

# Interactivity in the Cognition of Users to Dynamic Contents

Fatimah Binta Abdullahi 


Department of Computer Science, University of Abuja, Nigeria

Email: [fatimah.abdullahi@uniabuja.edu.ng](mailto:fatimah.abdullahi@uniabuja.edu.ng)

Zainab Adamu

Department of Computer, Ahmadu Bello University, Zaria, Nigeria.

Email: [zadmu31@gmail.com](mailto:zadmu31@gmail.com)

Fatima Isiaka 

Department of Computer Science, Nasarawa State University, Keffi, Nigeria

Email: [isiakafatima@nsuk.edu.ng](mailto:isiakafatima@nsuk.edu.ng)

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## Abstract

Understanding emotional evaluation and invisible dialogue in users is crucial for anyone who builds digital content, yet the subtle mechanisms that drive users' cognitive responses remain largely unexplored. This abstract delves into the psychological underpinnings of how layout, typography, color, and interactive cues trigger mental processes such as pattern recognition, mental load, and affective resonance, revealing actionable insights that can transform web design from merely aesthetic to truly cognitively attuned. The method used in the paper is based on pre-determined data from a non-invasive method experimental setup, consisting of forty participants with their consent) that interacted with both a video and dynamic web content. A custom algorithm is applied that wirelessly synchronises and captures event procedures to analyse the cognition of users to these dynamic contents. This allows for scenarios that hinge on the intercorrelation of dynamic content engineering and physiological response correlates, an intersection that transforms passive consumption into an interactive dialogue between mind, body, and media.

**Keywords:** Visual field, Cognitive response, Fixation points, Video feed, Physiological response correlate, Webpage visual field, Dynamic contents

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**Corresponding Author: Fatimah Binta Abdullahi**

Correspondent Email:

[fatimah.abdullahi@uniabuja.edu.ng](mailto:fatimah.abdullahi@uniabuja.edu.ng)



## 1 INTRODUCTION

In an age where webpages flicker, videos autoplay, and personalized feeds morph in real time, the very fabric of the digital experience is no longer static—it's a living, breathing environment that adapts to every click, swipe, and glance. Yet behind the glossy animations and algorithms (Reese (2017); Kim and Lee (2020)) with recom-

mendations lies a fundamental question: *how does the human brain actually perceive, process, and react to this ceaseless stream of dynamic content?* Understanding the cognitive responses of users—from attention capture and memory encoding to emotional arousal and decision fatigue—is the key to designing interfaces that are not just eye-catching, but mentally ergonomic, persuasive, and ultimately humane. This section delves into the neuroscience, psychology, and behavioural insights that illuminate how our minds navigate the ever-shifting digital

landscape, and why those insights matter for creators, marketers, and technologists alike. Yet while marketers, designers, and developers hustle to make their sites and apps feel “alive,” they often overlook a critical question: *How does the human brain actually react to constantly changing digital experiences?* Understanding the cognitive response to dynamic content isn’t just academic trivia. It influences click-through rates, conversion funnels, brand trust, and even user well-being. In this paper, we discuss the psychology behind the brain’s interaction  $F(x)$  with moving, personalised, and real-time digital material ( $U_i, X_j, Y_i$  and  $C_j$ ) (Equation 1) within a certain time frame  $N$ , that ties these insights to concrete design principles, and points toward the research that supports the theme behind it.

$$F(x) = \int_{i=0}^N \int_{j=0}^N \begin{bmatrix} U_i & X_j \\ Y_i & C_j \end{bmatrix} \quad (1)$$

When pressing the “play” button on the video (active children in a chess game), the user is instantly being pulled into a world where the images, sounds, dynamic movements and narrative collide—once the brain lights up, parses meaning, and decides whether to linger, share, or forget. This split-second flucturate between sensory input and mental processing lies at the heart of users’ cognitive response to video content, a dynamic interplay that shapes attention, emotion, memory, and ultimately behaviour (Equation 2). As streaming platforms vie for our attention and marketers gamble on the next viral clip, understanding how viewers encode, interpret, and retain moving media isn’t just an academic curiosity—it’s the key to crafting ideas that stick, designing interfaces that delight, and building digital experiences that resonate long after the screen goes dark. In this introduction, we unpack the psychological mechanisms that drive our reactions to video content as one of the stimuli, explore the factors that amplify or dampen engagement, and glimpse the mechanisms we applied to measure the invisible choreography happening on the skin reaction (Skin conductance response (SCR), Pupil changes and heart rate) every time the dynamics are replayed.

$$B(x) = f(P(x), E(x)) \quad (2)$$

where user behaviour  $B$  is a function of the person ( $P$ ), and their environmental factors ( $E$ ), and  $x$  is the attributes of these surrounding factors.

When scrolling through the news feed or product page of a commercial website that seems to anticipate our curiosity, watching a virtual museum guide that intuitively highlights the artifacts our brain is primed to remember, or playing a game that reshapes its difficulty the moment we lose focus. These seamless, almost mechanical experiences are the product of a grow-

ing dialogue between cognitive science and the creation of dynamic content—where insights into perception, attention, memory, and emotion are baked directly into the algorithms and design principles that drive interactive media. By translating the subtle rhythms of human thought into real time, adaptive narratives, designers are not just delivering information; they are orchestrating a cognitive choreography that keeps users engaged, informed, and empowered. This intersection, the “Cognitive Phenomenon to Dynamic Contents” frontier, promises to reshape how we learn, entertain, and connect in the digital age. The table below (Table 1) highlights some of these phenomenon.

Table 1: Cognitive Phenomenon to Dynamic Contents

Cognitive Phenomenon	What It Means for Dynamic Content	Design Steps
<b>Attentional Capture</b> – The orienting reflex drives us to notice new stimuli	Motion, colour shifts, or fresh information instantly pull focus	Use motion purposefully to highlight calls to action, not as a decorative afterthought.
<b>Habituation</b> – Repeated exposure dulls the response.	A banner that slides in every second quickly becomes “background noise.”	Vary timing, animation style, or content to keep the stimulus salient.
<b>Cognitive Load Theory</b> – Working memory can hold $\leq 4 \pm 1$ chunks at a time.	Rapidly updating dashboards can overload users, leading to errors or abandonment.	Chunk information, use progressive disclosure, and give users control over update frequency.
<b>Prediction Error &amp; Dopamine</b> – Unexpected changes release dopamine, reinforcing engagement.	Personalised product recommendations that surprise you feel rewarding.	Balance novelty with relevance—too random feels spammy, too predictable feels stale.
<b>Serial Position Effect</b> – Items at the beginning and end of a sequence are remembered best.	In a carousel that auto rotates, the first and last slides are most memorable.	Place high value messages at those positions or allow users to manually navigate.



## 2 LITERATURE REVIEW

In an era where web pages flicker, videos autoplay, and personalized feeds reshape every scroll, understanding how users cognitively process such dynamic content has become a cornerstone of human-computer interaction research. This literature review maps the evolving landscape of scholarly work that probes the mental mechanisms—attention, perception, memory, and decision-making—triggered by ever-changing digital environments. By synthesizing findings from cognitive psychology, neuroscience, and interactive design, we illuminate how motion, interactivity, and adaptive media can both amplify engagement and overload the brain's processing capacity (Zhiyuan and Chubotina (2024); Vishakha (2025)). The review also uncovers critical gaps—particularly the interplay between individual differences and real-time content adaptation (Figure 1—setting the stage for future investigations that aim to harness dynamism without compromising usability or cognitive well-being (Gaggioli et al. (2017); Shin (2025); Salamida (2023); Upreti et al. (2026)).

When one lands on a website, our eyes dart across headlines, images flicker into focus, and a cascade of thoughts—curiosity, confusion, delight—races through your mind in a split second. That fleeting, subconscious choreography is the essence of users' cognitive response to webpage content, a dynamic interplay of perception, attention, memory, and emotion that ultimately determines whether a visitor stays, clicks, or clicks away (Bitgood (2010); Pearce (2020); Torabi et al. (2025)). As digital environments become ever more saturated and design choices ever more nuanced, scholars across psychology, human-computer interaction, and marketing have begun to untangle the mental mechanisms that translate pixels into comprehension, persuasion, and action. This literature review surveys the emerging body of research that maps those mechanisms, critically evaluates methodological strides and gaps, and sets the stage for a deeper understanding of how the architecture of a page shapes the architecture of the mind (Groat and Wang (2013); Dougrusoz (2016); Niezabitowska (2018)).

The explosion of video-driven platforms—from short-form TikTok clips to long-form documentaries on streaming services—has turned visual media into the dominant conduit for information, entertainment, and persuasion. Yet, behind each click, pause, or replay lies a complex tapestry of cognitive processes that shape how viewers perceive, interpret, and retain what they watch. Understanding these mental mechanisms is crucial not only for designers seeking to craft compelling narratives, but also for educators, marketers, and policymakers aiming to harness video's persuasive power responsibly (Mishra and Shah (2024); Smith

et al. (2025); Ediriweera et al. (2023)). This part also reviews the interdisciplinary scholarship that maps the terrain of users' cognitive responses to video content, tracing how attention, memory, emotion, and mental workload intersect with narrative structure, visual style, and interactivity. By weaving together findings from cognitive psychology through physiological response, media studies, and human-computer interaction, the review identifies converging insights, persistent gaps, and emerging frontiers that chart the path for future research in an increasingly visual world (Fang and Zhu (2023); Ghosh et al. (2024); Samala et al. (2024)).

In an era where screens morph from static billboards into fluid, interactive canvases, understanding how users mentally navigate that ever-shifting landscape has become both a scientific frontier and a design imperative. Recent methodological breakthroughs—ranging from high-resolution eye-tracking coupled with real-time neurophysiological monitoring, to machine-learning-driven cognitive models that parse split-second decision pathways—are finally giving researchers the tools to peel back the layers of perception, attention, and memory that underlie our responses to dynamic content (Zhang (2019); Chun and Johnson (2011); Manicka and Levin (2019)). By rigorously evaluating these new approaches, we can change how incremental shifts in animation, personalization, and interactivity translate into measurable changes in user cognition, paving the way for experiences that are not just visually captivating but also cognitively resonant. The preceding sections discuss the methods and analysis of user cognitive response to dynamic content (Chen et al. (2006); Li et al. (2020); Isiaka (2025)).

$$L_r(p, q) = X_0 + X_{n+1} \quad (3)$$

$$A_r(p, q) = \frac{d^n(p, q)t}{dy^n} + 2 \frac{d^{n-1}(p, q)}{dy^{n-1}} \quad (4)$$

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### Algorithm 1 Pre-processing SCR and Pupil Response

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- 1: **for** *iteration* = 1, 2, ... *N* **do**
  - 2:     **for** *SCR* = 1, 2, ... , *N* **do**
  - 3:         Run reaction  $R_{\theta_{ota}}$  in room environment for *T* time stamps
  - 4:         Compute advantage Amplitudes  $\hat{A}_1, \dots, \hat{A}_T$
  - 5:     **end for**
  - 6:     Optimize response rate *SCR* wrt.  $\theta$ , with *Pupil response* epochs and magnitude size  $P \leq M$
  - 7:      $R_{\theta_{ota}} \leftarrow \theta$
  - 8: **end for**
-

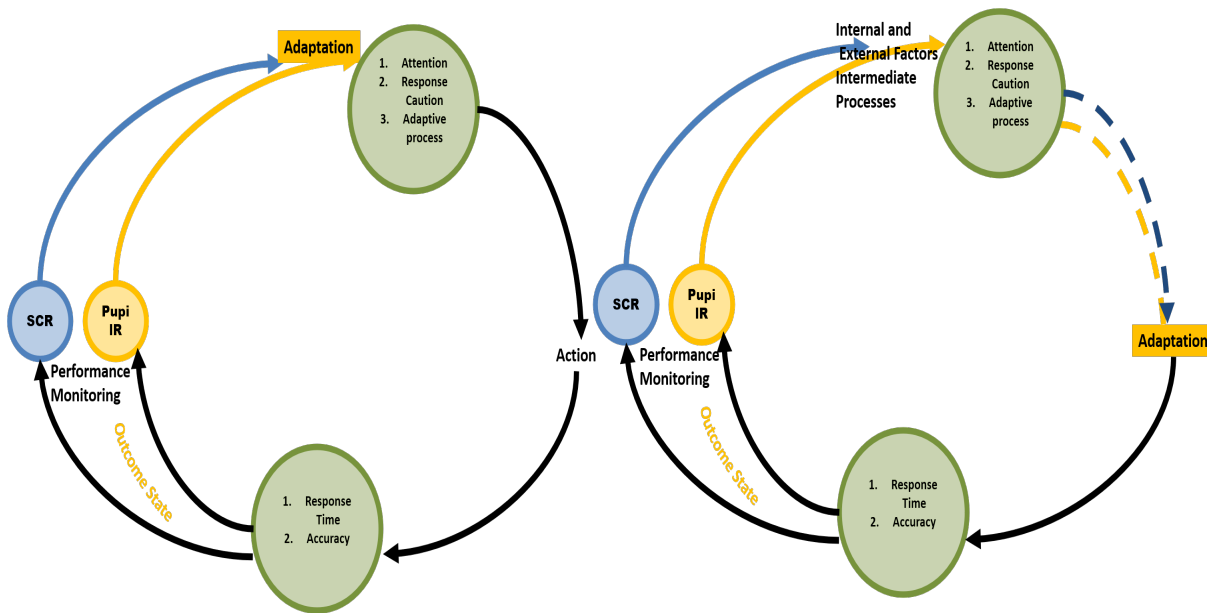


Figure 1: Real-time content adaptation for future investigations that aim to harness dynamism.

$$\int_{x=0}^m L_r(p, q) + 2(A_r(p, q) - L_r(p, q)) + \frac{1}{2}(A_r(p, q) - L_r(p, q)) = R_r((p_{n-1}, q_{n-1}) - 1) \tag{5}$$

### 3 METHOD

Imagine peering into the mind of a user as they scroll through a sleek website or binge-watch a dynamic video, watching every split-second decision, flicker of attention, and flash of comprehension unfold in real time. In today’s hyper-connected world, understanding those silent cognitive reactions isn’t just an academic curiosity—it’s the secret sauce that powers persuasive design, boosts retention, and turns casual browsers into loyal fans. Setting up experiments to capture these invisible processes demands a delicate blend of behavioural science, cutting-edge technology, and meticulous experimental design, from eye-tracking and SCR to nuanced stimulus timing and controlled user-flow scenarios. By thoughtfully orchestrating the interplay between webpage layouts and video narratives, we can decode how visual hierarchy, motion, and storytelling shape perception, memory, and decision-making. This section unpacks the essential steps, pitfalls, and best-practice tools we used to transform raw cognitive data into actionable insights that elevate digital experiences to the next level. The data used were pre-defined data from an experiment involving an aggregation of (Forty) 40 participants who interacted with both web content (Commercial webpage (Amazon)) and video content. The SCR is based on latency  $L_r(p, q)$  from the initial state  $X_0$  to the stimulus onset  $X_{n+1}$ , amplitude  $A_r(p, q)$  and resultant reaction  $R_r$ . (Equation 3, 4 and 5). Each fixation on the stimulus at each point  $(p, q)$  is synchronised to the SCR response rate.



Figure 2: An example of a user interacting with video content inside an eye-tracker, a laptop for wireless data synchronisation and analysis.



**Algorithm 2** SCR and Pupil Preprocessing for Event Detection. Every time step do

```

2: Calculate response rate  $R_r$  (Eq.: 5)
3: for All map measurements from  $F_{Map}$  do
4:   Denormalise measurement (Eq.: 4)
5:   Add environmental const.
6:   Calculate amplitude difference  $\Delta A_{(p,q)_j}$  to
   Pupil change (
7:     if  $\Delta h_{(p,q)_j} > 0$  then
8:       Add all measurement to result response
 $M_{crit}$  (Eq.: 5)
9:     end if
10:  end for
11:  for All measurements in  $R_r$  do
12:    Calculate environmental vectors
13:  end for
14:  Sum over all local environmental vectors (Eq.:
3.22)
15:  Transform to global coordinate frame to receive
 $R_r$  (Eq.: 5)
16:  Calculate mapping weight  $m_{(p,q)}$  based on criti-
cal zone AOI
17:  Calculate Timestamp for SCR  $T_{ts}$  as  $1 - T_r$  (Eq.:
3.13)
18:  Calculate Fixation duration  $F_r = R_r R_r + w_{ts} 2 R_r$ 
(Eq.: 5) for event detection on stimuli.
19: end for

```

### 3.1 Task

The datasets were pre-determined, with the web contents consisting of dynamic contents with both video and pictures of the commercial website changing every 3 seconds, while the video content (courtesy of Google archives) displays little children playing on a chessboard. The participants were simply asked to identify the most active child every few seconds in the eye tracker and the best product of choice from the commercial websites, while their physiological response (SCR attached on wrist) was observed and recorded during these activities. The major criterion is not to test the child’s performance, but the cognitive response of the observer based on four classes (Relaxed, Stress, clicking, Looking and typing), where there is no formal activity at all, the response is simply numeral this process is obtained based on Algorithm 2. Because the stimulus never stays static, the physiological response cannot be treated as a single, isolated measurement. Instead, we examine how the body tracks the flux—how the SCR and Pupil changes accelerate, then decelerate; how skin conductance spikes at moments of stress, then settles; how ocular metrics follow attentional shifts; how cortical oscillations lock onto rhythmic patterns of the pupil changes.

These signals are correlated because they do not di-

Table 2: Conductance as a Core Physiological Correlate.

Correlate	What it tells us	Measurement device
Electrodermal Activity (EDA) Skin Conductance	Sympathetic nervous system activation, emotional intensity	Skin electrodes (finger or palm)
Pupillometry	Cognitive load, stress, relax mood	Eye tracking cameras

rectly read “stress” or “relax” mood; they are proxies that, when interpreted in context, reveal the underlying affective and cognitive landscape.

### 3.2 The Design Procedures for the Users’ Cognition to Both Video and Webpage Contents

When scrolling and streaming become second nature, the real battle isn’t just for attention—it’s for comprehension. Every click, swipe, and frame is a cognitive shortcut that can either illuminate or overload the mind of the users. Translating the science of perception, memory, and decision making into concrete design rules isn’t a luxury; it’s the secret sauce that turns complex websites and tangled video streams into intuitive experiences. The design process here pulls the current insights from cognitive psychology and human-centred design into practical, bite-sized guidelines that empower creators to craft web pages and video content that not only capture attention but also respect and enhance the way users think, learn, and act. During autoplay in the videos and web surfing that jump start our attention, the real battlefield isn’t the screen—it’s the cognition behind it. Designing web and video content with users’ cognition at its core isn’t trivial; it’s a strategic imperative that transforms passive viewers into engaged participants, boosts comprehension, and drives meaningful action. By aligning visual cues, narrative flow, and interactive elements with how our brains and physiological responses process information, designers can cut through the noise, reduce cognitive overload, and create digital experiences that feel intuitive, memorable, and persuasive. This cognitive first approach is the idea that turns clicks into connections and fleeting impressions into lasting impact.

### 3.3 Measuring the Cognitive Impact

When scrolling through contents like clicking on the video to select the best active child, and instantly feeling that familiar mental cognition and recognition, partici-



pants usually feel the almost invisible tug on their attention, memory, and emotions from their subjective perspective. As users navigate the web pages and streaming platforms, the true power of that digital content lies not just in clicks or views but in how it reshapes the way they think, learn, and decide. Measuring this cognitive impact—tracking eye-movements, brainwaves, recall rates, and emotional resonance—turns the fleeting moments of online engagement into concrete insights that can unlock smarter design, more effective storytelling, and a deeper understanding of the human mind in the digital age. The table below reveals the methodologies and real-world applications that we used in differentiating the once-intangible experience of web and video consumption into measurable, actionable data.

Table 3: The metrics for user cognition to web and video contents.

Metric	Procedure	Output
Eye tracking fixations	Track gaze duration on moving vs. static zones.	Determine whether dynamic elements truly draw visual focus.
Pupil dilation	Via webcam (Tobii eye tracker).	Cognitive load – larger dilation = higher effort.
Task completion time	Compare the speed on pages or frames with/without auto refresh.	Impact of real time updates on efficiency.
Self reported mental fatigue	Short post session surveys .	Subjective perception of overload.
Engagement loops	Frequency of repeat visits after a “relax” or “stress” recommendation.	Effectiveness of event driven novelty.

Normally, A/B testing remains the gold standard, but pairing it with behavioural analytics like scroll depth, click through and physiological signals like eye tracking, facial expression gives a richer picture of the brain’s SCR and Pupil dilation response. The preceding section discusses the results obtained from these analyses.

## 4 RESULT

The way our brains process digital information is reshaping the very fabric of online storytelling. The study

here on user cognition reveals startling patterns: a single thumbnail can trigger a cascade of neural responses that are reflected on the SCR, while subtle layout tweaks can double a viewer’s retention of a video’s core message. By dissecting these cognitive fingerprints, we were able to uncover the hidden rules that make web pages feel intuitive and video content feel unforgettable. The results not only illuminate the silent dialogue between mind and medium, but also give designers, marketers, and educators the science-backed procedures needed to capture attention—retain it—amid the endless flood of digital noise.

Figure 3 and 4 shows that scrolling through the stimuli website and video content indicates that bright products and active children catch the eye as amplitudes and spikes in the physiological responses increases, a pop-up bursts onto the screen, and a cascade of links clamours for attention. Behind every click, hover, and scroll lies a hidden cognitive process between the brain’s limited processing capacity and the visual cognitive demands of the page itself. As we race to pack more content, animations, and interactivity into ever leaner screens, understanding the physiological signatures of users’ cognitive load—eye movement patterns, pupil dilation, heart rate variability, even neural oscillations—has become a vital compass for creating web experiences that feel intuitive rather than overwhelming.

In this section, we delved into how the body’s subtle signals reveal the mental effort required to navigate digital interfaces, and why translating these insights into smarter, user-centric design is the next frontier of web development. The SCR and Pupil dilation correlate to the commercial website, and the captivating video with children at chess shows that the users cognition is quietly broadcasting a vivid, real time report of every emotional twist and turn in their activities based on the consecutive “stress” and “relax” spike correlates to behavioural characteristics like the “Looking”, “Clicking” and “Typing”.

The tiny electrical fluctuations across the skin are indicated by these spikes when a headline snaps the attention, while the pupils in the eyes subtly dilate in response to surprise, suspense, or delight. By harnessing these involuntary physiological signals, we map a hidden layer of user experience, revealing exactly how web-pages and video content can ignite arousal, engagement, and immersion. This emerging frontier, where neuroscience meets digital design, promises to turn raw biometric data into actionable insights that transform the way we craft and evaluate online media. The two methods used in detecting event correlates includes the Dorsal Attention Network (DAN) and the Ventral Attention Network (VAN)



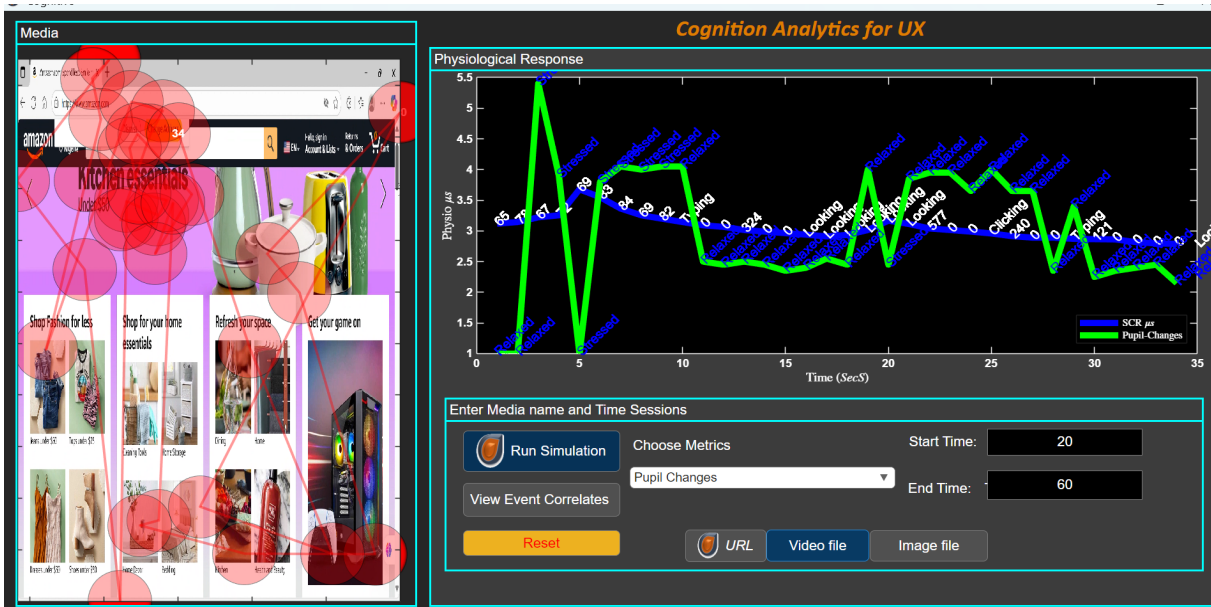


Figure 3: Real-time synchronisation of Physiological response to dynamic webpage content.

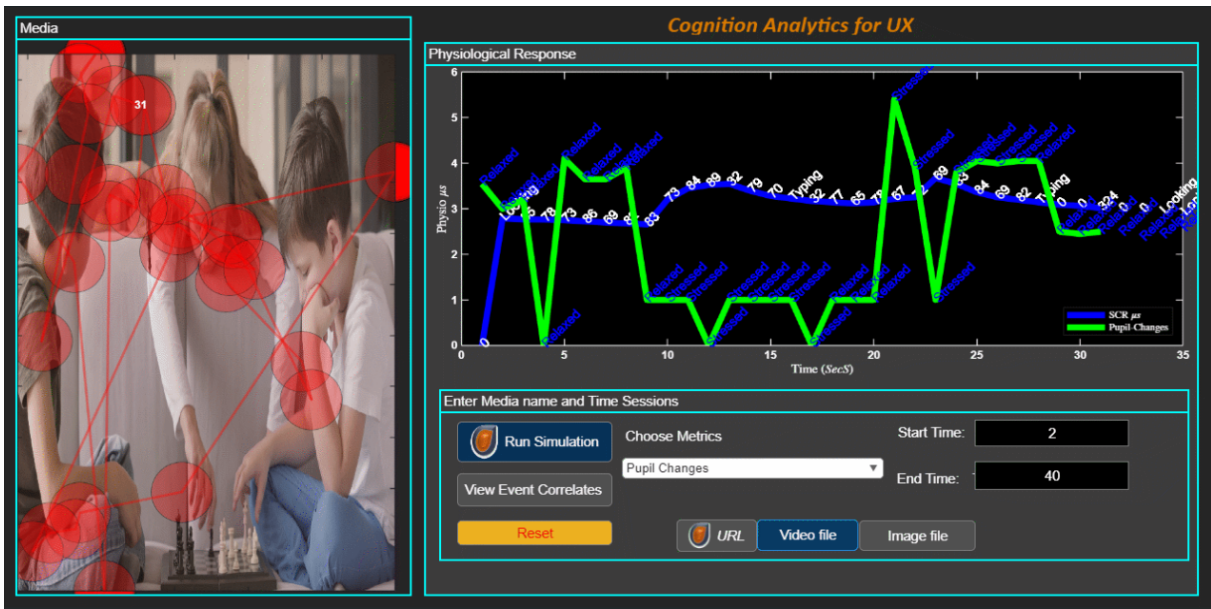


Figure 4: Real-time synchronisation of Physiological response to dynamic Video content of children on a chess.

#### 4.0.1 The Dorsal Attention Network (DAN)

Controls goal-directed attention. Motion, flashing icons, or sudden layout changes activate this network, making the participants aware of the content. A spotlight that instantly knows where to shine, steering the eyes and thoughts toward the most important details in the bustling scene. Nestled in the spikes on SCR and pupil dilation, this dynamic neural circuit acts like a high-speed traffic controller, rapidly allocating the visual and spatial focus whenever they need to surf for a

desired product, track a moving object (active Child on chess), or zero in on a crucial detail in a complex graphic. Generally, whether one is navigating a fast-paced video game, scrolling through a data-dense dashboard, or simply scanning a news feed, the DAN silently orchestrates the flow of attention, shaping what we see, remember, and act upon. The experiment and spikes in the physiological responses show how this hidden “attention engine” powers everyday perception and why understanding it can transform the way we design websites, craft

immersive videos, and build smarter, more engaging digital experiences.

#### 4.0.2 The Ventral Attention Network (VAN)

Triggers a “stop and look” response to unexpected events. Dynamic content that violates a user’s mental model (e.g., the product contents on the commercial websites that display consecutive visual aesthetics) can activate VAN, causing a momentary “surprise” pause that increases the spike amplitude. The brain’s “circuit breaker” snaps out of routine focus and redirects the gaze toward unexpected, salient stimuli. In the digital realm, it’s the invisible force that decides whether a user scrolls past a flagging item, clicks on a thumbnail, or binge-watches a video. Understanding how the VAN works—and how to design for it—can boost click-through rates, lower bounce, and keep viewers glued to the screen. The summarised results in the preceding sections show the correlates of cognition to the dynamic contents. When you design a dynamic experience, you are essentially orchestrating a conversation between these brain systems. Effective design aligns the DAN’s attention capture with the PFC’s decision making and the reward system’s reinforcement loop.

#### 4.0.3 Children on Chess Video

- Dynamic element: Personalized thumbnails that update within every 2 seconds.
- Cognitive display: Predicted error—the user expects the familiar “Continue Watching and searching for active child” row, then discovers an active point on each video frame.
- Design layout: Keep the playing motion subtle (slow slide) and limit to 4–5 items to avoid overload of video stream.

#### 4.0.4 Commercial Websites (Amazon)

- Dynamic element: Constantly streaming price changes on products.
- Cognitive challenge: High load for traders who need to spot critical moves.
- Solution: Colour code price swings (green/red), add a pause button, and aggregate minor changes into “summary ticks.”

### 4.1 Ethical Considerations

Dynamic content can be a double-edged sword. When used to nudge users toward healthier choices or to keep them informed (e.g., real-time children playing chess in

the video stimuli and the dynamic pages of the Amazon website), it’s a public good. However, the same mechanisms can be weaponised for dark patterns—infinite scrolling that exploits attentional capture, or personalised ads that exploit prediction error to foster compulsive buying behaviour. The ethical procedures to adopt a “human first” ethic include transparency, by clearly labelling auto-updating sections (“Live updates”), consent by offering opt-out choices for personalisation and real-time data and mental well-being by avoiding relentless motion that induces anxiety; provide calm modes for users who need reduced stimulation.

## 5 CONCLUSION

This paper tends to investigate the Cognitive Response of Users to Dynamic Content through pre-determined dataset based on an aggregate from participants. With large language models and generative video now accessible via APIs, we’re moving toward context aware dynamic experiences that adapt not only to past behaviour but to the current mental state of the user (e.g., detecting frustration via webcam analysis). Potential real time adjustments of difficulty in educational games, or dynamically toned down UI for users showing stress with challenges, ensuring privacy and avoiding over personalization that feels invasive. The cognitive study we have analysed in this paper will become a cornerstone for responsible AI-driven models and enable designers to keep the brain’s limits front and centre as algorithms gain more autonomy. Dynamic content is no longer a flashy add-on; it’s an integral part of how we interact with digital ecosystems. The brain’s interpretive responses are a delicate dance of attention capture, cognitive load management, prediction-driven reward, and memory encoding. By respecting those processes—using motion purposefully, limiting simultaneous updates, providing user control, and staying ethically transparent—designers can create experiences that feel alive without exhausting the user. Future perspective will be to test the novel model applied to other computational models and also include practice that asks question like when moving an element, *What cognitive need does it satisfy?* and *Does it respect the user’s working memory bandwidth as to whether the novelty is purposeful or merely decorative?*. These research questions will allow for dynamic content to appear on the screen at the right area of interest (AOI) that will resonate in the mind of every visitor and generally. The stimulus from the study is a scene pacing based on real-time physiological state, delivering a hyper-personalised suspense curve. The theta activity suggests mental fatigue, then resumes once attentional markers rebound. Such scenarios hinge on the intercorrelation of dynamic content en-



gineering and physiological response correlates, an intersection that transforms passive consumption into an interactive dialogue between mind, body, and media.

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## CONFLICT OF INTEREST

The authors wish to confirm that there is no conflict of interest regarding this paper.

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