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AUTOMATICALLY ADAPTING TO STRESS

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EYE-TRACKING IN VIRTUAL AND DIGITAL ENVIRONMENTS TO ESTIMATE AND ADAPT TO STRESS AND ANXIETY.

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AUTOMATICALLY ADAPTING TO STRESS

STRESS, ANXIETY AND PERFORMANCE

Stress is often experienced when the demands of a situation are perceived to outweigh the resources a person has available to them. It is usually considered a negative aspect of our lives, something that we should aim to reduce to increase our mental and physical well-being.

However, some stress can be beneficial and motivational, engaging us in effortful work and helping to sustain performance. For example, the pressure of an upcoming sporting competition can help an athlete to maintain focus and train harder. On the other hand, if stress is extreme or persists, it can lead to the negative emotion we call anxiety, which counter-productively disrupts performance.

By definition, anxiety is an unpleasant experience. It involves feelings of worry and apprehension, causing thoughts to race, and often creating a strong physiological response such as sweaty palms, increased breathing, and a raised heart rate. These effects can distract and derail attention to the task at hand, leading instead to focus on the self or on negative stimuli.

People tend to feel best about their performance with just the right amount of stress and anxiety. Too little, we may not be at our best or may find something too easy or boring. Too much, and we might have a negative experience which leads to negative outcomes.
Making sure stress is not too low nor too high can support the health, performance and efficiency of humans.

In other words, there is a 'Goldilocks' zone in the relationship between stress and performance on a task. This will vary by the specifics of the context but has often been visualised with an inverted 'U' shape as shown in Figure 1.

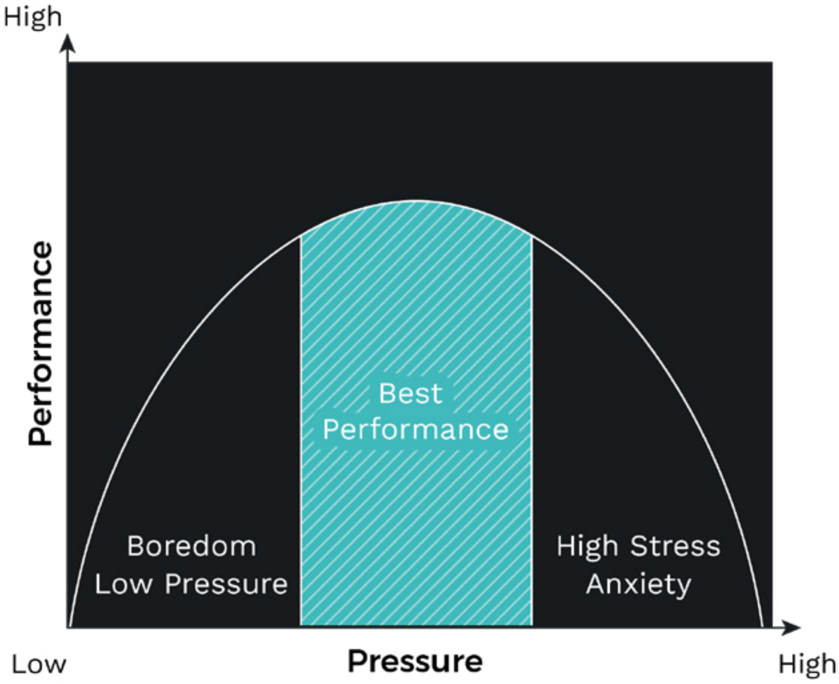


FIGURE 1

ESTIMATING STRESS AND ANXIETY WITH EYE-TRACKING

We can estimate someone's stress levels without asking them directly by leveraging technology that can track one's visual attention. This is because stress and anxiety affect how the eyes behave. Eye-tracking allows us to monitor where someone is looking and how their pupil changes in response to internal and external changes. Someone who is stressed and anxious can become easily distracted, might focus on the wrong things, or may lose concentration. Decades of research have shown that stressed or anxious individuals experience distinct changes in how they control their visual attention and that these changes are revealed in the way their eyes move.

The way that stress reveals itself in a person's eye movements is reasonably consistent, with stress usually associated with an inability to inhibit distraction, and less efficient collection of task-relevant information. For example, high stress during a complex aiming task like a golf putt might lead to fewer gaze fixations on important visual areas, but more overall fixations as the eyes move about the scene. By contrast, too much stress when a pilot is learning to fly a plane can lead to more erratic and unpredictable eye movements (Figure 2). These patterns can be quantified and related to stress and anxiety in real-time, enabling live visualisation and assessment of stress and anxiety levels through eye movements alone.

EYE MOVEMENTS UNDER STRESS

In some contexts, eye movements can become faster and more erratic under stress or anxiety. The diagrams below show how different stress levels can lead to different eye movement patterns, and how we can measure this.

FIGURE 2

ADAPTIVE VIRTUAL ENVIRONMENTS ARE MORE INTELLIGENT

Cineon are combining the estimation of stress and anxiety with an adaptation engine, which will enable a virtual or digital system to not only intuit the emotional state of the user, but also make changes to the environment to suit this state of mind.

By leveraging the integration of eye-tracking in virtual reality hardware, we can therefore create emotionally-intelligent software systems for detecting and adapting to someone's stress and anxiety levels.

OUR PROCESS:

1. Develop an initial understanding of how stress affects eye movements based on existing data and expertise from our Research Team.
2. Build on this using established and advanced machine learning techniques led by our Data Science team.
3. Integrate these techniques into a live system that can estimate anxiety and stress levels in real time.
4. Allow the system to fine-tune to the individual in real-time, enabling personalisation while maintaining data privacy and security.
5. Use estimated anxiety levels to adapt the virtual environment, aiming to keep within that 'Goldilocks' zone of stress.
6. Let the system learn in real-time, assessing the outcomes of its own changes to the environment to optimise the experience.

BEYOND STRESS, ANXIETY AND EYE MOVEMENTS

The power of our approach is that any inputs, outputs, and environments are interchangeable.

- Instead of eye movements, we could use heart rate, physical movement, pupil size, or a combination of any of these signals. Note that the relationship between these measures and a particular psychological construct (e.g. stress) will depend on the context.
- Instead of stress and anxiety, we could estimate boredom, flow, happiness, or mental effort. Instead of using these to optimise performance, they might be the construct we aim to optimise for learning, adherence, enjoyment or other important outcomes.
- Instead of a virtual reality experience, we could apply the system to a video-game on a laptop, an automated talking therapy session, or an e-learning site. Any situation that may benefit from adapting to a user's psychological state with a means of passive psycho-physiological measurement (such as eye-tracking) could implement the system. The aim is to provide a general-purpose architecture for psychologically intelligent and adaptable systems, able to optimise performance or other outcomes depending on the context.

We are currently focusing our efforts on stress, eye-tracking, and virtual reality because we have compelling use cases. However, the possibilities are wide-ranging.

THE SCIENCE: VISUAL ATTENTION

The effects of stress and anxiety on visual attention have been well-studied by psychological scientists and mental health researchers.

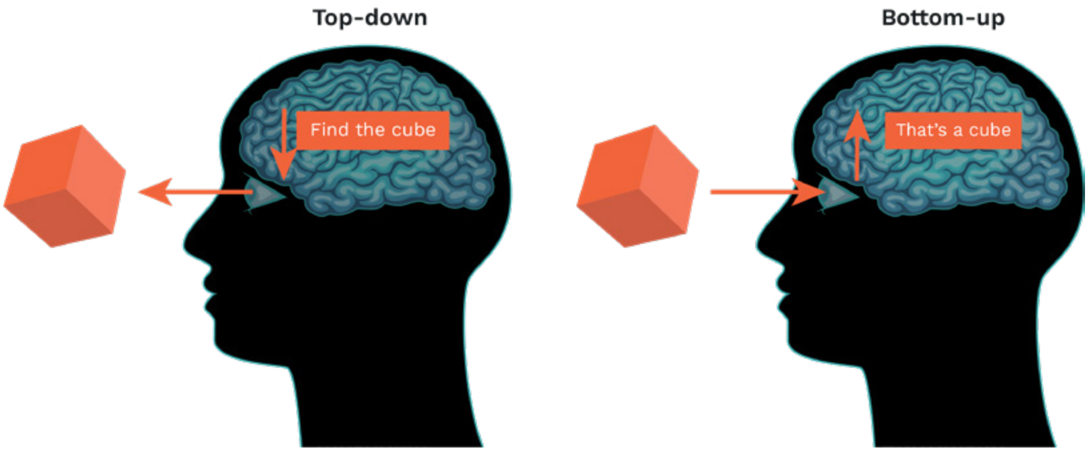


FIGURE 3

Where we direct our visual attention is guided by both our current goals and motivations (top-down) and visual characteristics of the environment (bottom-up). Different brain networks underlay these attentional systems, although they work cooperatively under normal conditions. Highly stressful or anxiety-inducing situations can affect attentional control, reducing the effectiveness of top-down processing leading to an over-reliance on bottom-up, stimulus-driven visual attention. This in turn affects how the eyes behave. Studies have consistently provided evidence for reduced top-down control of eye movements under anxiety, usually based on experiments that require some inhibition or target-locking of gaze to achieve a task.

Additionally, there other context-dependent hallmarks of anxiety in eye movements. For example, people with social anxiety will look at faces and eyes less in real-world interactive situations, and anxious readers will tend to return to previous words more than their less anxious counterparts.

THE SCIENCE: MACHINE LEARNING

To provide accurate estimates of stress and anxiety across a range of contexts, our data science team are validating machine learning models using new data collected by our research team.

To ensure that our models can generalise across individuals, over time, and under different attentional demands, we are collecting rich data across a range of virtual experiences from willing volunteers. We ask participants to provide frequent self-report feedback, allowing us to relate eye-tracking patterns to emotional state. This forms the basis of our continuously-improving anxiety estimation: our core model.

A variety of machine learning methods can be applied to this situation. Highly performant deep learning approaches can pick up on subtle features of the data that relate to stress and anxiety. However, these are difficult to interpret alone, so we also run models based on pre-defined metrics for comparison.

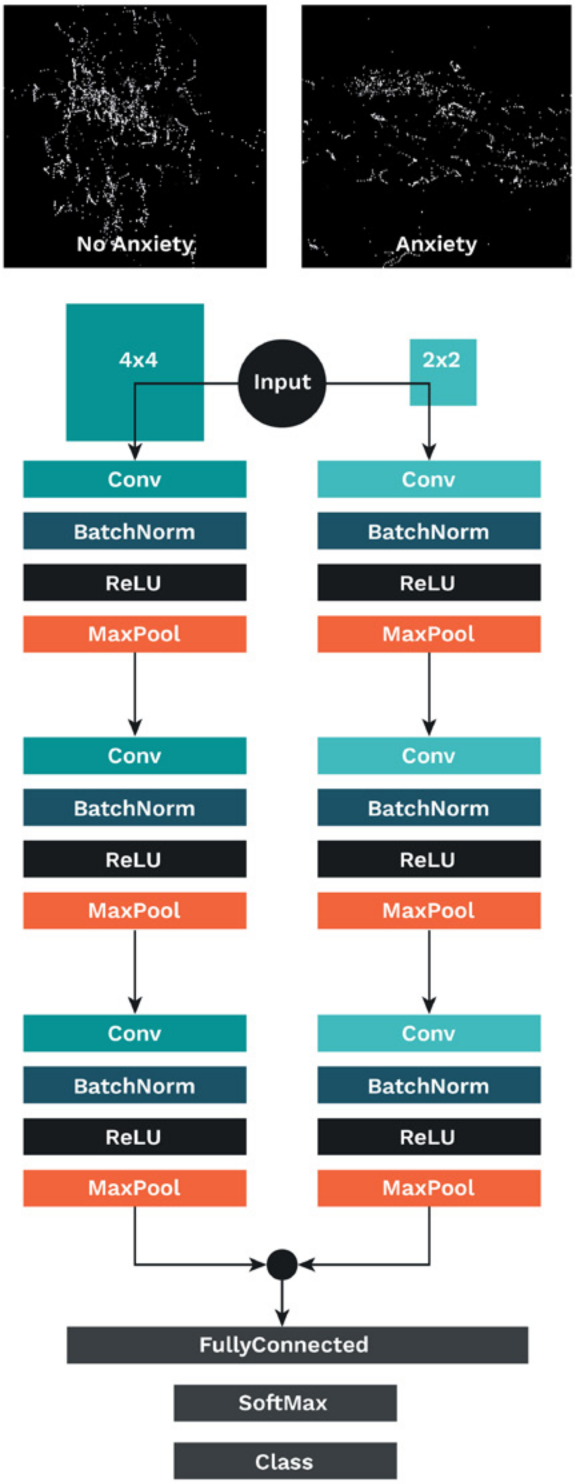


FIGURE 4

SECURE AND ETHICAL TOOLS

A key consideration when collecting and processing eye data is the consent and privacy of the user. At Cineon, we are dedicated to upholding the privacy and security of all individuals whose data we handle. Our company vision is to develop secure and ethical digital tools that improve health, performance, and productivity.

In practice, this means we operate under four pillars of data security when using eye-tracking and other physiological data:

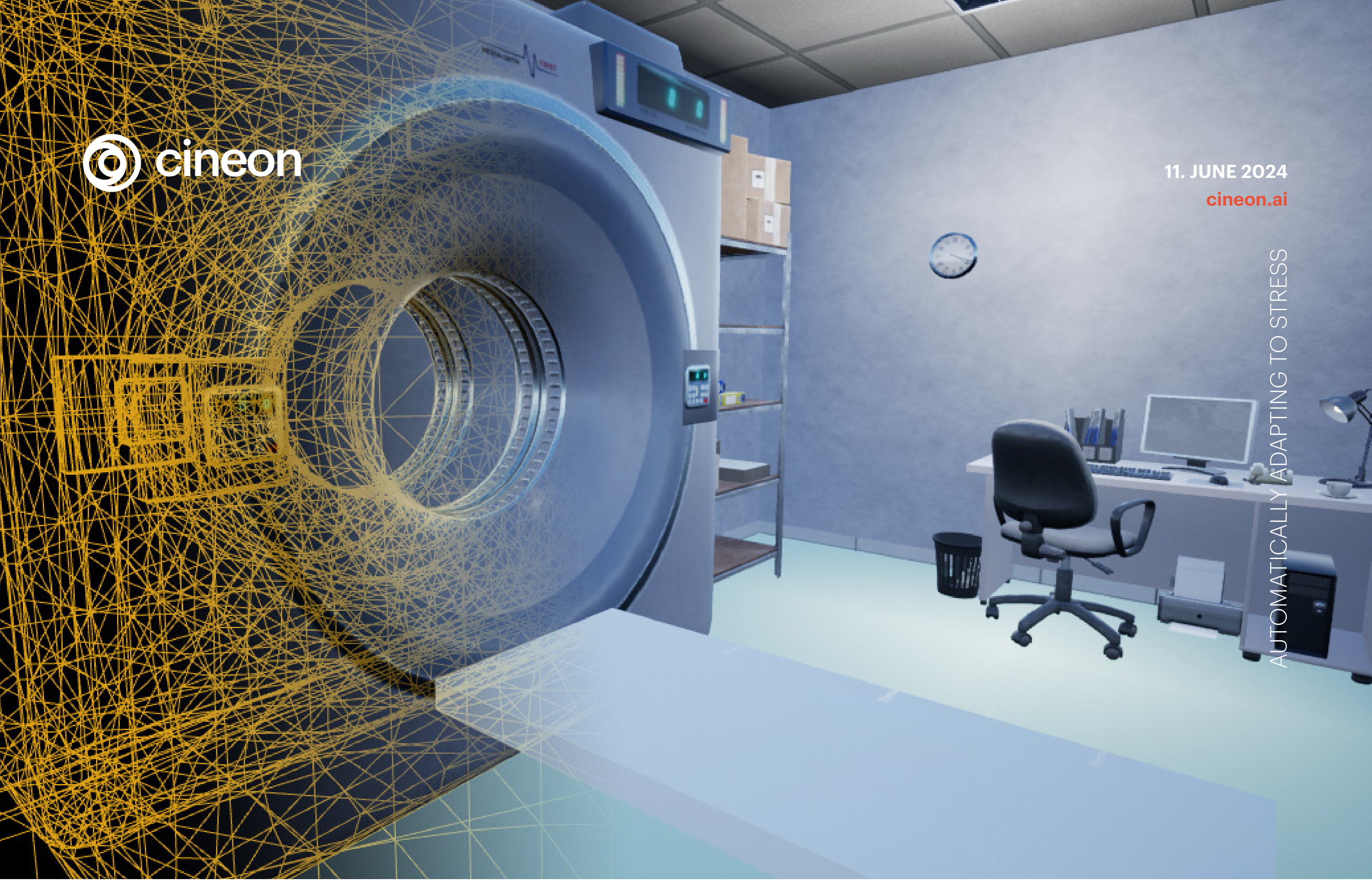
1. KEEP DATA ANONYMOUS
As soon as we collect data we sever any connection to personal information.

2. KEEP DATA MINIMAL
We don't collect data that we don't need for our products. For example, we would not collect iris data, despite eye-tracking, because this is not helpful for our ability to estimate emotional state.

3. KEEP DATA SECURE
All records, even when anonymised, are kept in a secure server with managed access. However, even if this was breached, data could not be used to identify individuals based on the data we have saved.

4. KEEP OUR DATA PROCESSES OPEN
All of our data processing will be provided with informed consent from users, and our data procedures are clearly explained in our Privacy and Security Charter.

→ APPLICATIONS



isave

ADAPTABLE EXPOSURE THERAPY FOR SCANNING-RELATED ANXIETY AND PHOBIAS.

Currently, missed MRI appointments cost the NHS £11m per year. Research suggests this is partly due to fear and anxiety around the scanning experience. We are working with X NHS Trust to develop a virtual MRI scanning simulator that can semi-automatically adapt to a user's anxiety levels and fear-response. This provides a non-threatening means of helping users prepare for their scanning appointments.

Using eye-tracking, we can estimate anxiety levels to inform automatic adaptations of the virtual experience, such as assistant support, time in the scanner, and calming interventions. Combining these passive measurements with explicit self-reports (i.e. asking participants directly how anxious they are feeling), can provide an optimised, personalised exposure treatment.

tacet

A COST-EFFECTIVE YET IMMERSIVE SOLUTION TO BOLSTER PILOT COMPETENCY TRAINING AND ASSESSMENT

The root cause of most aircrew accidents are related to non-technical competencies, such as communication, decision-making, and situational awareness. Our tools aim to bridge the gap between classroom-based and full flight simulation-based methods of competency assessment, aiming to augment rather than replace current methods, reduce the need for an instructor and provide highly detailed feedback for pilots. Our goal is to improve training accessibility and enhance elements of the training process, making it more efficient and better for improving pilot human factors.

TACET (Training Aircrew Competencies using Eye-Tracking) incorporates AI software analytics to systematically capture critical performance and psychometric insights based on Eye Tracking. This objective analysis serves as a measure to evaluate various competencies and levels of expertise by automatically capturing particular behaviours demonstrated in the scenario, enabling a more precise assessment of proficiency.

r-cat

TRAINING SECURITY FORCES TO MAKE SUCCESSFUL SPLIT-SECOND JUDGEMENTS IN COMBAT

Effective room clearance demands rapid threat detection, situational awareness, and split-second decision-making. Traditional training methods often struggle to replicate real-world cognitive demands, reducing their effectiveness in high-stakes scenarios. RCAT (Room Clearance Adaptive Training) is an AI-driven eye-tracking solution designed to enhance operational effectiveness in tactical environments. By systematically capturing visual attention and decision-making behaviours, RCAT provides objective, data-led insights into trainee performance. This analysis provides precise proficiency evaluation, identifying areas for improvement and ensuring training interventions are tailored to individual needs.

RCAT has undergone rigorous testing with UK Ministry of Defence units, demonstrating its effectiveness in enhancing combat readiness. The system immerses trainees in high-pressure, adaptive virtual scenarios, replicating the complexities of real-world room clearance procedures. This approach accelerates skill development, enhancing their visual attention, threat perception, and decision-making skills through targeted training interventions. By reducing reliance on instructor-led evaluation and offering highly detailed, automated feedback, RCAT optimises training efficiency and learning retention.

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