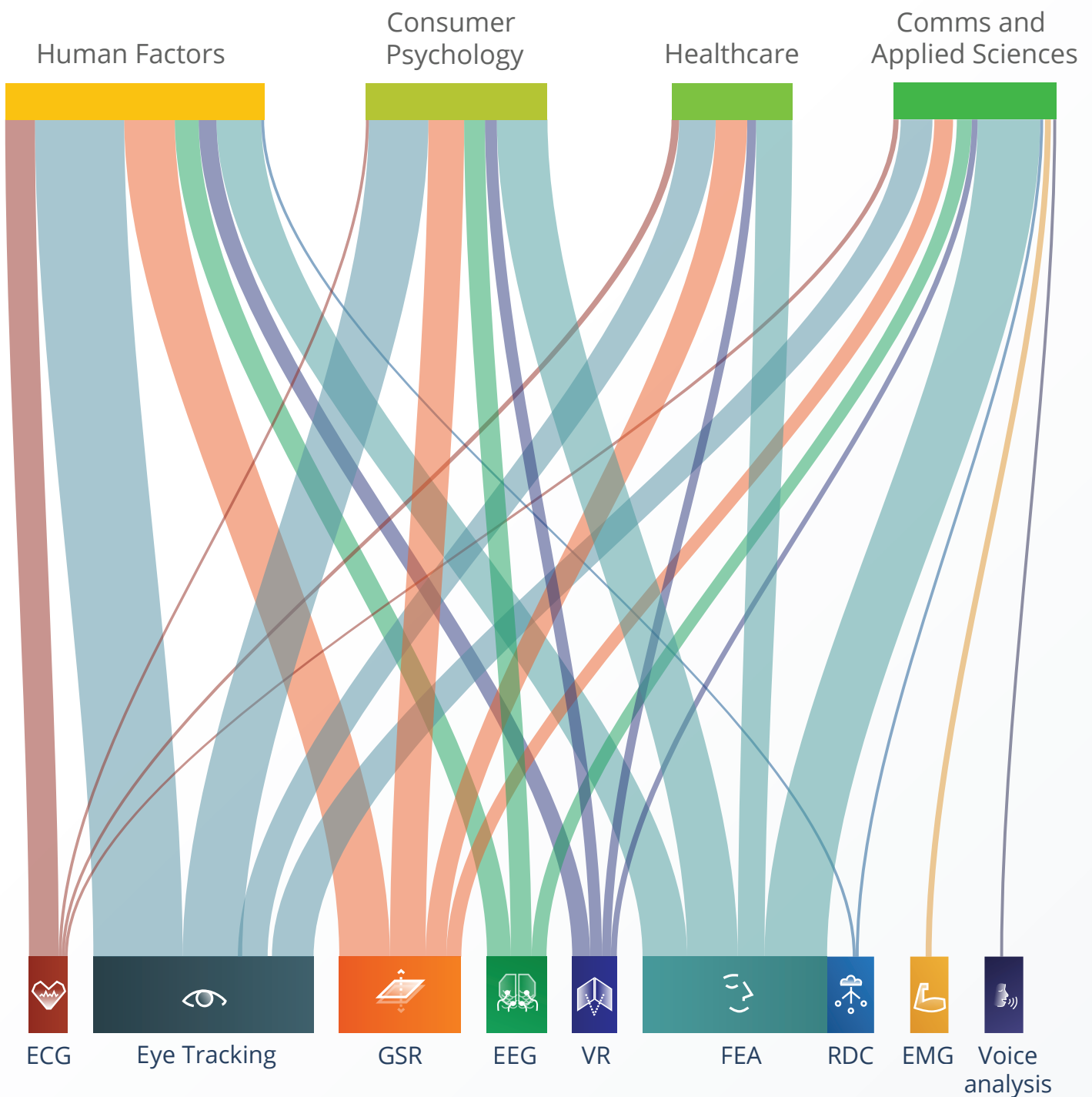


Some modalities are used more often together than others ...



The width of the connections represent the relative frequencies of two modalities being used in combination.

How are modalities distributed across different research areas?





Human Factors



Human factors and usability research provides new insights into how human beings perform under various conditions, and how the environment around them can be improved based on this understanding of human behavior. These environments could be industrial workplaces, vehicles, iconic buildings, or everyday landscapes.

A significant amount of this research focuses on understanding humans in new and emerging technologies, such as with virtual reality, allowing researchers to customise environments virtually in order to study their effects.

Eye tracking is the most popular biosensor within this field, and is often used alongside measures of galvanic skin response. Together they inform researchers about when, where, and how visual attention is allocated; and how the body's sympathetic system reacts to the environment it is in indicating increased arousal levels. This field shows itself to be curious and open to physiological measures of stress, focus, and well-being such as the use of ECG, electromyography (EMG) and respiration.

Highlights

- Eye tracking dominates the field with its flexible use in different real-life, lab-based, and virtual environments.
- Engagement with a wide variety of physiological measures, such as GSR, ECG, EMG, and fNIRs.
- A broad range of topics cover how humans react to different environments and can be aided to improve performance, increase feelings of well-being, and decrease stress and cognitive workload.



Research stories

Learn from your peers

GSR and Self-Reports Reveal Emotional Impact of Crowding in Public Spaces

Mashkov and Shoval studied visitors' subjective and objective emotional responses to congestion in public spaces such as a market, focusing on how visitors perceive and react to crowding and density. Participants wore GSR sensors and provided real-time self-reports of their emotional arousal using online questionnaires before, during the walk and after each standing point.

The findings suggest that overcrowding in public spaces can negatively impact visitors' emotional well-being, with higher arousal linked to stress responses. This highlights the need for urban planners and destination managers to monitor and manage congestion for better visitor satisfaction. The study emphasizes using both subjective and objective measures to assess emotional responses in real time, offering deeper insights into crowding's effects. These insights can guide urban design and crowd management to improve public space use, reduce negative emotions, and enhance the visitor experience. Despite its specific focus, the study demonstrates how various tools can improve the human experience.



Multimodal Biometrics Reveal Cognitive Workload Dynamics for Adaptive Systems

[Mark et al.](#) conducted a four-week study in which participants completed weekly sessions assessing cognitive tasks related to memory, attention, and risk assessment. Six cognitive domains were tested using tailored tasks: working memory, vigilance, risk assessment, shifting attention, situational awareness, and inhibitory control.

The study employed six biometric monitoring methods (EEG, fNIRS, ECG, PPG, EOG, and eye-tracking) to capture real-time brain and body responses to different cognitive tasks. Functional near-infrared spectroscopy (fNIRS) and electroencephalogram (EEG) demonstrated the highest sensitivity in detecting changes in cognitive workload across varying tasks, accounting for most of the explained variance in the workload assessment.

While cardiac (ECG and PPG) and ocular measures (EOG and eye-tracking) contributed less to overall variance, they provided valuable complementary data that helped to refine the understanding of workload dynamics. The comprehensive approach of using multiple biometric modalities to assess cognitive workload can inform the design of adaptive training systems.

Understanding the dynamics of cognitive workload through physiological measures can improve the design of human-machine interfaces, making them more responsive to the user's cognitive state, which is crucial for high-stakes environments like control rooms and driving. These systems can tailor task difficulty based on real-time workload measures, improving training efficiency in complex fields like aviation or surgery.





Consumer Psychology



In the field of consumer psychology, eye tracking has become a valued tool, frequently coupled with facial expression analysis to glean deeper insights into consumer motivations and by combining attention and emotion metrics towards brands and products.

The research landscape of 2024 has seen a wide range of publications from packaging, advertising, branding to understanding different subsets of consumers and their decision making processes. By analyzing where a consumer's gaze lingers and combining this data with expressed emotions via facial expression or voice analysis and implicit emotions via GSR, researchers can unravel the complex interplay of emotion, attention, and demographic and personal values in purchasing decisions.

This research not only highlights the evolving preferences of consumers but also guides companies in tailoring their marketing strategies to align with the beliefs of their targeted consumers. It's a compelling blend of science and marketing, revealing the nuanced relationship between consumer behavior and the drive for better tailored products and marketing.

Highlights

- Eye tracking dominates the field
- Combination of sensors aimed at understanding emotional and attentional parameters.
- Scope shows biosensors being employed in every part of the product cycle and brand evaluation.



Research stories

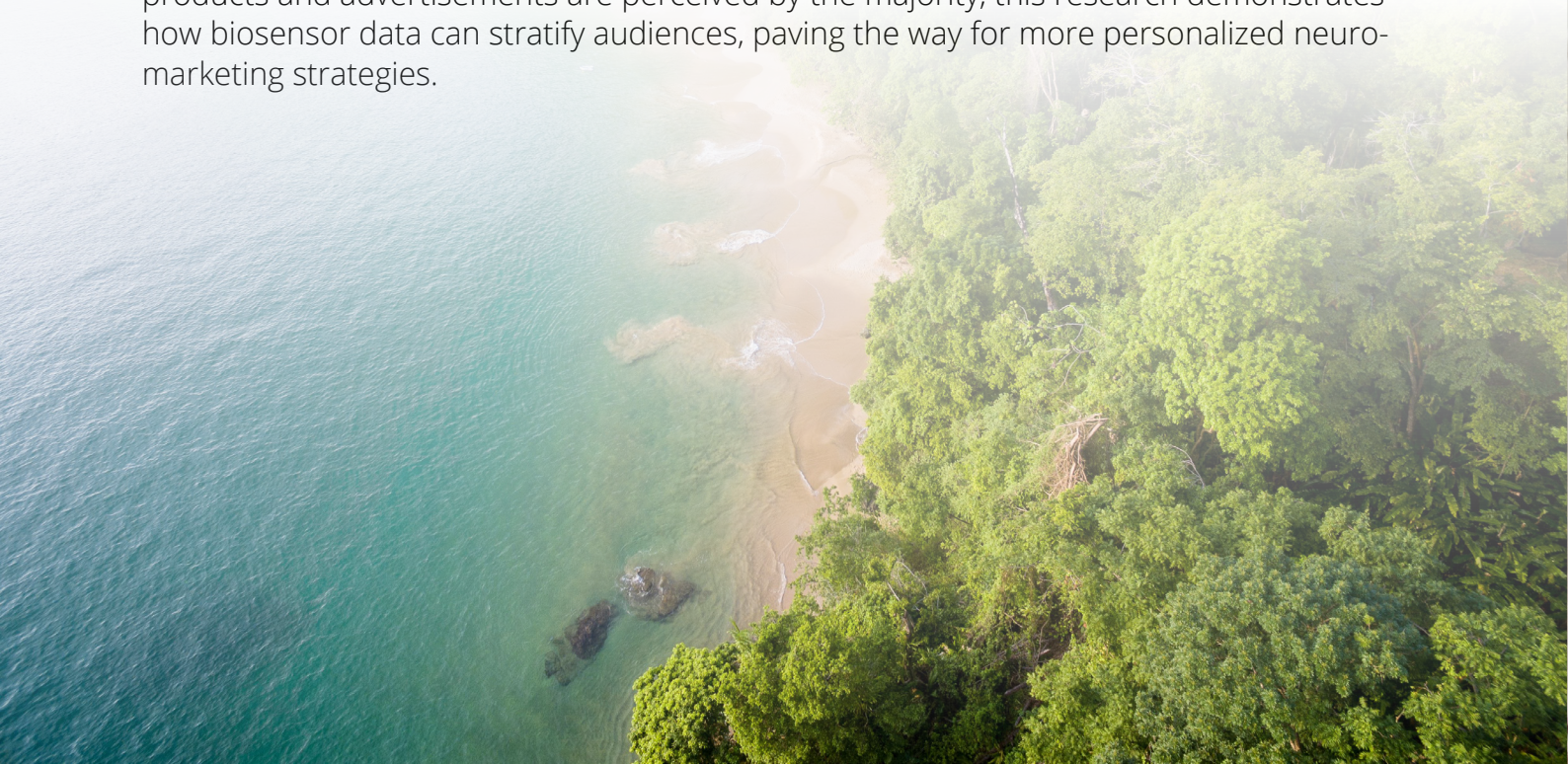
Learn from your peers

Eye-Tracking Reveals Virtual Tourist Typologies in Immersive Experiences

[Liu et al.](#) developed a typology of virtual tourists by analyzing their visual patterns and attentional cues in immersive virtual environments using eye-tracking technology. Sixty-three participants viewed a 360-degree video of Noosa Biosphere Reserve, featuring nature-based attractions like beaches and national parks. Eye-tracking within the virtual reality environment measured visual attention through fixation counts, saccades, and dwell time, supplemented by self-reported interview data.

Participants were categorized into four types based on their exploratory and viewing behavior. Visual Passives had the longest time to first fixation and the shortest fixation duration, indicating delayed attention and minimal engagement. Curious Scanners exhibited the longest saccades, thoroughly exploring the environment. Focused Observers showed the highest processing efficiency, with the shortest time to first fixation and the longest fixations. Comprehensive Engagers balanced visual exploration and cognitive engagement.

The study highlights the importance of segmenting virtual tourists based on visual and cognitive behaviors to help destination marketing organizations and virtual tourism platforms create tailored experiences. While consumer neuroscience often examines how products and advertisements are perceived by the majority, this research demonstrates how biosensor data can stratify audiences, paving the way for more personalized neuro-marketing strategies.



Facial Expressions, GSR, and Machine Learning Predict Consumer Ad Preferences

Marques et al. studied facial expression and GSR responses in Chinese consumers exposed to video advertisements from cosmetics brands originating in Brazil, France, and South Korea. They used three machine learning classifiers—k-Nearest Neighbors, Support Vector Machine, and Random Forest—to predict ad preferences based on physiological data. Two-way ANOVA tests and Pearson correlation were applied to analyze relationships between emotions, attention, engagement, and ad preference.

The study identified Attention, Engagement, Joy, and Disgust as the most significant predictors of consumer ad preferences. A strong positive correlation was found between Joy and Engagement, indicating that ads eliciting joy also increased viewer engagement, influencing preferences. These features played a crucial role in determining consumer responses to video advertisements.

By combining EDA and FEA, this approach provides a cost-effective, scalable way to measure consumer reactions. The study highlights the growing trend of integrating multiple modalities with machine learning in biometric research. As machine learning models advance, their combination with implicit biometric measures continues to strengthen predictive and statistical modeling in consumer behavior analysis.





Healthcare



The majority of the research in this field is devoted to unraveling the emotional and cognitive responses of clinical populations, including individuals with major depression, anxiety, neurodevelopmental disorders and cognitive decline.

A significant portion of these research endeavors is focused on identifying discriminatory biomarkers for distinct diagnoses, or to understand and quantify patient struggles and therapy outcomes. The metrics obtained from biosensors are proving invaluable in the creation of effective clinical biomarkers.

What's particularly striking about the research emerging from the healthcare sector is its profound impact on understanding varied clinical profiles. By examining behavioral and psychophysical responses during specific tasks, this research is not only enhancing our comprehension of different mental health conditions but is also paving the way for more tailored and potentially more effective treatment options.

This highlights the critical role of biosensor research in advancing our knowledge and capabilities in the realm of mental health care.

Highlights

- Eye tracking and facial expression analysis were equally appreciated by this field.
- Combination of sensors aimed at emotional and cognitive evaluations of disorders.
- Trends show advancements in the use of VR to modulate the environment and study symptoms in a controlled but realistic environment.



Research stories

Learn from your peers

Harnessing Biosensors and VR for Postpartum Depression: A Randomized Trial on Cognitive and Biofeedback Training

[Bjertrup et al.](#), ran a randomized controlled trial with 292 pregnant participants at high or low risk of developing post-partum depression. Half received standard prenatal care, while the other half participated in individual sessions over five weeks, using computer-based and virtual reality-assisted cognitive training. These included cognitive bias modification, attention bias modification, and mindfulness exercises.

The specialized biofeedback training incorporated biofeedback using eye-tracking and galvanic skin response (GSR) in a VR environment to monitor responses to infant stimuli, aiming to enhance emotional regulation and attentiveness. Preliminary findings suggested that this biofeedback-based intervention could decrease negative biases in perceiving infant stimuli, correlating with lower postpartum depression symptoms.

The use of eye-tracking allowed researchers to analyze attention to infant stimuli, while GSR provided insights into participants' physiological reactions. Biofeedback based on visual attention and physiological cues offers a non-pharmacological, low-risk intervention for post-partum depression.

This study highlights how biosensors are shaping the future of diagnostic markers and precision medicine, enabling more individualized therapy for clinical disorders.



Eye-Tracking Insights into AI-Assisted Dental Radiograph Analysis

Caster et al. used eye-tracking to analyze the visual strategies of dental professionals reviewing bitewing radiographs (used to detect caries) under AI-supported and non-AI-supported conditions. Metrics such as task time, fixation duration, and transition frequency between UI elements were examined to compare visual patterns.

The study found that dentists toggled AI support intermittently, using it for about 25% of their assessment time, with significantly more time spent on AI-assisted elements. While total fixation count was higher with AI, fixation frequency and duration remained unchanged, suggesting cognitive load was not significantly increased. Experts primarily used AI as a secondary reviewer to confirm their initial assessments.

The findings suggest that future AI designs should minimize workflow disruptions to prevent fatigue and extended inspection times.

The findings suggest that AI systems for medical imaging should complement, not disrupt, an expert's visual strategy. This would enable smoother AI integration into clinical workflows, improving efficiency and accuracy while maintaining user trust. As AI assistance grows, biosensor research helps identify beneficial tools, their users, and the future direction of AI.



Communication and applied sciences



Emotional reactions to communications have guided this field in 2024. The most employed biosensor was facial expression analysis with over half the publications finding it valuable in a wide range of setups.

Studies explore decision making, classroom interactions, speeches and presentations in business and political settings and the impact of sustainability communications on consumers and businesses. This field also extends to subtle perceptions in interpersonal dynamics, examining varied topics from perceived attractiveness and resume assessments to the effects of facial mimicry.

A lot of the studies were combined with eye-tracking to understand what stimuli or environmental manipulations were producing the emotional effects. Each study, with its distinct emphasis, enriches our understanding of human perception and interaction, highlighting the dynamic and multifaceted aspects of communication research advanced by iMotions software.

Highlights

- Facial expressions dominate the field, with potential for other measures of emotion such as GSR and Voice analysis.
- Eye-tracking pairs well to give another dimension to the emotional measures.
- The breadth of topics cover how people and messages in the environment are perceived and evaluating interpersonal interactions.



Research stories

Learn from your peers

Eye-Tracking and Emotion Analytics in Environmental Awareness Messaging

[Romero-Luis et al.](#), designed an experimental model to evaluate how effective audiovisual products are in promoting environmental awareness and fostering behavioral change towards the circular economy (CE), especially among young people.

In their study they collected expert interviews and measured eye-tracking and facial expressions of high school students while watching advertisements with or without a call to action. The findings show that while environmental awareness campaigns can generate attention, translating that awareness into actual behavior change remains challenging. Simple, direct messages that appeal to individual responsibility may have a greater impact.

The study highlights the value of combining neurocommunication techniques like eye-tracking and emotion analytics with traditional surveys to assess communication effectiveness.

This multimodal approach provides deeper insight into emotional and cognitive responses to messages. While the focus was on environmental awareness messaging, such research contributes to the broader understanding of the emotional and cognitive foundations of perceived communication.



Biosensor Research Reveals FOMO's Impact on Investment Decisions

[Meyer et al.](#), conducted extensive research involving two lab experiments with neurobiological measures using EEG and GSR, two online experiments, and a discrete choice experiment to understand the effects of fear-of-missing-out (FOMO) messaging on investment choices.

The study found that while FOMO can increase interest in traditional cryptocurrencies, it tends to reduce interest in greener, more sustainable alternatives. The study suggests that FOMO appeals can increase emotional engagement for traditional investments but have a weaker or negative impact when applied to sustainable investments. This discrepancy can deter investors from choosing greener options when influenced by FOMO messaging.

Higher cognitive load in decision-making processes was observed when investors were exposed to FOMO messages, leading to impulsive decisions that favor short-term gains over long-term sustainability.

The findings emphasize the importance of regulatory support and messaging strategies that align with the long-term benefits of green investments. Policymakers could use these insights to better promote sustainable investment choices among consumers.

The fact that policy decisions can be informed by biosensors is not restricted to this study, even though it highlighted quite nicely how very new topics of the 21st century can effectively be studied because the science to understand human processing has been built over decades of biosensor research.



Conclusions

- **Multimodal research is becoming more prevalent**, with nearly half of published studies incorporating multiple modalities.
- Established research areas, such as **visual attention** and **cognitive load**, are now being applied to novel emerging topics.
- Biosensor applications are evolving, with researchers exploring innovations like webcam-based eye-tracking and fNIRS combined with other sensors.
- **Integrating multiple modalities enables personalized applications** in healthcare, human factors research, and marketing.
- **Advances in AI and machine learning (ML)** are driving innovations in biometrics, improving both data analysis and interpretation.

Looking forward to see you next year!

