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HIDDEN DIGITAL DEPENDENCE ON SMARTPHONES AMONG MOROCCAN USERS: A FIELD STUDY FROM A NEURO-CYBERNETIC PERSPECTIVE

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Abstract
Objectives: The study aims to examine the prevalence of hidden digital dependency on smartphones among Moroccan users from a neuro-cyber perspective, analyze its relationship with daily usage intensity and neuro-related psychological and behavioral symptoms, and explore differences between the studied groups..
Methods: The study used the descriptive analytical approach to describe and analyze the hidden digital dependency phenomenon among Moroccan smartphone users, relying on the statistical method and data analysis using SPSS software (version 26).
Results:. The findings revealed a significant prevalence of hidden digital dependency in Morocco, especially among youth, with a positive correlation between intensive smartphone use and levels of anxiety, sleep disorders, and physical fatigue. The study also observed low awareness of cybersecurity risks and difficulty regulating use despite awareness of its negative consequences.
Conclusions: The study confirms that digital dependency is a phenomenon combining neurological, psychological, and social effects within the Moroccan digital environment. It recommends developing comprehensive strategies that include national awareness campaigns, technical and psychological intervention programs, enhancement of cybersecurity skills, and active family involvement in prevention efforts.
Keywords: Digital dependency, smartphones, Morocco, mental health, cybersecurity, neuro–cybernetic perspective.

1.INTRODUCTION

The world today is witnessing an exceptional digital explosion characterized by the widespread proliferation of smartphones across all social and cultural groups, making them an integral part of daily life and a key element in shaping individuals' digital identities (Busch & McCarthy, 2021; Miller, D. et al., 2021; ITU,2023). This rapid transformation has given rise to new behavioral and psychological phenomena, foremost among them the concept of hidden digital dependency, which refers to patterns of behavioral, emotional, and obsessive attachment to smart devices without users being fully aware of the reality and nature of this almost daily clinginess (Panova & Carbonell, 2018; Ratan et al., 2021 ; Ratan, ZA et al.,2020; Alwazzeh, M., 2024).

The discussion of digital addiction is no longer confined to psychological aspects but has become a highly complex phenomenon where neurological dimensions (activation of brain reward centers and changes in neuroplasticity) intersect with cyber-social factors (Anbumalar, C. et al., 2024; Brand et al., 2014), linking digital dependency to neuro-psychological backgrounds and the cyber context. Systematic reviews have shown that smartphone dependency has direct negative effects on mental health (increased anxiety, depression, poor social adjustment, sleep disorders, chronic stress), in addition to latent physical symptoms such as eye strain and muscle pain (Sarhan, A. L., 2024; Ding, K., et al., 2023; Adams, S. K., 2013 ; Augner, C., et al.,2023; Cheung, M. C, et al., 2022).

Hidden digital dependency is associated with contemporary life phenomena that cannot be separated from everyday cyber contexts. The behavior goes beyond functional needs, seeking momentary psychological gratification or escape from stress; it becomes automatic and the relationship with technology grows more complex (Panova & Carbonell, 2018; Kuss & Griffiths, 2017). The literature documents that the intensity of daily smartphone use is positively correlated with higher levels of behavioral dependency and withdrawal symptoms when the device is lost (Elhai et al., 2017; Lin et al., 2016).

At the Moroccan level, recent studies have highlighted a rapid spread of digital dependency, especially among university youth, with established or increasing rates approaching 40% in some groups (Choujaa et al., 2023; Archou et al., 2025; Meskini et al., 2024). This spread, according to researchers, is linked to the influence of the social environment, levels of digital education, weak awareness campaigns, limited cybersecurity awareness, and low digital self-protection skills (Hadlington, 2017).

Brain imaging and neuro-measurement studies have revealed changes in the executive reward circuits of individuals with higher dependency, explaining the difficulty of regulating usage and the appearance of withdrawal-like symptoms (Brand et al., 2014; Ding et al., 2023). These changes are associated with increased anxiety, poor sleep, and decreased self-control (León Méndez et al., 2024; Liu et al., 2024).

Accordingly, this Moroccan study, from a neuro-cyber perspective, aims to monitor the prevalence of hidden digital dependency on smartphones among Moroccan users of different ages and qualifications, analyze its relationship with daily usage intensity and neuro-correlated psychological and behavioral symptoms. It also seeks to explain differences between groups and highlight the challenges of cyber awareness and the future of protecting Moroccan society from latent digital risks (Choujaa et al., 2023 ; Busch & McCarthy, 2021 ; Benhammou et al.,2024).

1.1.Study Importance

Scientific Importance: This study is distinguished by offering an integrative approach that combines concepts from computational neuroscience, cybernetics, and digital sociology, making it one of the researches addressing the phenomenon of hidden digital dependency from a multidisciplinary perspective. This approach reflects the importance of filling a clear knowledge gap, as it enables a deeper understanding of the neural, behavioral, and social mechanisms controlling individuals' increasing reliance on smartphones in Moroccan society. The scientific value of the study is also highlighted by shedding light on a phenomenon that transcends all societal sectors, including families, educational institutions, and work environments. This enables anticipation of the digital transformation's implications on the structure, values, and daily interactions of Moroccan society. The expected outcomes of this study will enrich scientific literature in neuroscience and digital sociology both regionally and internationally, as well as open new horizons for future applied and interdisciplinary research.

Practical Importance: The practical significance of this research lies in it being a fundamental knowledge source for multiple groups, primarily students' families, policymakers, educational specialists, and educators. It provides them with a deep understanding of the nature of hidden digital dependency on smartphones among Moroccan users. This precise understanding will help them grasp the psychological, behavioral, and social aspects of the phenomenon, along with the neuro-cybernetic backgrounds behind its formation and infiltration in contemporary society. The research results are expected to serve as effective tools for guiding intervention and prevention policies by contributing to the preparation and design of targeted intervention campaigns and specialized awareness programs. These will directly respond to the peculiarities of the local digital culture while respecting Moroccan societal values and customs. Furthermore, the results will enable stakeholders to develop more effective strategies to protect individuals, especially youth and adolescents, from the challenges and risks associated with smartphone misuse, thereby supporting efforts to enhance mental and behavioral health on both individual and community levels.

1.2.Study Objectives

This study is based on several primary objectives aimed at constructing a comprehensive and accurate picture of the phenomenon of hidden digital dependency on smartphones. First, it aims to measure the prevalence rate of this hidden dependency among smartphone users in Morocco, enabling an understanding of its commonality and identifying the most vulnerable groups. Second, the study seeks to explore the neuro-cybernetic indicators accompanying this dependency by linking changes in neural patterns with users' daily digital behavior, thus adding a novel scientific dimension to the Arab research environment. Third, the study focuses on monitoring and analyzing the psychological, behavioral, and social effects associated with this phenomenon to determine its positive and negative impacts on social identity formation, family interaction, and individuals' mental and behavioral health.

Achieving these objectives will contribute to enriching scientific literature on digital dependency and opening new avenues for intervention and future research locally and regionally.

1.3.Study Concepts

-Hidden Digital Dependency: Hidden digital dependency refers to a gradual, invisible pattern of attachment to smartphones or digital devices that permeates an individual's behavior without necessarily manifesting as obvious addiction, such as loss of control or complete social disconnection. Instead, it appears in subtle and escalating symptoms like difficulty detaching from the device, a constant urge to check notifications, increased anxiety or discomfort when access to the phone is lost, and disturbances in sleep or concentration—even without self-recognition of a problem (Elhai et al., 2016; Panova & Carbonell, 2018; Dong, R., et al., 2025). This condition is especially pronounced with app algorithms designed to encourage continuous device return and intensify immediate digital rewards, reshaping the brain's neural reward circuit and making dependency more hidden and persistent amid a culture of constant connectivity and comprehensive digitization (Montag et al., 2021; Elhai et al., 2016). Recent studies have called for adopting precise diagnostic tools to monitor the psychological and behavioral dimensions of this dependency, particularly among youth and students, due to its cumulative effects on mental, social, and personal health in modern societies (Panova & Carbonell, 2018; Elhai et al., 2016; Lin, Y.-H., et al., 2016; De-Sola Gutiérrez, J., 2016).

-Smartphones: Smartphones today have become an inseparable part of daily life, as most people use these devices for social communication, work management, education, entertainment, and shopping on a single fast and accessible digital platform. This rapid and multifunctional development of smartphones has profoundly reshaped digital habits and patterns of human interaction, with smartphones becoming a central gateway between virtual and everyday reality (Lopez-Fernandez, 2017). Smartphones have become integral to the daily behavior patterns of people from various ages and social groups, contributing to a highly dynamic digital environment where notifications and alerts multiply and applications are continually updated (Busch & McCarthy, 2021). Research shows that this continuous use reshapes the perception of time, cultivates digital habits, and makes smartphones a central mediator in most personal and professional life aspects (Elhai et al., 2017). Despite significant benefits, many studies warn of the psychological and behavioral risks of this digital integration, as intensive smartphone use is linked to increased anxiety, depression, attention disorders, decreased sleep quality, and decline in traditional social relationships, alongside a higher likelihood of hidden digital dependency even among those who consider their use "normal" (Panova & Carbonell, 2018; Horwood & Anglim, 2021). Recent literature advocates for enhancing digital literacy and self-awareness to achieve balanced and "healthy use" of

smartphones, maximizing benefits while minimizing associated risks (Montag & Elhai, 2023; Montag, C., & Elhai, J. D.,2021; Brailovskaia, J., et al., 2024; Elhai, J. D., et al, 2020; Montag, C., Yang, H.,2021; Brand, M., et al, 2025).

Neuro-Cybernetic Perspective: The neuro-cybernetic perspective is an advanced theoretical framework combining computational neuroscience and cybernetics theory, viewing the human brain as a dynamic unit continually influenced by daily digital interactions. Studies indicate that frequent and intense use of smartphones and digital technologies modifies the operation patterns of reward and self-motivation circuits in the brain, especially due to streams of immediate notifications and rapid digital feedback, which reinforces the formation of repetitive habits and continuous behavioral dependency (Montag et al., 2021; Elhai et al., 2017). Research shows that this highly responsive digital environment enhances the effectiveness of digital feedback and reshapes neural connections related to instant gratification and rapid connection, making it more difficult for individuals to break free from hidden digital dependency even when self-control awareness is present (Panova & Carbonell, 2018; Kuss, D. J., & Griffiths, M. D.,2017). Brain imaging and neural activity correlations have demonstrated that repeated engagement with digital interactions can reset the brain's sensitivity to external stimuli, contributing to sustained digital dependency especially among youth.

Psychological and Behavioral Symptoms Associated with Digital Dependency: These refer to a series of disorders accompanying excessive or dependent use of smartphones and digital devices, gradually reflected in an individual's behavior, mood, and daily life(Darvesh, N., et al., 2020). Common symptoms include a compulsive need for constant checking of the phone or apps, difficulty fully engaging in real-life activities such as study, work, and direct relationships. Digital dependency is associated with increased anxiety, stress, sleep disorders, and diminished quality of night rest (Busch & McCarthy, 2021; Horwood & Anglim, 2019, Bartel, K., 2019). Other symptoms include feelings of emptiness, reduced social engagement, poor self-control, and frequent episodes of distraction and attention deficits, which are more pronounced among university students and adolescents (Elhai et al., 2017; Panova & Carbonell, 2018; Chang, M. L. Y., & Lee, I. O., 2024; Ding, K., et al, 2023; Pontes, H. M., et al., 2015; Burns, R. D.,et al.,2019). Research findings also indicate that ongoing unchecked digital dependency can lead to chronic psychological disorders, such as anxiety and depression, and negatively impact academic or professional performance as well as family and social relationships (Elhai et al., 2020; Luo, J., Cai, G., et al.,2025).

Cyber Awareness and Digital Security: Cyber awareness and digital security are fundamental concepts in the era of rapid digital transformation, reflecting individuals' and institutions' ability to understand digital risks and grasp the dynamics of threats surrounding them via the internet and smart devices. Recent literature suggests that cyber awareness extends beyond theoretical knowledge of threats like phishing, data leaks, or malware to include adopting effective preventive behaviors such as password management, application permission auditing, and privacy policy analysis (Busch & McCarthy, 2021; Altarawneh, M. H. M., 2025; Vrhovec, et al., 2024). Recent studies emphasize the importance of cyber awareness among decision-makers and institutions, noting that a lack of such awareness can lead to insufficient strategic decisions to prevent cyberattacks, especially with the increasing complexity of attacks such as DDoS or industrial espionage. This requires a combination of cognitive awareness and practical security behavior in work and educational environments (Vrhovec et al., 2024; Li, L., et al., 2016; Chaudhary, S., 2024; Duzenci, A.,2023). Researchers call for integrating systematic education and training within institutions to raise awareness among both employees and students as a prerequisite for data protection and maintaining performance quality (Shillair et al., 2022; Al-Fatlawi, 2024). Other research stresses the need to integrate security culture building with technological programs amid comprehensive digitization, pointing out that user awareness of digital risks is insufficient unless accompanied by actual behavioral changes and practical skills to protect the self, devices, and work accounts (Ahamed et al., 2024). Systematic reviews confirm that building effective cyber awareness requires combining theoretical learning, applied practice, and continuous knowledge updates to protect users from rapidly evolving contemporary digital threats (Busch & McCarthy, 2021; Vrhovec et al., 2024; de Bruijn, H., & Janssen, M.,2017).

1.4.Previous Studies

-Study (Sadiq et al., 2023): "Scrolling through sleep: Moroccan high school students smartphone uses and sleep quality": This study revealed that smartphone addiction has become a widespread phenomenon among Moroccan high school students, with 57.8% of participants exhibiting high levels of digital dependency and 59.9% simultaneously suffering from poor sleep quality. The study used scientific tools such as the Smartphone Addiction Scale-Short Version (SAS-SV) and the Pittsburgh Sleep Quality Index (PSQI). The sample included 389 students from public schools in Marrakech with balanced gender and grade distribution. Results showed a moderate and clear correlation between addiction levels and sleep quality deterioration, particularly regarding difficulties in falling asleep, frequent nighttime disturbances, and lower satisfaction with sleep. Additionally, poor sleep quality and excessive phone preoccupation significantly undermined academic performance: higher addiction levels correlated with lower academic achievement, with addicted students performing worse than their peers. The study also found no significant differences between males and females, indicating the phenomenon affects all students regardless of gender or grade. Researchers recommended urgent interventions by families, educational, and health institutions to develop awareness and prevention programs to reduce the risks of excessive smartphone use, given its direct impact on adolescent sleep quality, mental health, and academic outcomes.

-Study (Archou et al., 2025): "The relationship between smartphone addiction and anxiety: a cross-sectional study among Moroccan nursing students": This cross-sectional study of 308 nursing students in Meknes reported that smartphone addiction is a notable phenomenon in Moroccan medical university settings, with a prevalence of 41.2% (42.4% females, 39.5% males) with no significant gender differences. High rates of anxiety were also recorded, with 34.1% experiencing severe anxiety and 21.1% moderate anxiety. Multivariate statistical analysis showed anxiety as an independent factor associated with smartphone addiction (OR=1.33; 95% CI: 1.04–1.70; p=0.02), alongside living with

parents (OR=1.68; p=0.05) and morning phone use (OR=0.80; p=0.02). Results indicated that students with higher anxiety levels were more prone to digital addiction, with a strong statistically significant correlation between anxiety and addiction scores (p=0.000). The study concluded that the co-occurrence of anxiety and smartphone addiction places nursing students at psychological and behavioral risk, emphasizing the importance of raising awareness about rational device use and integrating psychological and social support programs in academic institutions to mitigate the negative impact on students' quality of life and academic performance.

-Study (Ramdani et al., 2024): "Internet addiction, social phobia, substance abuse, and depression in the university setting: a cross-sectional study in the southern region of Morocco":This study surveyed 1690 students from six universities in southern Morocco, finding an internet addiction prevalence of 30.6%. Severe depression symptoms appeared in 44.1% and social phobia in 30.2%, with half of the socially phobic students also addicted to the internet. A strong association between social phobia and high internet addiction scores was reported (OR=3.45, p<0.001), along with links between addiction and cocaine use, and the early onset of smoking. No significant association was found between depression symptoms and digital addiction. Researchers recommended multidisciplinary preventive strategies to monitor and support students regarding internet addiction and its psychological and social effects, focusing on early diagnosis and multidimensional intervention to reduce the behavior's impact on mental health and academic success.

-Study (Choujaa et al., 2023): "Problematic smartphone use among Moroccan medical students": This cross-sectional study conducted from October 2020 to March 2021 involved 878 medical and pharmacy students in Casablanca, highlighting the prevalence of smartphone addiction and related factors in Moroccan medical university settings. Addiction prevalence was 37.9% for both genders, with an average participant age of 22 years and majority Moroccan nationality (97.15%) and single status (94.76%). Females were more vulnerable to addiction than males. Previous psychological or medical history, concomitant psychoactive substance addiction (31.2% of addicts), and prior psychological treatment were all linked to higher digital dependency rates. Psychological indicators such as elevated anxiety, loss of control, withdrawal symptoms, and behavioral disturbances were more prominent than physical symptoms like neck and wrist pain. Univariate analysis showed addiction correlated statistically with less than five years of phone use and middle social class, while easy internet access alone was not a significant factor. A significant link was found between addiction and previous psychological treatment or prescribed psychiatric drugs. Smokers and substance users were more prone to addiction. The study highlighted the growing challenge faced by Moroccan medical education due to widespread smartphone use among students and its psychological, behavioral, and physical consequences. Researchers recommended further research on the long-term impacts of this behavior, especially as these students transition to professional medical environments, with a focus on awareness and early interventions to reduce digital dependency risks.

-Study (MomJunction, 2025): "10 Harmful Side Effects Of Mobile Phones On Teenagers": This research article reviews major physical and psychological harms associated with excessive and improper mobile phone use by teenagers. Key findings include musculoskeletal issues such as teen tendonitis and neck and back disorders, alongside increased rates of stress, anxiety, and depression among youth. Keeping phones near the bed negatively affects sleep quality and increases fatigue. Some studies indicated a potential link between excessive phone use and heightened risk of tumors such as acoustic neuroma, though more evidence is needed. Psychological effects highlighted include increased social anxiety and isolation, behavioral addiction to instant messaging, exposure to cyberbullying with psychological consequences like sadness, disinterest, sleep disturbances, and recurrent headaches, as well as risks of inflating one's self-image unrealistically and engaging in unrealistic obsessions influenced by online content. The article also associates excessive phone use with reduced physical activity, weight gain, poor health habits, and vision problems like digital eye strain. Practical recommendations for parents include setting usage limits, banning phone use while driving or immediately before sleep, and promoting physical and real-life social activities to maintain balanced psychological, physical, and social health among teenagers.

-Study (Han et al., 2023): "Digital Addiction and Related Factors among College Students": This cross-sectional study of 199 South Korean college students found digital addiction to be a rising phenomenon in university contexts. The mean digital addiction score was 54 out of 95, with no significant differences by gender or major. The study revealed a positive association between body dissatisfaction and higher addiction levels, with addiction indicators rising as dissatisfaction or obesity-related concerns increased. Additionally, there was a strong inverse correlation between time-management skills and digital addiction, where poor self-organization and low perseverance were linked to higher dependency. No significant association was found between general mental health (anxiety, depression) and digital addiction according to multiple regression analysis. The study recommended university interventions focus on enhancing time management and body image confidence among students to mitigate negative effects of excessive digital device use on academic achievement and mental health.

-Study (Fradkov, 2024): "Definition of Cybernetical Neuroscience": This study introduces a new scientific framework called "Cybernetical Neuroscience," which integrates principles of cybernetics (control and communication science) with mathematical modeling used in computational neuroscience. The field aims to study mathematical models of neural processes using cybernetic control and monitoring tools and examine their practical applications in brain understanding and stimulation. The paper reviews the development of computational neuroscience and biological models such as Hodgkin-Huxley, FitzHugh-Nagumo, and Hindmarsh-Rose, representing individual neuron or network behavior. Cybernetic neuroscience focuses on incorporating input/control variables and output/drives into these models to study external stimuli effects (e.g., electrical currents) and measurable physiological responses.

Key tasks in this field include:

-Analyzing conditions for brain-like behaviors such as synchronization and chaos in neural generation models;

-Designing control inputs to induce specific neural patterns;
-Estimating neural system states and conditions from real measurements;
-Classifying neural states and human intentions using AI and machine learning;
-Designing control algorithms ensuring effective interaction between neural systems and controllers (e.g., brain-computer interfaces).
The author explains model building for single neurons and large networks, emphasizing inclusion of inputs/outputs for optimal control and hypothesis testing in applied neuroscience. Examples include organizing and inducing synchronization or chaos, parameter estimation, AI applications, and neurofeedback using brain-computer interfaces to enhance neural responses via cybernetic circuits. The paper concludes that merging cybernetics and neuroscience opens new horizons for understanding and controlling brain behavior, outlining methodological paths crucial for applied research in neuroscience, artificial cognition, and smart prosthetics.

Summary and Critical Review

A review of previous research on digital dependency in the Moroccan context, such as studies by Sadiq et al. (2023), Archou et al. (2025), Choujaa et al. (2023), Ramdani et al. (2024), and others, shows a main focus on visible, direct dimensions of digital addiction—tracking its prevalence among students, linking it to sleep disorders or academic performance, and exploring psychological impacts like increased anxiety and depression. Many of these studies rely on behavioral scales and quantitative questionnaires to measure dependency levels, producing extensive digital data supporting hypotheses on the phenomenon's spread and severity, while revealing the vulnerability of young groups to contemporary digital system temptations.
However, most studies, even those claiming "neuro-cybernetic" or "multidisciplinary" approaches, remain largely one-dimensional, prioritizing psychological or social dimensions (e.g., anxiety, sleep quality, academic success, isolation) with limited, sporadic references to cybernetic or neural stimulation roles, without thorough analysis of the structural relation between neuroscience and digital cyberdynamics. For example, Archou et al. (2025) emphasize anxiety's intersection with smartphone addiction but do not deeply explore internal neural circuits or link these to phone usage patterns as interactive informational environments with strong feedback loops. Likewise, Sadiq et al. (2023) focus on digital behaviors' connection to sleep quality and academic achievement but do not provide an explanatory model relating neurostimulation and reciprocal cybernetic responses inside smart devices.
Non-Moroccan studies like Han et al. (2023) often add qualitative variables such as body image satisfaction or time management's relation to digital addiction, enriching the understanding angle, but their interpretations of brain and cyber mechanisms remain constrained to statistical correlations without detailed discussion of neural-cybernetic structural dimensions.
This methodological gap indicates a structural shortfall in hidden digital dependency research, where strict separation between psychological/social and neural/digital aspects weakens capacity to explore new dynamics characterizing the digital generation—particularly at the intersection of technological culture, algorithms, dopaminergic stimulation, and loss of self-regulation fueled by digital feedback systems (notifications, instant gratification, etc.).
Therefore, the importance of the current research contribution arises from advocating for interdisciplinary approaches combining computational neuroscience, cybernetics theory as per (Fradkov, 2024), and social psychology models (Ball-Rokeach & DeFleur, Griffiths, Katz et al.), enabling deep structural analysis of hidden digital dependency and tracking how psychological, biological, and cybernetic controls intersect to produce new digital behaviors in Moroccan society. Integrating this perspective is urgently needed not only to enhance research originality but also to provide scientifically and practically specialized insights capable of guiding preventive and educational policies and steering future neuro-cyber digital innovation research.

1.5.Study Problematic

Given the rapid penetration of digital technologies and the unprecedented spread of smartphones across various segments of Moroccan society, the phenomenon of smartphone dependency has become a subject of growing attention and concern at both individual and collective levels. It has been observed that intensive use of these devices is no longer limited to facilitating quick communication or daily tasks but often transforms into a repetitive behavioral pattern that may lead to excessive use affecting quality of life. This overuse is accompanied by numerous behavioral, psychological, and physical effects that many individuals within this social group may neither fully recognize nor understand the seriousness of, necessitating an examination of the causes, dimensions, and ways to address this dependency. The study thus raises a fundamental question: To what extent does excessive smartphone use impact the lifestyle and mental and physical health of a segment of Moroccan society, and how aware are they of the related cyber risks?

1.6.Study Questions

Based on the research objectives and the issue of hidden digital dependency among smartphone users, the study seeks to answer the following questions:
1-What is the prevalence of daily smartphone dependency among Moroccan users, and how is it distributed by age, gender, and educational level?
2-What is the nature of the relationship between smartphone usage intensity and manifestations of anxiety or stress when the phone is forgotten or lost?
3-To what extent does excessive smartphone use contribute to the emergence of concentration or sleep disorders among users?
4-How severe are the physical symptoms (such as headaches and eye strain) associated with continuous smartphone use?
5-What is the level of users' awareness of cyber risks (monitoring, privacy, hacking or fraud attempts) related to smartphones?

6-How does hidden digital dependency affect user behaviors (e.g., difficulty detaching from the phone during study/work or daily activities)?
7-What are the users' motivations and behaviors regarding controlling or reducing digital dependency, and what obstacles do they face in doing so?
8-What is the expected role of educational institutions and the government in raising awareness about digital overuse risks according to users' perspectives?

1.7.Study Hypotheses

1-There is a statistically significant relationship between the intensity of smartphone use and the level of hidden digital dependency among Moroccan users.
2-Excessive smartphone use contributes to an increased likelihood of sleep and concentration disorders among Moroccan users.
3-Statistically significant differences in the level of hidden digital dependency are attributable to demographic variables (age, gender, educational level).
4-Individuals with hidden digital dependency experience more physical symptoms (headaches, muscle or eye fatigue) compared to moderate smartphone users.
5-Levels of poor cybersecurity and privacy awareness increase proportionally with rising hidden digital dependency among smartphone users.
6-Users with high levels of hidden digital dependency exhibit greater difficulty in controlling or reducing their usage despite repeated attempts.

1.8.Study Methodology

The study adopted a descriptive-analytical approach aimed at describing and analyzing the phenomenon of hidden digital dependency among Moroccan smartphone users from all perspectives to answer the research questions, achieve its objectives, and test its hypotheses. To accomplish this, a survey method was employed through the design and development of a questionnaire as the primary data collection tool. This enabled the measurement of patterns and symptoms of digital dependency, its prevalence, and its psychological and behavioral determinants. The questionnaire was based on the latest scientific literature in digital psychology and neuro-cybernetic sciences and was rigorously reviewed by a panel of specialized referees for validation and accuracy. A pilot test was also conducted to ensure the instrument's reliability and its capacity to measure the study's multiple variables objectively and precisely.
The study also utilized statistical methods to process and analyze data collected via the questionnaire, relying on the specialized statistical software SPSS version 26. Various appropriate statistical techniques were applied, including frequency analysis and percentages to describe the sample's demographic characteristics, alongside calculating means and standard deviations to measure the level of digital dependency accurately and objectively.
This research is grounded in the theoretical framework of Cybernetical Neuroscience, a modern interdisciplinary field combining control and cybernetics sciences with computational brain sciences to analyze human behavior in digital environments. This framework enables understanding individual interactions with digital stimuli such as smartphones from an organizational and functional perspective, viewing the brain as a feedback-dependent processor that reshapes its reception and behavioral mechanisms in response to continuous digital stimuli(Fradkov, A.,2025; Benjamin, L., et al.,2020). The study also relies on computational neuroscience models explaining how digital usage intensity affects neural network patterns involved in learning, attention, and motivation, thereby elucidating the emergence of dependency patterns and associated psychological and behavioral difficulties(Ding, K., et al., 2023; Small, G. W., et al., 2020; Shanmugasundaram, M., & Tamilarasu, A.,2023; Lage Gonçalves, L., et al; 2023). Thus, this framework provides a comprehensive entry point to analyze digital dependency as an intersection of neural, psychological, and cybernetic factors in the context of contemporary societal transformations.

1.9.The theoretical analysis in this study integrates four main interpretive approaches:

1-Neuro-Cybernetic Perspective (Cybernetical Neuroscience): This perspective interprets the human brain's interaction with digital stimuli through advanced mathematical models that combine cybernetics principles (control, feedback loops, inputs, and outputs) with computational neural process modeling. It highlights the importance of studying how digital environments reshape brain reward and motivation pathways, enhancing physiological responses at a speed exceeding individual self-regulation capacity. This explains the emergence of hidden digital dependency without classic addiction markers (Fradkov, 2024; Ferrer-Pérez, C., 2024).
2-Media Dependency Theory: Proposed by Ball-Rokeach and DeFleur, this model explains the ascending relationship between an individual and digital media. As dependence on smartphones for knowledge, social interaction, or psychological escape increases, individuals become more vulnerable to self-control loss (Ball-Rokeach & DeFleur, 1976). In the Moroccan context, hidden digital dependency results from the interaction of basic needs with engagement strategies imposed by the networked digital environment.
3-Behavioral Addiction Model: This model (Griffiths, 1996; Brand et al., 2019) provides a psychoneurological explanation for digital dependency phenomena, focusing on immediate reinforcement mechanisms ("instant feedback") and the impact of digital algorithms in producing compulsive behaviors. It illustrates how repeated reward stimuli amplify neural excitation (dopaminergic) making addictive behavior more covert and intrusive in daily life.
4-Uses and Gratifications Theory: This approach is based on the idea that individuals turn to smartphones driven by motives such as social integration, information gratification, or escaping contemporary psychological anxieties. The theory explains how these motives become routine habits linked to neural stimulation, contributing to stabilizing patterns of hidden digital dependency(Katz et al., 1973; Sichach, M., 2023; Wei, D., 2024).

Summary Synthesis: The framework merges the neuro-cybernetic explanation of immediate brain operation patterns within a dynamic digital environment (Fradkov, 2024) with psychological and sociological characteristics of dependency as explained by Media Dependency Theory (Ball-Rokeach & DeFleur, 1976), the Behavioral Addiction Model (Griffiths, 1996), and Uses and Gratifications Theory (Katz et al., 1973). This integration allows a deeper understanding of the structural and contextual causes of hidden digital dependency in Moroccan society, where individual motives (need for belonging, instant rewards, self-regulation, anxiety, and stress) intersect with cybernetic factors (app design, algorithms, real-time notifications).

Importance of the Neuro-Cybernetic Theory in the Study

The neuro-cybernetic theory provides an advanced analytical framework for understanding the precise mechanisms leading to hidden digital dependency amid intense daily engagement with smartphone environments. It goes beyond viewing digital behavior as a mere habit or superficial social phenomenon to delve into the neural processes influenced by a continuous stream of digital stimuli, such as instant alerts, nonstop information flow, and immediate app responses. This theory explains how ordinary smartphone use gradually transforms into a dependency that may not be superficially noticeable but is biologically and psychologically entrenched due to activation of brain reward and motivation circuits, generating patterns of instant gratification and unconscious reinforcement(Chóliz, M., 2010; Hartogsohn, I., & Vudka, A., 2022).

Moreover, the neuro-cybernetic perspective links external digital environmental inputs (app policies, interaction algorithms, user interface design) with internal brain and central nervous system responses, forming a continuous, interactive feedback loop between human and device. The effects extend beyond behavior to mood regulation, self-control, attentional focus, and emotional management (Korte, M., 2020; Wells, A.,2019; Han, S. W., & Kim, C. H., 2022).

This analytical framework enables studying the human brain's adaptability and reshaping of behavior under a volatile, fast-paced digital environment. It also facilitates analyzing the specificity of the Moroccan context, where cultural, social, and cognitive factors intertwine with neuro-cybernetic components to produce a distinct form of hidden digital dependency that may be more elusive and challenging to detect and address.

Finally, the theory allows proposing scientific and educational interventions grounded in a deep understanding of neuro-cybernetic circuits, directing efforts toward developing digital self-regulation skills, controlling environmental stimuli, and modifying app designs to reduce the dominance of hidden digital dependency while promoting the psychological and social well-being of users, especially youth and students in Moroccan society.

2.Study Population and Sample

The study population in this research consisted of a group of Moroccan individuals who use smartphones, drawn from diverse social and cultural backgrounds across the national territory, without restricting by age or specific educational level. This was intended to create a more comprehensive picture of the hidden digital dependency phenomenon on smartphones within Moroccan society. Due to the large population size and a commitment to achieving statistical representation fairness, a simple random sampling method was used. The sample included various age groups ranging from under twenty years old to over forty years, with careful consideration of gender distribution between males and females.

The study sample also featured clear diversity in educational levels, including participants who were non-enrolled in formal education, those holding primary and middle school certificates, as well as secondary, university, and higher education degree holders. This diversity enabled examination of variables related to hidden digital dependency in relation to age, gender, social, and educational contexts.

The final sample size comprised 400 individuals selected randomly who voluntarily agreed to complete the electronic questionnaire and met all research requirements, enhancing the objectivity of the results and their generalizability at the national level. Table 1 illustrates the demographic and social characteristics of the surveyed sample according to age, gender, and educational level variables.

Table 1: Distribution of Sample Individuals According to Personal Variables

Variable	Level	Frequency	Percentage
Gender	Female	230	57.5%
	Male	170	42.5%
Age	Under 20 years	117	29.25%
	20 to 30 years	78	19.5%
	30 to 40 years	81	20.25%
	Over 40 years	124	31%

Variable	Level	Frequency	Percentage
Educational Level	Non-enrolled	2	0.5%
	Primary	75	18.75%
	Middle school	35	8.75%
	Secondary	52	13%
	University	89	22.25%
	Higher education	147	36.75%
Total		400	100%

2.1.Study Tool: The study relied on a questionnaire as the main tool to collect data from the sample individuals, due to its ability to objectively and accurately measure psychological and behavioral dimensions in field studies. The questionnaire was designed to include comprehensive sections covering demographic data, smartphone usage patterns, and the number of usage hours, in addition to indicators of psychological and behavioral symptoms related to hidden digital addiction, as well as the level of cybersecurity awareness and digital security among the respondents. The questionnaire also included questions about attempts at self-regulation of usage, proposed solutions to reduce dependency, along with participants' opinions on the importance of digital awareness campaigns.
The researcher ensured the instrument was reviewed and validated by specialists to confirm the clarity and comprehensiveness of the items, then conducted a pilot test to verify the reliability and validity of the questionnaire before distributing it electronically to the targeted sample, ensuring ease of participation and data privacy.
2.2.Statistical Measures: The study data were processed and analyzed using the statistical analysis software SPSS version 26. Descriptive statistics such as frequencies, percentages, means, standard deviations, and others were used to describe the characteristics of the sample and to observe response patterns related to hidden digital addiction. This approach enhanced the reliability of the results and ensured their scientific interpretation according to the standards adopted in modern field studies.

3.STUDY RESULTS ANALYSIS

3.1.Daily smartphone usage patterns and number of hours: Studying the relationship between age and the daily number of hours spent using smartphones is an important topic that reflects the impact of technology on different lifestyle patterns of individuals. In this study, data obtained from the questionnaire form were analyzed to determine the extent of correlation between the amount of time people spend on their smartphones and different age groups. This analysis provides a clear insight into how phone usage behavior differs across ages, helping to understand usage trends and their potential impacts on psychological, physical, and social health. Below is a detailed presentation of the research steps and the results that highlight this important statistical relationship.
3.1.1.Statistical relationship between age and daily number of hours using smartphones: A study was conducted to analyze the relationship between age and the number of hours individuals spend daily on their smartphones, using the Chi-Square test. This test is a statistical method used to examine the association or correlation between two categorical variables by comparing the observed data distribution to the expected distribution under the null hypothesis. The test aims to determine whether there is a statistically significant relationship between the two variables. The study yielded the following results:

(table 2): The table below summarizes the cross-tabulation between participants' age and the number of daily hours spent on smartphones:

Participant Age	**Less than 1 hour**	**Between 1 and 3 hours**	**Between 3 and 6 hours**	**More than 6 hours**	**Total**
Under 20 years	1	4	21	91	117
Between 20 and 30	1	19	40	18	78

Participant Age	Less than 1 hour	Between 1 and 3 hours	Between 3 and 6 hours	More than 6 hours	Total
Between 30 and 40	5	43	21	12	81
Over 40 years	8	66	35	13	122
Total	15	132	117	134	398

Table (3): Chi-square Test Results

Test	Value	Degrees of Freedom (df)	Significance (p-value)
Pearson Chi-Square	182.756	9	0.000
Likelihood Ratio Test	189.791	9	0.000
Linear-by-Linear Association	131.973	1	0.000

-Number of valid observations: 398
-Note: 4 cells (25.0%) have an expected count less than 5, with the minimum expected count being 2.94.

Interpretation of Results: The analysis of the relationship between age and the daily number of hours spent using smartphones indicates a strong and highly statistically significant association (Chi-square test = 182.756, degrees of freedom = 9, $p < 0.001$). The detailed distribution shows that the youth category under 20 years old is the most dependent on smartphones, with 91 out of 117 participants in this age group spending more than 6 hours daily on their smartphones. Conversely, this percentage decreases significantly with age, as the group over 40 years old has only 13 participants in the heavy usage category (>6 hours).

This distribution suggests that excessive digital dependency tends to be more prevalent among younger individuals, which can be explained from a neuro-cybernetic perspective: the reward system in young people's nervous systems is more active and sensitive to digital stimuli, promoting prolonged use and frequent interaction with smart devices. In contrast, older adults exhibit greater capacity for controlling and regulating their phone usage time, reflecting greater maturity in neural pathways associated with executive control (Brand, et al., 2014; Steinberg, L., 2010, Karabey, S. C., et al., 2024).

An important caveat to consider is that 4 cells, representing 25% of the table cells, have an expected count below 5, which is the minimum recommended for the Chi-square test to ensure the validity of the results. This calls for caution in overgeneralizing the findings and may require conducting additional studies or adjusting analytical methods to avoid the impact of these cells on the accuracy of the conclusions. However, this limitation does not diminish the strong statistical significance of the results.

Therefore, these findings highlight the importance of focusing preventive and awareness interventions on the younger age group regarding digital dependency. It is also essential to integrate a neuro-cybernetic perspective to understand the neural mechanisms underpinning this behavior, which would enhance the effectiveness of research and therapeutic strategies in the Moroccan context.

Table (4): Pearson Correlation Results between Participant Age and Daily Hours of Smartphone Use

Variable	Participant Age	Daily Hours on Smartphone
Participant Age	1	-0.577**
Significance (2-tailed)	—	0.000
N (Sample size)	400	398
Daily Hours on Smartphone	-0.577**	1

Variable	Participant Age	Daily Hours on Smartphone
Significance (2-tailed)	0.000	—
N (Sample size)	398	398

****Correlation is significant at the 0.01 level (2-tailed).**

Interpretation of the Pearson Correlation Test Results between Age Groups and Daily Hours of Smartphone Use:

-The value of 1 for participant age with itself means that age is perfectly correlated with itself, which is expected since a variable is always fully correlated with itself.

-The Pearson correlation coefficient of -0.577 between age and daily hours of smartphone use indicates a moderate to strong negative linear relationship, meaning that the time participants spend on their smartphones decreases as age increases.

-The significance value (Sig.) of 0.000 indicates that this relationship is highly statistically significant (less than 0.01), meaning the probability of this result occurring by chance is very low, confirming the reliability of the finding.

-The sample size of approximately 398-400 participants reflects a large sample, which enhances the study's strength and the reliability of the results.

This analysis indicates a clear statistical relationship between age and the duration of daily smartphone use, with younger age groups relying more heavily on smartphones compared to older ones. It also highlights the importance of considering age as a factor in studies examining the impact of smartphone usage, as the average usage varies significantly across age groups and decreases with age. These findings are valuable for social, psychological, and health-related research concerning digital use and its effects on different age demographics.

3.1.2.Statistical Relationship between Educational Level and Daily Hours of Smartphone Use:

A study was conducted to analyze the relationship between educational level and the number of hours individuals spend daily on their smartphones, using the Chi-Square test. This test is a statistical method used to examine the association between two nominal or categorical variables by comparing the observed data distribution to the expected distribution under the null hypothesis. The goal is to determine whether there is a statistically significant relationship between educational level and smartphone usage patterns. The study yielded the following results:

Table (5): Summary Table of the Cross-Tabulation between Educational Level and Daily Hours Spent on Smartphones

Educational Level	Less than 1 hour	Between 1 and 3 hours	Between 3 and 6 hours	More than 6 hours	Total
Illiterate	0	1	0	1	2
Primary	2	17	24	31	74
Intermediate	3	11	8	13	35
Secondary	2	23	12	14	51
University	4	24	20	41	89
Higher Education	4	56	53	34	147
Total	15	132	117	134	398

Test	Value	Degrees of Freedom (df)	Approximate Significance (2-tailed)
Pearson Chi-Square	26.679	15	0.031
Likelihood Ratio	27.035	15	0.028
Linear-by-Linear Association	3.744	1	0.053

Test	Value	Degrees of Freedom (df)	Approximate Significance (2-tailed)
Valid Observations	398		

Note: 8 cells (33.3%) have an expected count less than 5, with the minimum expected count being 0.08.

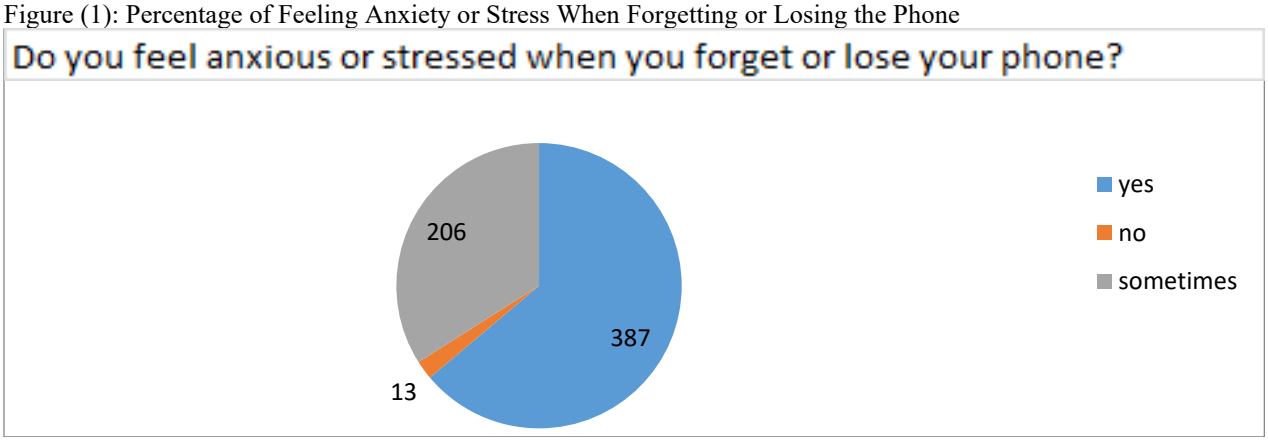
3.1.3.Interpretation of the Correlation Test Results between Educational Level and Daily Hours Spent on Smartphones: The analysis of the relationship between educational level and daily hours spent on smartphones indicates a statistically significant association ($P = 0.031 < 0.05$) based on the Chi-Square test, confirming that educational level has a tangible effect on smartphone usage patterns. The data show that the university and higher education groups contain the largest number of users spending more than 6 hours daily on their phones, with counts of 41 and 34 respectively, reflecting a higher likelihood of digital dependency among them. However, there is also a considerable number of primary education users (31 individuals) in the intensive usage category, indicating that the phenomenon of digital dependency spreads across different educational levels. This aligns with neuro-cybernetic hypotheses that dependency is not confined to specific groups but may arise from multiple factors linked to continuous digital activity and complex interactions with smartphone platforms (Tymofiyeva, O., 2020).

It is important to note that a sizable proportion of cells (33.3%) have an expected count less than 5, which necessitates caution when generalizing the results and calls for complementary studies using more appropriate statistical tools or larger samples. Overall, these results emphasize the need to consider qualitative differences in digital dependency according to educational contexts and levels of digital awareness, as well as the importance of incorporating the neuro-cybernetic dimension to understand the underlying mechanisms of intensive use and digital obsession in Moroccan society.

3.2.Neuropsychological indicators

3.2.1.The level of anxiety or stress when forgetting or losing a smartphone

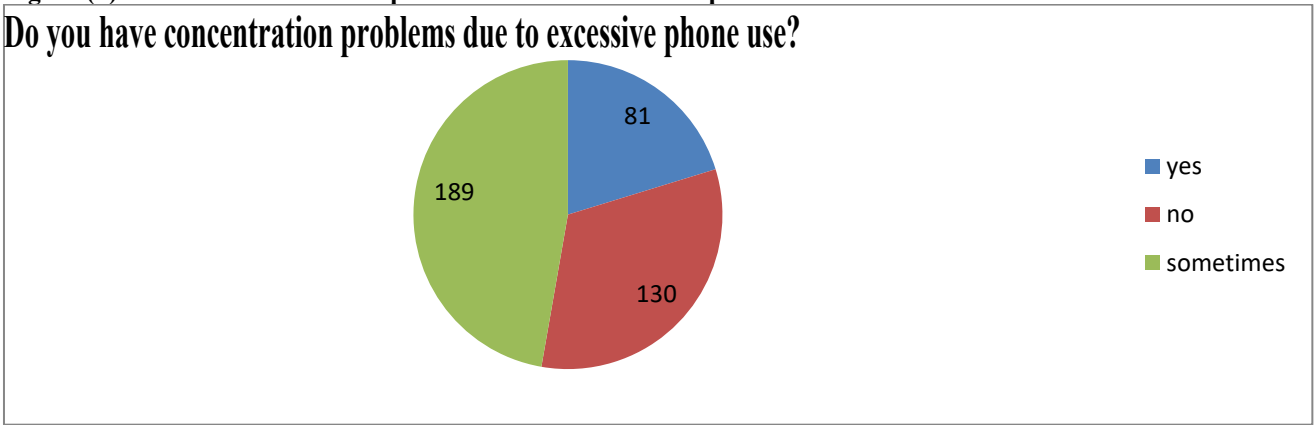
Figure (1): Percentage of Feeling Anxiety or Stress When Forgetting or Losing the Phone



An analytical study was conducted on the "level of anxiety or stress when forgetting or losing a smartphone" using field survey data from Moroccan users. The results showed that the vast majority of participants experience anxiety or stress to varying degrees when forgetting or losing their phone: 66.17% of participants reported feeling anxious or stressed sometimes, 27.32% feel this way always, and only 6.52% do not feel anxious or stressed at all. These results reflect the significant psychological and neurological dependence on smartphones in the daily lives of Moroccan users, where forgetting or losing the phone is a notable source of anxiety for them. This level of anxiety can be considered a sign of hidden digital dependence that may require deeper study and reflection on the effects of intensive smartphone use on users' mental health and behavior.

3.2.2.The spread of concentration problems associated with excessive phone use

Figure (2): The effect of excessive phone use on concentration problems

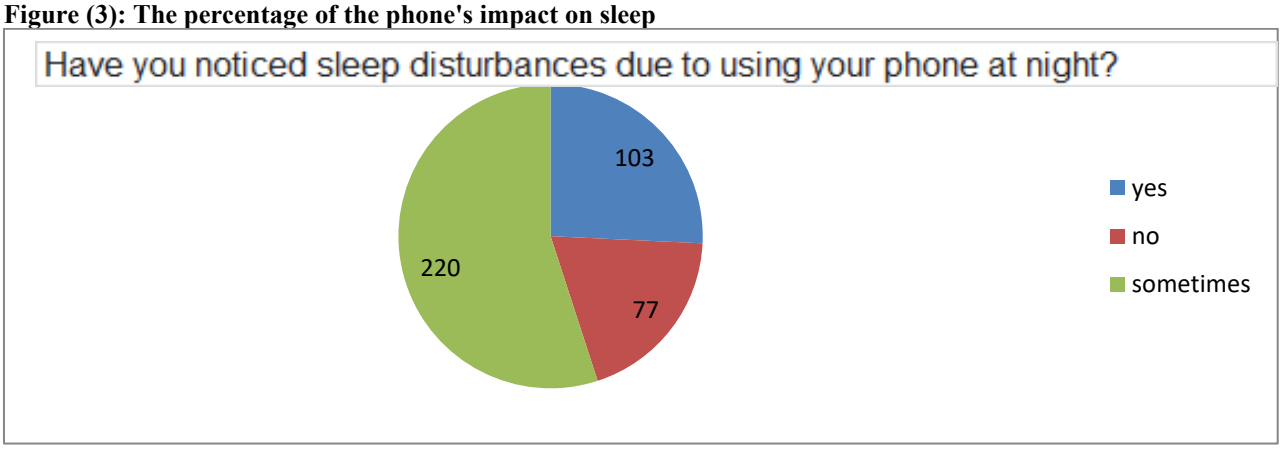


The chart shows that 47.3% of participants sometimes experience concentration problems due to excessive use of smartphones, while 20.3% reported ongoing issues with this problem. Meanwhile, 32.5% denied any impact on their

concentration. These results reflect a clear neurological and behavioral effect of hidden digital dependency on users, as the high percentage of partial or continuous suffering indicates that excessive smartphone use actually affects the ability to concentrate. This calls for attention to improving usage management and adopting strategies to reduce its negative effects amid the growing reliance on digital technology.

3.2.3.Monitoring sleep disorders caused by using the phone at night

Figure (3): The percentage of the phone's impact on sleep

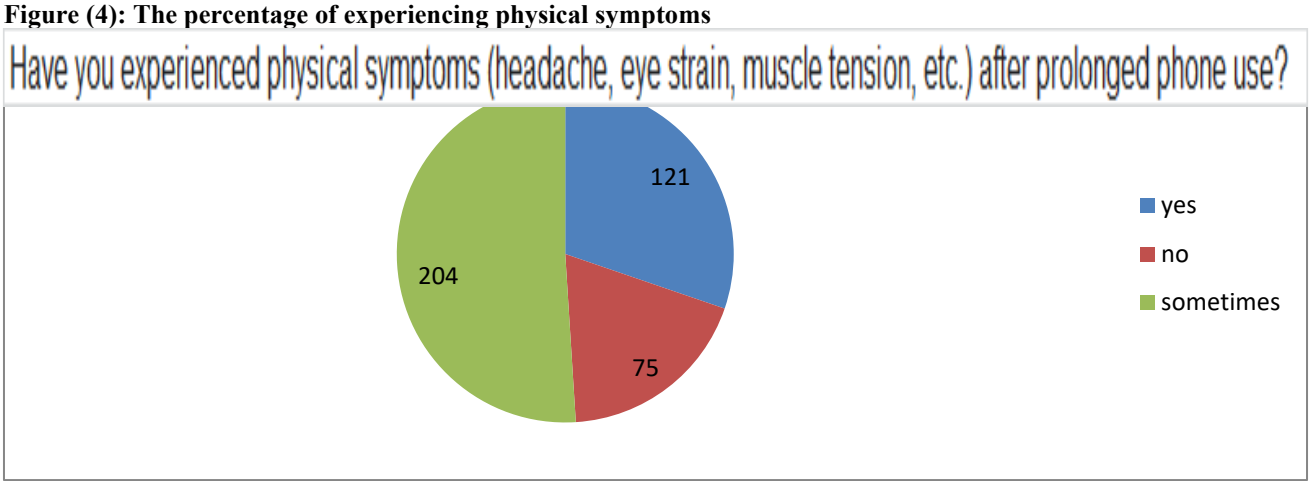


The chart shows that 55% of participants sometimes notice sleep disturbances due to phone use, while 25.8% reported experiencing clear sleep disorders, and 19.3% denied any disturbances. These percentages reflect that more than two-thirds of the participants suffer from a negative impact of smartphone use on their sleep, indicating a strong link between digital dependency, especially phone use before bedtime, and sleep problems and disorders.

This aligns with research showing that prolonged exposure to phone screens, especially before sleep, affects sleep quality and increases levels of nervous tension. This falls within the neurological aspects of hidden digital dependency, which is the focus of this study (Arshad, D., et al., 2021; Li, J., & Yang, H.,2024; Zhao, C., et al, 2024). Therefore, it is essential to recognize these effects and work on reducing phone exposure during pre-sleep hours to promote healthy sleep and psychological well-being.

3.2.4.The appearance of physical symptoms (headache, eye fatigue, muscle tension, etc.) after prolonged phone use

Figure (4): The percentage of experiencing physical symptoms



The survey results indicate that the vast majority of Moroccan users (51%) sometimes experience physical symptoms such as headaches, eye fatigue, and muscle tension after prolonged smartphone use, while 30.3% suffer from these symptoms continuously. This shows that digital dependency is not limited to psychological effects but also extends to physical and health-related aspects. These indicators reflect a state of hidden digital dependency that leads to frequent and multi-dimensional strain, affecting users' quality of life. This underscores the importance of adopting preventive and educational strategies that focus on raising awareness about digital health and modifying usage behaviors, taking into account both neurological and physical aspects within a comprehensive approach that combines the neurological and cyber dimensions of the study.

To confirm the above, the means and standard deviations were calculated to assess the neurological and psychological indicators in the studied sample, with the results as follows:

Table (6): Means and standard deviations for the evaluation of neurological and psychological indicators in the studied sample

Question	Always (%)	Sometimes (%)	Never/No (%)	Average	Standard Deviation	Index Value	Index Classification
Do you feel anxious or stressed when you forget or lose your phone?	27.3	66.2	6.5	3.20	0.65	0.80	High
Do you have concentration problems due to excessive phone use?	20.3	47.3	32.5	2.56	1.03	0.64	Medium
Have you noticed sleep disturbances as a result of using your phone at night?	25.8	55	19.3	2.84	0.87	0.71	Medium
Have you experienced physical symptoms (headache, eye strain, muscle tension...) after long phone use?	30.3	51	18.8	2.91	0.89	0.73	Medium

Interpretation of the results: Participant responses were coded based on the frequency of the feeling or condition asked about, with "Always" assigned a value of 4, "Sometimes" a value of 3, "Rarely" a value of 2, and "Never" a value of 1. Based on this coding, the average score for each indicator was calculated by multiplying the coded value by the percentage of participants who selected each response, then summing the results to provide a value representing the intensity or frequency of the phenomenon in the group. Additionally, the standard deviation was calculated to show the dispersion or consistency of responses around this average, where a higher standard deviation indicates greater variability in participants' opinions.

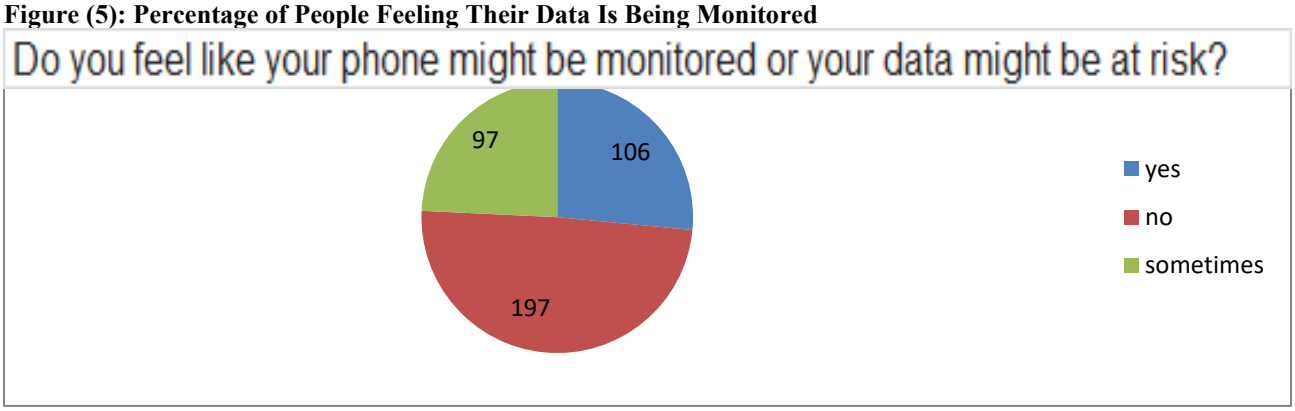
The study results, involving about 400 participants, indicate clear effects of mobile phone use on mental, neurological, and physical health. The average anxiety and stress indicator related to forgetting or losing the phone was 3.20 out of 4 (converted to 80 out of 100), with a relatively low standard deviation reflecting limited dispersion, indicating widespread prevalence of this psychological problem. Regarding concentration problems due to intensive use, the indicator was 64 out of 100 with moderate variability in responses, as 67.6% of participants reported difficulties concentrating always or sometimes. Similarly, a sleep disturbance indicator associated with nighttime phone use was recorded at 71 out of 100, with a high average and moderate standard deviation attributed to exposure to blue light and accompanying mental activities, affecting over 80% of participants. Finally, the physical symptoms indicator related to prolonged use increased to 73 out of 100, with symptoms such as headache, eye strain, and muscle tension reported by more than 81% of the sample, with variation in severity levels among participants.

These results highlight the importance of adopting preventive and awareness strategies to reduce the psychological, neurological, and physical harm caused by intensive mobile phone use, especially amid increasing reliance on digital technology in daily life.

3.3.Cyber and Behavioral Threats

3.3.1.Feeling of Surveillance or Risk to Personal Data

Figure (5): Percentage of People Feeling Their Data Is Being Monitored

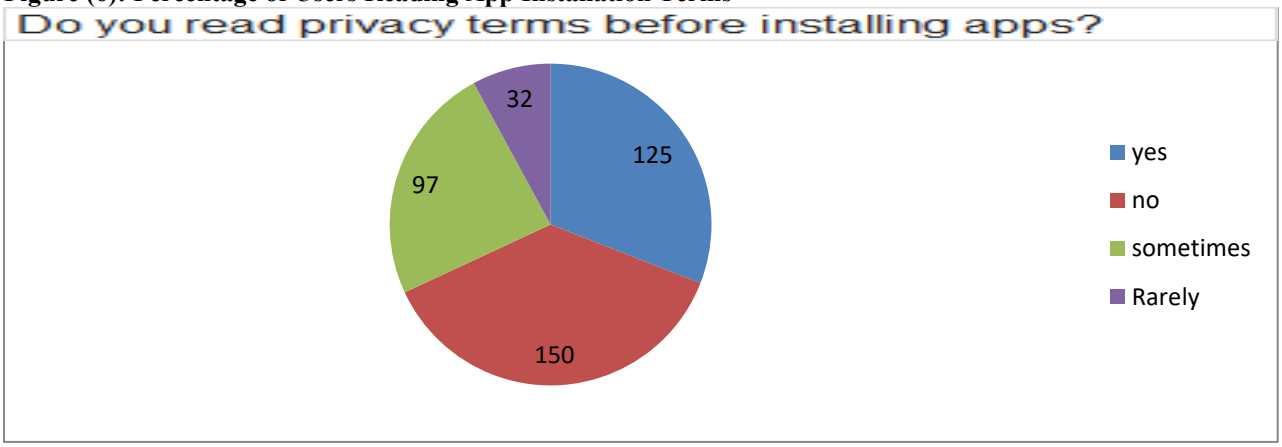


The survey results regarding users' feelings of being monitored or their digital data being at risk indicate a varied awareness of digital privacy risks. About half of the participants do not feel this risk, while a significant portion

sometimes or always feel concerned. This varied awareness reflects the importance of phones in our daily lives and highlights concerns related to digital security and privacy. While people benefit from phone technologies, they simultaneously experience a degree of stress or anxiety both from losing their phone and from the risks of data tracking. This points to an urgent need to enhance security awareness, privacy protection, and personal data safeguarding to ensure safe usage and greater peace of mind for users. Overall, heavy reliance on phones is accompanied by a dual anxiety: worry about losing the device and worry about data exposure risks.

3.3.2.Extent of Reading Privacy Policies Before Installing Apps

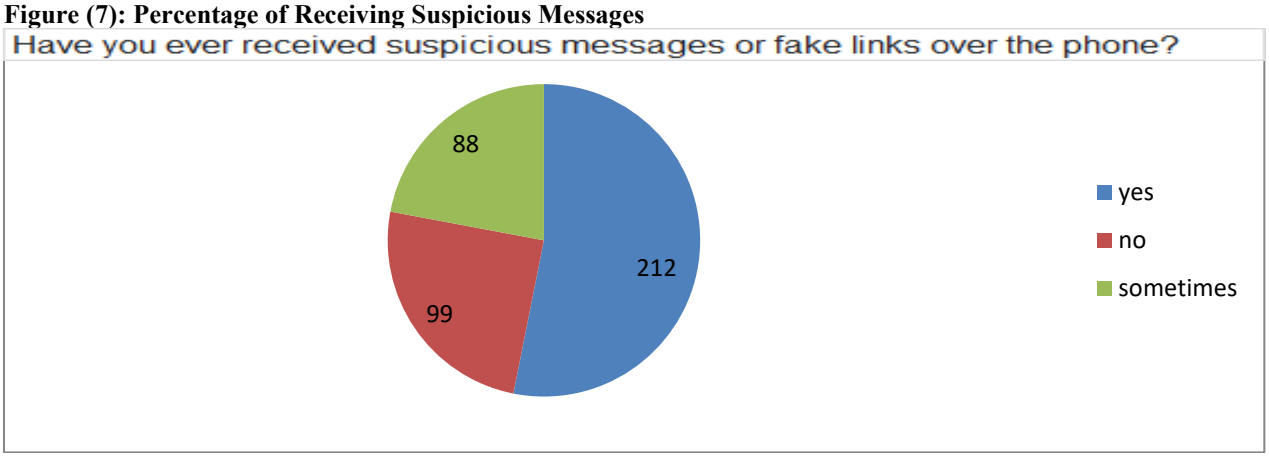
Figure (6): Percentage of Users Reading App Installation Terms



The survey reflects that users' awareness of the importance of protecting their digital data remains insufficient, with a large proportion either not reading privacy terms or doing so only intermittently. This lack of attention and awareness represents an aspect of hidden digital dependence, as users rely daily on smartphones to meet their digital needs while ignoring the real risks associated with app usage and their personal data. From a neuro-cyber perspective, this pattern can be interpreted as a result of users' neurological and cyber adaptation to technology, where interacting with the phone becomes almost automatic without full awareness of the risks. This reinforces an invisible dependency that may increase digital anxiety or stress when faced with privacy issues or phone loss. Therefore, the study emphasizes the importance of integrating security and digital privacy awareness into strategies addressing digital dependency, through a deeper understanding of the effects of this relationship on users' mental and psychological behaviors within the Moroccan context.

3.3.3.Frequency of Receiving Suspicious Messages or Fake Links via Phone

Figure (7): Percentage of Receiving Suspicious Messages



The survey results regarding habits of reading privacy policies before installing apps indicate a clear weakness in Moroccan users' awareness of the importance of protecting their personal data. A large proportion either do not pay sufficient attention to these terms or read them only intermittently or rarely. This behavior reflects an aspect of hidden digital dependency, where users' brains and neuro-cyber systems rely almost automatically on smartphones without full awareness of the risks related to privacy and digital security. The results illustrate how intensive smartphone dependence is associated with a decline in conscious insight behaviors toward privacy terms, increasing psychological vulnerability and digital stress linked to a feeling of loss of control over personal data.

The study highlights the need to enhance security and digital privacy awareness not only at the cognitive level but also through understanding the neuro-cyber effects of this dependency. This calls for developing strategies that support safe and responsible smartphone use and reduce the negative psychological impacts of hidden digital risks faced by Moroccan users.

To confirm this, means and standard deviations were calculated to assess cyber and behavioral threats in the studied sample, with results shown as follows:

Table (7): Means and Standard Deviations for Assessing Cyber and Behavioral Threats

Question	Always (%)	Sometimes (%)	Never/No (%)	Average	Standard Deviation	Indicator Value	Indicator Classification
Do you feel that your phone might be monitored or that your data is at risk?	26.5	24.3	49.3	1.28	1.31	0.43	Medium
Do you read the privacy terms before installing apps?	31.4	30.9	37.7	1.56	1.28	0.52	Medium
Have you ever received suspicious messages or fake links via phone?	53.1	22.1	24.8	2.03	1.00	0.68	High

The table was created based on participants' responses to three main questions regarding cyber threats and digital behaviors related to mobile phone use. For quantitative analysis, the available response options were divided into three main categories: "Always" (Yes), "Sometimes" (which includes the "Rarely" category merged with Sometimes for simplification), and "Never/No." These categories were numerically coded with values to facilitate calculation: the "Always" category was assigned 3 points, "Sometimes" 2 points, and "Never/No" 0 points.

Using these values, the average score for each question was calculated by multiplying the number of responses by the assigned point value for each category, then dividing the total points by the total number of responses. For example, for the question "Reading privacy terms before installing apps," the combined percentage of "Sometimes" and "Rarely" was 30.9%. We multiplied the proportions of each category by the number of respondents to obtain actual counts, then calculated the average score, which reached 1.56 points.

The standard deviation was also calculated to assess the dispersion of responses around the mean for each question, indicating the variability of participants' experiences or perceptions. Then, the average score was divided by the maximum points (3) to calculate an "indicator value," representing a relative scale between 0 and 1. Based on this, the indicator was classified as low (below 1), medium (1–2), or high (above 2).

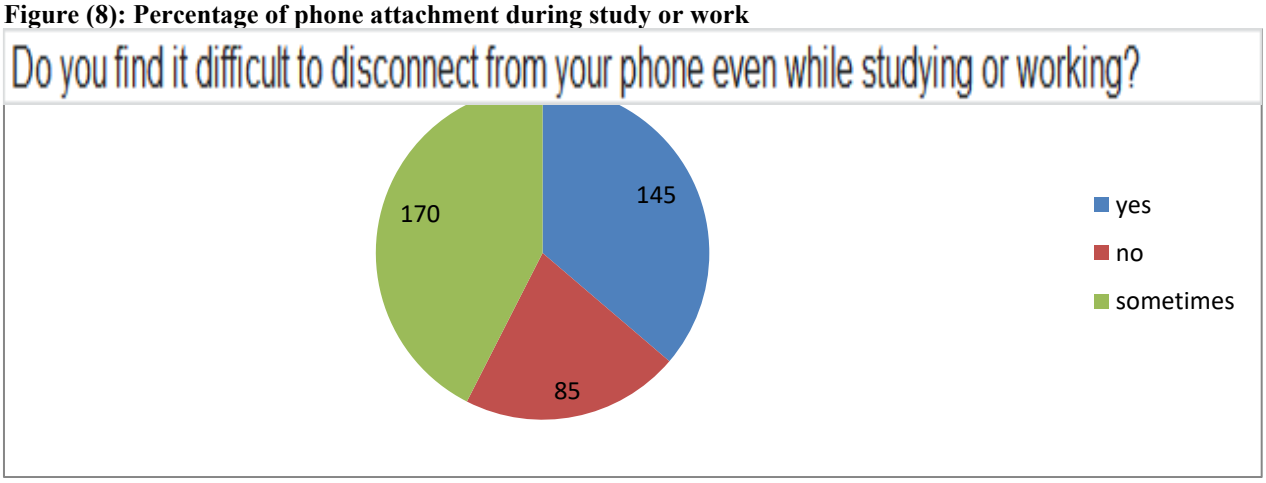
The results indicate that users' concern about their phones being monitored or their data being hacked has a medium indicator value (0.43), reflecting limited but not complete awareness of cyber risks. At the same time, reading privacy terms shows a medium indicator as well (0.52), suggesting a moderate level of attention to privacy protection. Conversely, a high indicator value for exposure to suspicious messages and links (0.68) highlights the actual vulnerability of users' digital security in cyberspace, with significant exposure to direct threats.

These analyses emphasize the need to enhance cybersecurity and digital awareness, not only in understanding risks but also in applying effective protective practices, to reduce exposure to direct cyber threats and preserve the privacy and safety of user data in a continuously evolving digital environment.

3.4.Digital Dependence and Compulsive Behavior

3.4.1.Difficulty in disconnecting from the phone during study or work

Figure (8): Percentage of phone attachment during study or work

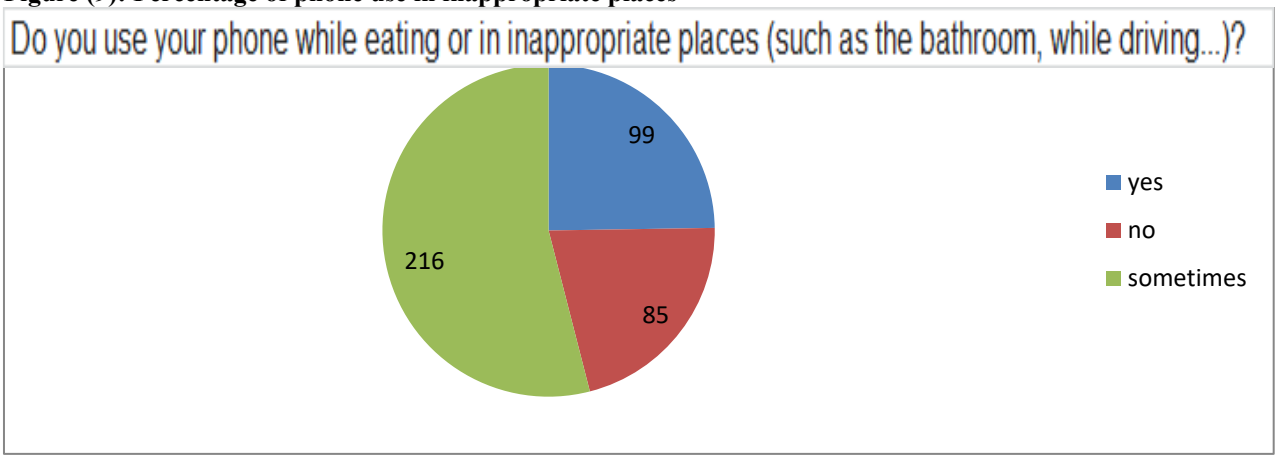


The attached survey results reveal an aspect of hidden digital dependence among smartphone users in Morocco, where the data indicates that a large proportion of participants (about 36.3%) find it difficult to disconnect from their phones even during study or work. Meanwhile, 42.5% report intermittent or "sometimes" difficulty with the same issue, compared to only 21.2% who do not face this problem. This indicator reflects the deep and unspoken connection between users and their smartphones, which is a concerning phenomenon within the topic of hidden digital dependence. The smartphone, due to its constant network access and neuro-cyber features, creates a state of psychological and functional

attachment that drives the user to continue interacting with it even during times requiring focus and productivity, such as study and work. This affects individual performance and deepens the cycle of unconscious digital dependence among Moroccan users.

3.4.2.sing the phone in inappropriate places and contexts (eating, restroom, driving, etc.)

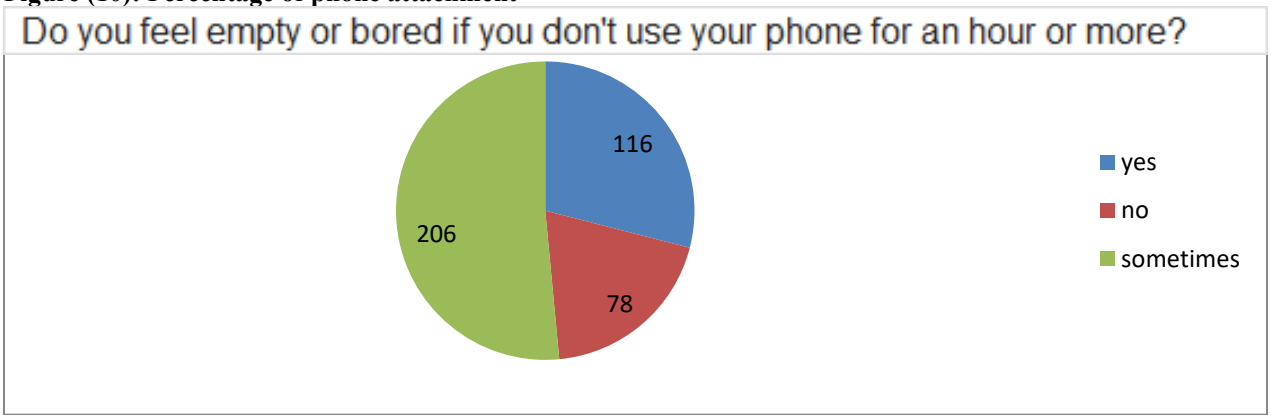
Figure (9): Percentage of phone use in inappropriate places



The results of this chart reflect an aspect of hidden digital dependence among smartphone users in Morocco, showing that a large proportion of them use their phones while eating or in inappropriate places such as the restroom or while driving. According to the data, 54% of participants admit to using their phones "sometimes" in such situations, while 24.8% answer "yes" to using their phones at these moments, and 21.2% deny it. This behavior reflects the deep integration of smartphones into users' daily lives and highlights digital dependence that can become unconscious at times. Smartphones are no longer just communication tools but have turned into part of daily habits that may jeopardize personal safety or privacy, such as usage while driving or in sensitive places. Therefore, this indicator forms an important part of the study focusing on hidden digital dependence among Moroccan users, as continuous use and digital escape subtly influence their daily behaviors.

3.4.3.Feeling empty or bored when away from the phone for an hour or more

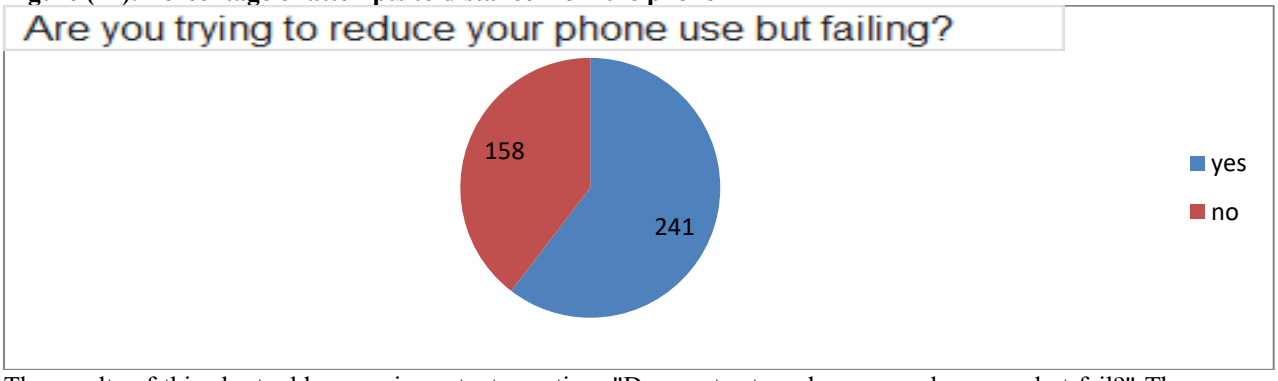
Figure (10): Percentage of phone attachment



The data shows that 51.5% of participants sometimes feel empty or bored if they do not use their phone for more than an hour, 29% clearly feel this way, while 19.5% do not experience it. This reflects hidden digital dependence, where the phone becomes a central part of daily interaction for Moroccan users, illustrating its neuro-cyber impact in creating a continuous need for communication and usage.

3.4.4.Attempts to reduce phone usage and the level of success or failure in doing so

Figure (11): Percentage of attempts to distance from the phone



The results of this chart address an important question: "Do you try to reduce your phone use but fail?" The answers confirm the presence of a certain level of dependence, as 60.4% of participants attempted to reduce phone usage but were

unsuccessful, while 39.6% either did not try or did not fail. This highlights a significant aspect of hidden digital dependence: users are aware of their need to limit phone use, but the psychological or neuro-cyber attachment to the smartphone prevents them from doing so. In other words, it indicates a real difficulty in controlling usage, reinforcing the hypothesis that smartphones have become an integral part of Moroccan users' daily lives. This challenge is evident in their failed attempts to reduce electronic dependence. This reflects the neuro-cyber dimension of the field study, which aims to understand the mechanisms of this hidden digital dependence and its impact on daily user behavior.
The aggregated data from the survey indicates that digital dependence on smartphones among Moroccan users is a compulsive behavioral pattern manifested in difficulty disconnecting from the phone, the urgent need to use it in inappropriate situations, feelings of emptiness and boredom when not using it, and failed attempts to reduce usage. The responses were coded into quantitative values to calculate the mean and standard deviation, allowing the measurement of the strength and variability of dependence among individuals.

Table (8): Means and standard deviations evaluating phone dependence and its impact on daily behavior in the studied sample of Moroccans

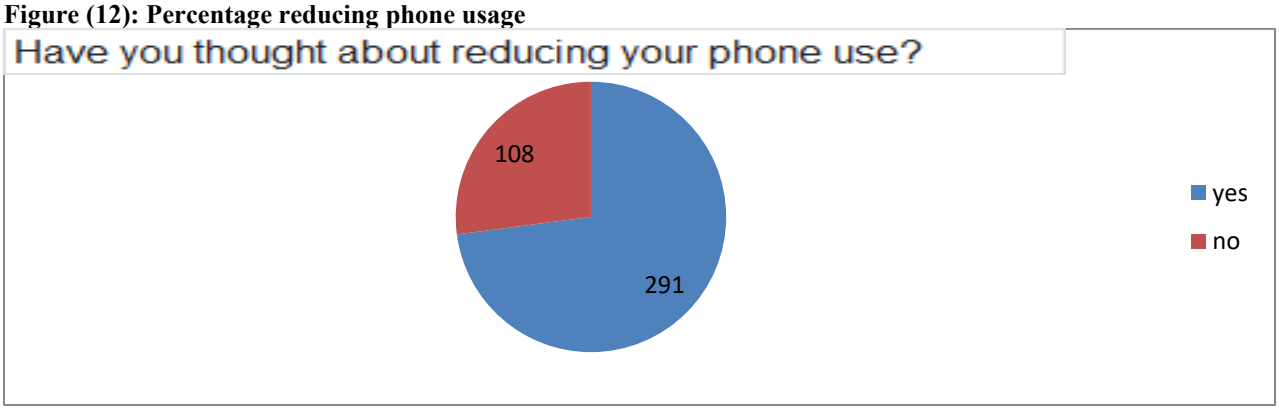
Question / Aspect	Yes (4)	Sometimes (3)	No (1)	Mean	Standard Deviation	Brief Interpretation
1. Do you find it difficult to disconnect from the phone during study or work?	36.3%	42.5%	21.2%	2.94	1.10	Clear psychological dependence with moderate individual variation.
2. Do you use the phone while eating or in inappropriate places?	24.8%	54%	21.2%	2.82	1.03	Dependence in inappropriate situations reflects an almost continuous relationship with the phone.
3. Do you feel empty or bored if you don't use the phone for an hour or more?	29%	51.5%	19.5%	2.90	1.03	Indicates dependence as a way to escape emptiness.
4. Do you try to reduce phone use but fail?	60.4%	—	39.6%	2.81	1.47	Clear challenges in controlling compulsive behavior and excessive use.

The calculated averages indicate a strong digital dependence and compulsive behavioral pattern among most Moroccan smartphone users, with dependence levels ranging from medium to high and variability in intensity among individuals. Question four shows the highest dispersion, reflecting significant difficulty in reducing usage. These results support the hypothesis of hidden digital dependence with a neuro-cyber dimension, highlighting the need to adopt integrated awareness measures, technical policies, and psychological interventions to address this phenomenon and reduce its negative effects on users.

3.5.Exploring Solutions

3.5.1.Motivations for considering reducing smartphone usage

Figure (12): Percentage reducing phone usage

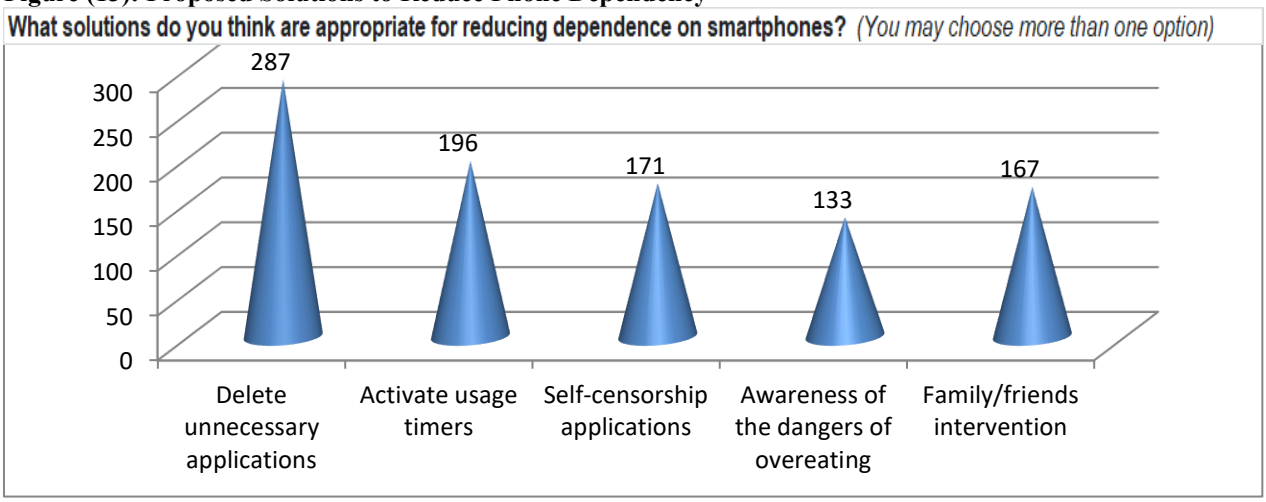


The pie chart reflects the results of an important question: "Have you ever thought about reducing your phone usage?" It shows that the vast majority, 72.9% of participants, have already considered reducing their phone use, compared to 27.1% who have not. This distribution indicates a relative awareness of excessive or dependent use affecting their digital and personal lives, highlighting the hidden nature of digital dependency that puts users in an internal struggle to control their

phone habits despite the difficulty in doing so. This indicator emphasizes the importance of focusing on psychological and behavioral aspects when studying digital dependency and reinforces the need to develop solutions and support programs to help achieve a healthy digital balance in users' lives.

3.5.2.Proposed Solutions by Participants to Reduce Digital Dependency

Figure (13): Proposed Solutions to Reduce Phone Dependency



The chart shows the results of an important question in the study "Hidden Digital Dependency on Smartphones among Moroccan Users": "What solutions do you consider appropriate to reduce dependency on smartphones? (Multiple choices allowed)"

Interpretation of the results:

-Deleting unnecessary apps (72.1%): The majority of participants believe that removing apps that are not needed or cause distraction is the most effective solution. This reflects awareness that reducing sources of distraction limits unconscious and excessive phone use, consistent with studies like (Oulasvirta et al., 2012) which emphasize how digital habits and multiple triggers increase dependency.

-Activating usage timers (49.2%): Nearly half of the participants think that setting fixed usage times helps reduce dependency, aligning with recommendations from technical interventions focusing on regulating daily behavior, as noted in research like (Billieux et al., 2019 ; Yang, L., et al., 2023).

-Self-monitoring apps (43%): The presence of tools to track usage helps users increase awareness of their behavior and reduce excessive use, supporting the neuro-cyber dimension linking self-control and compulsive behavior (Kuss & Griffiths, 2017).

-Family/Friend intervention (42%): Social support is important to overcome dependency, as familial and community backing enhances positive behavior and control, confirmed by studies on digital health (Park et al., 2014; Wang W et al., 2024).

-Raising awareness about overuse risks (33.4%): A significant percentage highlight the importance of spreading awareness about the harms of excessive use, relating to the psychological and social aspects of the study, consistent with findings by (Elhai et al., 2017) connecting awareness to compulsive behavior control.

These solutions combine three main elements:

Technical Interventions

-Deleting apps, usage timers, self-monitoring apps;

-Supported by research on digital habits and control technologies (Oulasvirta et al., 2012; Billieux et al., 2019);

-Emphasizes modifying digital triggers to reduce compulsive usage behavior.

Psychological and Social Factors

-Awareness campaigns and social/family support;

-Highlighted by studies (Elhai et al., 2017; Park et al., 2014; Kuss & Griffiths, 2017);

-Psychological understanding is crucial for motivating users and enabling control, especially through social support.

Neuro-Cyber Dimension

-Developing smart tools integrating neurological techniques for self and behavioral control;

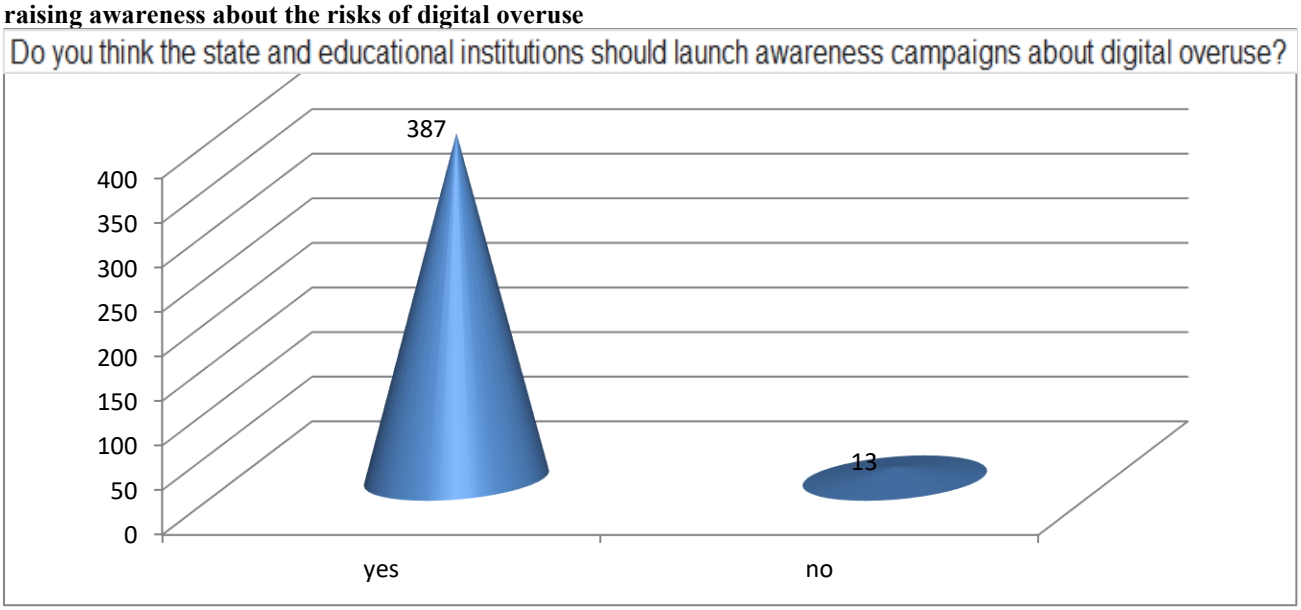
-Confirmed by prior studies (Billieux et al., 2019);

-Dependency is not only psychological but linked to the dynamic interaction between brain and technology.

The chart clearly reflects a strong alignment between Moroccan users' perceptions of effective solutions and recent research findings. Technical solutions reducing digital temptations, combined with psychological and social support, form a solid foundation to combat digital dependency and compulsive behavior through a neuro-cyber perspective. This reinforces the study's call for adopting multidimensional strategies addressing behavioral, neural, social, and technical aspects of the phenomenon.

3.5.3.Participants' Views on the Importance of Institutional Awareness Campaigns Against Digital Overuse

Figure (14): The studied sample's perception of the responsibility of the state and educational institutions in raising awareness about the risks of digital overuse



The chart in the image presents the results of the question: "Do you think the state and educational institutions should carry out awareness campaigns about digital overuse?" The vast majority, 96.8% of participants, answered "Yes," while only 3.2% said "No." This indicates broad support among participants for the important role of the state and educational institutions in launching awareness campaigns to reduce digital overuse. It reflects significant awareness of the importance of education in addressing digital dependency and compulsive behaviors related to excessive technology use. The result aligns with the study's emphasis on the neuro-cyber dimension of digital dependency, highlighting an urgent need for institutional and structural awareness interventions to enhance self-control and provide a healthy digital environment that protects users from the risks of excessive smartphone and digital technology use.

This high percentage supports the perspective linking digital dependency to the need for comprehensive solutions, including awareness campaigns led by the state and educational institutions to promote psychological and technical awareness and reduce widespread compulsive and dependent behaviors.

The survey results on appropriate solutions to reduce digital dependency on smartphones among Moroccan users show precise statistics regarding the percentage choosing each solution, along with the calculation of the mean and standard deviation for each option based on the binary distribution (solution chosen = 1, not chosen = 0). The following table summarizes these results:

Table (09): Means and Standard Deviations of Solution Evaluations by the Studied Sample of Moroccans

Solutions	Number of Participants	Percentage Choosing the Solution	Mean	Standard Deviation	Brief Interpretation
Awareness campaigns by the state and educational institutions	387	96.8%	0.968	0.178	Strong support for official awareness campaigns as a key element in reducing digital dependency.
Deleting unnecessary applications	287	72.1%	0.721	0.449	Reducing digital temptation sources is effective in limiting dependency.
Activating usage timers	196	49.2%	0.492	0.500	Organizing time and monitoring usage to reduce phone overuse.
Self-monitoring applications	171	43.0%	0.430	0.495	Increasing user awareness of usage behavior through monitoring tools.
Family/friends intervention	167	42.0%	0.420	0.494	Social support helps control compulsive behavior.

Solutions	Number of Participants	Percentage Choosing the Solution	Mean	Standard Deviation	Brief Interpretation
Awareness of overuse risks	133	33.4%	0.334	0.472	Psychological and social awareness acts as a motivating factor for change.

Interpretation of the Results:

-Awareness campaigns by the state and educational institutions have the highest selection rate (96.8%), indicating participants' recognition of the vital role of official bodies in raising awareness to reduce digital addiction;

-Deleting unnecessary applications. Nearly half of the participants see deleting unnecessary apps as an effective technical solution, with 72.1% supporting it. Users understand that reducing distractions helps lower digital dependency. They also value activating usage timers and self-monitoring apps that help organize their digital behavior.

-Social support through family and friends highlights the importance of psychological and social factors in addressing compulsive dependency.

-Although the percentage choosing awareness of overuse risks is relatively lower (33.4%), it remains necessary as part of a support system to reduce compulsive behaviors.

The data reveal a clear desire to adopt integrated solutions combining technical, psychological, social, and official (state and educational campaigns) dimensions, aligning with the neurocybernetic perspective that views digital dependency as a multidimensional phenomenon requiring comprehensive interventions to enhance self-control and digital well-being among Moroccan users.

4.CONCLUSION

This field study addressed the hidden phenomenon of digital dependency on smartphones among Moroccan users from a neurocybernetic perspective. The importance and widespread nature of the subject and its multidimensional effects on mental and physical health as well as social behavior, especially among youth, have become clear. The results showed a close link between intense smartphone use and increased levels of anxiety, sleep disorders, physical fatigue, alongside weak awareness of cybersecurity and privacy risks. The study also revealed the difficulty in regulating and controlling digital use despite many users recognizing potential negative effects.

This reality necessitates adopting comprehensive and integrated approaches intertwining technical, psychological, social, and official aspects to confront the challenges arising from digital dependency, with reliance on the neurocybernetic framework to understand and explain the nature of this phenomenon. Accordingly, the following recommendations are made:

-Enhance national and educational awareness campaigns: The state and educational institutions must play active roles in spreading awareness about the risks of excessive smartphone use, focusing on the neurological and psychological aspects, and the need for early education in digital self-regulation skills.

-Adopt multidimensional intervention programs: These should include technical measures such as deleting unnecessary apps, activating usage timers, using self-monitoring applications, alongside psychological and social support from family and community to help users reduce compulsive dependency and improve quality of life.

-Develop cybersecurity skills: Strengthen digital culture and knowledge about privacy risks and self-protection through workshops, training courses, and informational materials targeting different user groups, while boosting societal responsibility for digital security.

-Encourage scientific and technological research: Support future studies based on neurocybernetic methodologies to gain deeper understanding of the complex neurological mechanisms underlying digital behavior and develop smart tools for self-control.

-Involve family and civil society: Enhance the role of families as the first defense line in monitoring and guiding smartphone use, and encourage civil society initiatives to provide psychological and social support to users.

Implementing these recommendations will help build a more aware and balanced digital environment in Morocco, protecting users' mental and physical health and supporting sustainable digital development. This will reduce the risks of hidden digital dependency and promote social and cultural performance in meeting the challenges of the digital age.

Declarations

Consent to Participate

All participants provided informed consent prior to their inclusion in the study.

Ethics Approval

This study was conducted under the supervision of Sidi Mohamed Ben Abdellah University in Fez, with adherence to the ethical standards applied by the university.

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Conflict of Interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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