Would eye-tracking, face movement, skin conductance, and HRV be more effective at detecting anxiety than other types of sensors?

Non-invasive and Easy to Measure: These sensors are relatively unobtrusive and straightforward to integrate into psychometric testing. Eye-tracking glasses can be worn comfortably, while skin conductance sensors are often attached to the fingertips. They don't require significant changes to the testing environment or pose discomfort to participants compared to intrusive methods like blood draws (Rösler et al., 2021).

Link to Autonomic Nervous System Activity: Anxiety is a complex emotion, but it is closely linked to the autonomic nervous system, which controls involuntary body functions. These sensors provide indirect measures of autonomic nervous system activity:

> **Eye Tracking:** Increased fixation durations on specific areas during tests might indicate heightened focus related to anxiety.
>
> **Facial Movements:** Certain facial expressions, like furrowed brows or pursed lips, can be associated with anxiety.
>
> **Skin Conductance:** Skin conductance, also known as electrodermal activity, measures sweat gland activity. Increased anxiety often leads to sweating, reflected in changes in skin conductance.
>
> **HRV:** HRV measures the variation between heartbeats. During anxiety, the sympathetic nervous system increases heart rate and reduces variability. Analyzing HRV parameters like SDNN and RMSSD provides insights into this change.

Specificity to Anxiety: While not perfect, these sensors offer a better chance of capturing physiological changes linked to the autonomic nervous system, which plays a key role in anxiety. Eye tracking (pupil dilation), facial expressions (furrowed brows), skin conductance (increased sweating), and HRV (reduced variability) are all commonly associated with anxiety states.

Complementary Information: Each sensor provides a unique piece of information. By combining data from eye tracking, facial movements, skin conductance, and HRV, researchers can build a more comprehensive picture of a participant's physiological response to anxiety during the test. This multi-modal approach strengthens the analysis compared to relying on a single data source.

Relatively Fast Response Time: These sensors provide a relatively fast response time, capturing changes that occur during the psychometric test. This allows researchers to link specific physiological changes to moments of anxiety during the test. For example, a sudden increase in skin conductance might coincide with a challenging question.

Existing Research and Established Techniques: There is a significant body of research on the relationship between these sensors and anxiety. Established analysis techniques exist for interpreting the data from these sensors, making them reliable and well-understood tools for anxiety detection.

While other sensors exist, they might not be as practical or informative for anxiety detection in psychometric testing settings. Here's a brief comparison:

Brain Imaging (EEG, fMRI): These provide high-resolution views of brain activity but are expensive, require controlled environments, and can be less sensitive to subtle changes during testing.

Muscle Tension Sensors: These can detect physical tension associated with anxiety but might not be specific to anxiety and could be influenced by posture or fatigue.

Voice Analysis: While vocal changes can occur during anxiety, voice analysis can be influenced by background noise or speaking style, making interpretation challenging.

Biochemical Sensors: Saliva or blood tests can measure stress hormones like cortisol. However, these require invasive procedures and are not suitable for real-time monitoring during psychometric testing.

Blood Pressure Sensors: Anxiety can lead to increased blood pressure. While wearable blood pressure cuffs are emerging, they can be uncomfortable for participants and require calibration, limiting their practicality in psychometric testing settings.

The advantages of Pupil Labs (Core) over Tobii Pro Glasses 3 and SMI Eye Tracking Systems?

1. **Open-Source Software:** Pupil Labs offers open-source software (Pupil Capture) which allows for greater customization and integration with your specific research needs.

2. **Higher Sampling Rate:** Pupil Labs Core boasts a 200 Hz sampling rate compared to Tobii Pro Glasses 3 (100 Hz) and SMI ETG 2.60 (60 Hz). This higher rate captures more detailed eye movement data, potentially leading to more precise analysis, especially for fast eye movements.

3. **3D Gaze Estimation:** Pupil Labs Core offers a 3D gaze estimation feature, which can be valuable if your study requires tracking gaze not just on a 2D screen but also in real-world environments.

As compared to the OptiTrack Slimx 13 motion capture system, why are the AXIS P1275 and AXIS P1245 cameras better suited for facial expression analysis using OpenFace?

1. **Resolution:** AXIS P1245 and P1275 offer high definition (HD) 1080p resolution, which captures more facial details compared to lower resolution cameras. Opti Track prioritizes tracking markers in 3D space, and resolution for facial features might be lower.

2. **Lighting**: Many indoor AXIS cameras have good low-light performance. OpenFace often works best with well-lit faces. OptiTrack might require a more controlled lighting environment for accurate facial data capture.

3. **Frame Rate:** AXIS cameras typically offer high frame rates (e.g., 30 frames per second). This captures subtle and rapid facial expressions that OpenFace can analyze. OptiTrack might focus on slower, larger movements for motion capture.

The advantages of TEA CAPTIV T-SENS GSR sensor over BioPac EDA Sensors?

1. **Wireless Capability:** TEA CAPTIV T-SENS GSR offers superior wireless capability compared to BioPac EDA Sensors. With wireless functionality, users experience enhanced

convenience and flexibility in data collection. This feature eliminates the need for cumbersome wired connections, allowing for greater mobility and ease of use.

2. **High Sampling Rate:** TEA CAPTIV T-SENS GSR boasts a high sampling rate, surpassing that of BioPac EDA Sensors. A high sampling rate is crucial for capturing detailed physiological responses accurately and in real-time. With TEA CAPTIV T-SENS GSR's high sampling rate, users can capture subtle changes in galvanic skin response (GSR) with precision, providing valuable insights into emotional arousal and stress levels.

3. **High Accuracy:** TEA CAPTIV T-SENS GSR utilizes advanced sensing technology and signal processing algorithms to deliver precise and dependable measurements of GSR activity. This high level of accuracy enables researchers and practitioners to confidently interpret physiological data and draw meaningful conclusions from their studies.

The advantages of Polar H10+ is over Empatica E4 Wristband?

1. **High Accuracy:** The Polar H10+ chest strap is known for its high accuracy in heart rate monitoring, especially during intense physical activities. It directly measures the heart's electrical activity, providing precise data. On the other hand, the Empatica E4 wristband also offers accurate heart rate monitoring, but wrist-based sensors may not be as accurate as chest straps (Kim et al., 2021).

Literature Review of Different Type of Sensor's

Category	Sensors	Description	Pros	Cons
Eye Tracking	Pupil Labs (Core)	Wearable eye tracking glasses that provide real-time tracking of eye movements and pupil size, suitable for studying natural behavior in various environments. - Technology: Dark pupil technique + 3D model - Calibration: 5 points - Accuracy 0.60º accuracy (with calibration) 0.02º precision - Resolutions and Frequencies: 1080p @30 Hz, 720p @60 Hz, 480p @120 Hz	- Wearable and mobile - Higher Sampling Rate - 3D Gaze Estimation - Records natural eye movements in real-world settings	- Require manual calibration using custom scripts or plugins, Unlike Tobii Pro Glasses 3 and SMI systems that have automatic and semi-automatic calibration
	Tobii Pro Glasses 3	High-resolution eye tracking device that accurately measures gaze direction and pupil dilation, commonly used in research involving visual attention, reading patterns, and cognitive processes. - Scene camera with a 106° field of view - Built-in microphone - 16 illuminators and four eye cameras integrated into scratch-resistant lenses	- High accuracy and precision - Real-time data capture - Wide range of research applications	- Expensive equipment - Requires controlled environment - Limited mobility for participants
	SMI Eye Tracking Systems	Another brand of eye tracking systems offering high-speed and accurate measurements of eye movements, used in various fields such as psychology, neuroscience, and marketing research. - Technique: Dark pupil - Resolution: 1280x960p @ 24FPS - Field of view: 60° horizontal, 46° vertical	- High-speed tracking - Versatile software for analysis - Compatible with various research environments	- Costly investment - Limited portability

Face Movements	AXIS P1275 Camera	The AXIS P1275 is a compact and robust network camera designed for indoor surveillance. - Resolution: HDTV 1080p - Capture: WDR – Forensic - Field of view: 53°-99° horizontal	- High-definition resolution for clear imaging. - Suitable for indoor environments.	- Designed primarily for security applications, may lack specialized features for precise movement tracking.
	AXIS P1245 Camera	The AXIS P1245 is an ultra-compact and lightweight network camera designed for discreet indoor surveillance. - Resolution: HDTV 1080p - Capture: WDR – Forensic - Field of view: 111° horizontal	- High-definition resolution for detailed imaging	- Similar to the AXIS P1275, primarily designed for security applications.
	OptiTrack Slimx 13 (Motion Capture Systems)	Optical or inertial systems that track the movement of reflective markers placed on the body, providing detailed 3D motion data used in biomechanics, animation, and clinical assessments. - 3D accuracy referenced is typical for a 30'×30' (9m×9m) tracking area. Range is estimated using a 14 mm marker with cameras at an exposure of 800, gain of 6, and the lowest f-stop.	- High precision and accuracy for 3D motion - Small footprint - lightweight	- Expensive setup and equipment - Time-consuming marker placement and calibration process
Skin Conductance	TEA CAPTIV T-SENS GSR	The TEA CAPTIV T-Sens GSR is a fingertip sensor that measures sweat gland activity, a sign of arousal. It works wirelessly for 8 hours and records data 32 times per second. This sensor is often used with CAPTIV software to analyze GSR alongside other physiological data in research on stress, emotion, and more.	- Wireless and portable - Long battery life: Records data for extended periods without needing a recharge.	- Limited measure: Focuses on sweat glands, which can be influenced by factors beyond arousal. - Research-oriented: May require specialized software for data analysis.

		- Sampling rate: 32 hz - Battery recording time: 8h - Recharging time: 3h - Dimensions: 52 mm x 25 mm x 14 mm - Weight: 20g Reference: 2034		- Cost: May be expensive depending on research needs.
	BioPac EDA Sensors	Sensors integrated into physiological data recording systems to measure skin conductance responses, often used in psychophysiology research to study emotional responses and autonomic activity. - Record EDA/GSR in both DC (tonic) or AC (phasic) modes - Automatically locate and mark skin conductance responses - Correlate EDA recording with stimulus events	- High-quality data acquisition - Integrated with other physiological sensors - Compatible with various data analysis software	- Expensive equipment and software - Requires specialized training for setup and operation - Limited portability and flexibility
HRV (Heart Rate Variability)	Polar H10+	Chest-worn sensor that accurately measures heart rate and heart rate variability, commonly used in sports science, stress research, and biofeedback training (Erdi et al., 2019). - Microprocessor speed: 64 MHz - Sensors: ECG	- Non-invasive and easy to wear - Real-time monitoring of heart rate and HRV - Compatible with various devices and software	- Requires chest strap for accurate HRV measurement - May cause discomfort for some participants - Limited to measuring HRV during specific activities
	Empatica E4 Wristband	Wearable device that combines EDA, HRV, and accelerometer sensors to monitor physiological responses such as stress, arousal, and physical activity levels in real-time. - Raw data: Temperature, Accelerometer, IBI (Systolic peaks), Blood volume pulse, User tags, Steps, Electrodermal activity	- Wearable and non-invasive - Integrates multiple physiological sensors - Real-time data streaming and analysis	- Limited accuracy compared to medical-grade devices - Requires regular calibration and validation - Data synchronization challenges

Eye Tracking

Several eye-tracking systems are suitable for psychometric research, but Pupil Labs (Core) offers advantages for studies investigating the link between physiological and self-reported data. Pupil Labs' open-source software allows for customization of data collection and analysis pipelines, potentially leading to more tailored insights. Additionally, its 200 Hz sampling rate captures more detailed eye movement data compared to competitor options. For studies requiring real-world gaze tracking, Pupil Labs' optional 3D gaze estimation feature is valuable. Its lightweight and non-intrusive design ensure minimal interference with natural behavior, enhancing data integrity. Moreover, Pupil Labs Core provides seamless integration with existing research setups and software platforms, facilitating streamlined data analysis (Alrefaei et al., 2019).

Face Movements

AXIS P1275 and AXIS P1245 Cameras offer advantages over OptiTrack Slimx 13 Motion Capture Systems, due to their simplicity and versatility. The AXIS cameras provide high-resolution imaging, capturing subtle movements with precision. Their wide field of view enables comprehensive coverage of subjects, ensuring no detail is missed. Additionally, the AXIS cameras offer flexibility in setup, allowing for seamless integration into various environments. In contrast, OptiTrack Slimx 13 systems may require complex calibration and setup, limiting their practicality. With their user-friendly interface and reliability, AXIS P1275 and AXIS P1245 Cameras are optimal choices for robust and efficient psychometric assessment protocols (Gualniera et al., 2019).

Skin Conductance

Skin Conductance, a pivotal measure in psychophysiological research, assesses sympathetic nervous system activity. Utilizing TEA CAPTIV T-SENS GSR Sensors over BioPac EDA Sensors for psychometric assessment offers distinct advantages. TEA CAPTIV T-SENS GSR Sensors deliver superior accuracy and reliability in capturing skin conductance responses. With their wireless capability and high sampling rate, they minimize data loss and ensure precise recordings even during dynamic activities. Additionally, the versatility of TEA CAPTIV T-SENS GSR Sensors allows for multi-modal data integration, enhancing the depth of psychometric analyses. These factors collectively position TEA CAPTIV T-SENS GSR Sensors as the preferred choice for robust and comprehensive psychometric assessment protocols (Erdi et al., 2019).

HRV (Heart Rate Variability)

The Polar H10 Heart Rate Sensor excels over the Empatica E4 Wristband for psychometric assessment due to its superior accuracy and reliability in measuring heart rate variability (HRV).

With its chest strap design, the Polar H10 reduces motion artifacts, ensuring precise HRV data collection vital for psychometric evaluation. Unlike the Empatica E4, the Polar H10 consistently provides high-quality HRV measurements, crucial for accurately assessing autonomic nervous system function and stress levels. Moreover, its compatibility with various devices and software platforms enhances its utility in psychometric research. For researchers prioritizing accurate and reliable HRV data for psychometric assessment, the Polar H10 Heart Rate Sensor offers unmatched performance (Kim et al., 2021).

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Then, to further understand the significant difference between the psychometric test results on a group level and for each sessions an ANOVA Two-Factor Without Replication was conducted for each psychometric tests.

The Two-Factor ANOVA results revealed significant differences in test scores both among participants and between sessions on the HADS-A, $F(9,18) = 6.48$, $p = 0.0004$ and HADS-D, $F(2,18) = 5.36$, $p = 0.0149$

To do : Quote the questions in the file: H