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AUGMENTED REALITY ESCAPE ROOMS AS NEUROCOGNITIVE TRAINING ENVIRONMENTS

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Abstract. The *purpose* of the paper is to examine the integration of augmented reality (AR) escape rooms as innovative neurocognitive training environments, synthesizing evidence from medical education, cognitive rehabilitation, and adaptive learning systems. *Methodology.* This study employs a comprehensive narrative literature review methodology, analyzing peer-reviewed publications from Web of Science, PubMed, Scopus, ERIC, and ScienceDirect databases spanning the period 2017–2025. The review synthesizes findings across four domains: VR and gamification in medical and nursing education; environment-integrated adaptive cognitive training systems; VR/AR applications in visuospatial neglect rehabilitation; and serious games for cognitive enhancement. Inclusion criteria encompass English-language empirical studies, design research, and systematic reviews addressing AR/VR escape rooms, gamification, or cognitive training in healthcare contexts. *Results* of the review showed that AR escape rooms demonstrate significant potential for neurocognitive training through enhanced clinical decision-making under time pressure, improved teamwork and collaboration, increased knowledge retention through engagement and motivation, and reduced stress in high-pressure scenarios. Key design elements identified include extrinsic motivation structures, direct and delayed feedback systems, environmental integration for ecological validity, and difficulty adaptation through fuzzy logic or machine learning. However, the evidence base remains emerging, with small sample sizes and pilot designs limiting generalizability. *Practical implications.* AR escape rooms are feasible and acceptable for neurocognitive training across medical education, stroke rehabilitation, and elderly cognitive maintenance. Implementation requires clear protocols, therapist training, adaptive difficulty settings, and performance tracking systems. Design must prioritize motivation, feedback, adaptability, and ecological validity. *Value / originality.* This synthesis provides a comprehensive overview of AR escape rooms as neurocognitive training environments across multiple application domains, identifying common design principles and evidence gaps. The findings inform researchers and practitioners seeking to develop or implement AR-ER interventions, while outlining future research directions including multicenter trials and cost-effectiveness analyses.

Keywords: augmented reality, escape rooms, neurocognitive training, gamification, serious games, cognitive rehabilitation, visuospatial neglect, medical education.

JEL Classification: I21, O33 , I12

1. Introduction

The landscape of cognitive training and healthcare education is undergoing a transformative revolution, driven by the integration of immersive technologies and gamification strategies. Among these innovations, escape rooms – originally designed as team-based puzzle-solving games – have been adapted for educational and therapeutic purposes, promoting critical thinking, collaboration, and problem-solving under time pressure (Nicholson, 2018; Veldkamp et al., 2021). The convergence of augmented reality (AR) with escape room mechanics creates unprecedented opportunities for neurocognitive training that combines ecological validity, adaptive difficulty, and intrinsic motivation.

Cognitive decline associated with aging, stroke, and neurodegenerative conditions represents a growing global burden. Traditional cognitive training methods face well-documented challenges: low engagement due to repetitive tasks; insufficient motivation among participants who may lack awareness of their deficits; limited accessibility and scalability; and poor transfer of trained skills to daily life (Choi, Twamley, 2013; Buitenweg et al., 2012). Serious games have emerged as a promising solution, with meta-analytic

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evidence supporting their effectiveness in cognitive rehabilitation (Maheu-Cadotte et al., 2021; Damaševičius et al., 2023).

Augmented reality escape rooms (AR-ERs) extend this paradigm by overlaying virtual elements onto the user's physical environment, enabling cognitive challenges that are both contextually embedded and dynamically adaptable. Unlike fully immersive virtual reality (VR), AR maintains connection with the real world, potentially reducing cybersickness and supporting applications in home-based or clinical settings (Zhang et al., 2025; Bousché et al., 2024). The design of AR-ERs for neurocognitive training draws upon principles from medical education – where VR and gamified escape rooms have demonstrated efficacy (Rafi et al., 2025) – and from cognitive rehabilitation – where AR-based visual scanning training has shown promise for visuospatial neglect (Bakker et al., 2020).

Thus, the research problem is stated as follows: how can AR escape rooms be effectively designed and implemented as neurocognitive training environments across diverse healthcare contexts? The current paper aims to: (1) review the theoretical and empirical foundations of AR-ERs for cognitive training; (2) synthesize design principles from medical education, cognitive rehabilitation, and adaptive learning systems; (3) analyze implementation requirements and user experience factors; and (4) outline future research directions and clinical implications. The methodology employed is a comprehensive narrative literature review, with findings organized thematically to inform both researchers and practitioners.

2. Gamification and Escape rooms in Healthcare

Gamification – the application of game-design elements in non-game contexts – has proven highly effective in fostering engagement, motivation, and active participation across healthcare and education (Deterding et al., 2011; Kapp, 2012). In medical education, gamification creates immersive learning environments that capture attention and enhance retention of complex concepts through challenges, rewards, and interactive storytelling (Rafi et al., 2025). Virtual reality has gained significant traction in medical training due to its ability to provide hands-on experiences without real-world risks (Kyaw et al., 2019; Moro et al., 2017).

Escape rooms adapted for educational purposes simulate scenarios where participants must work together to solve puzzles, diagnose conditions, and make critical decisions under time constraints. In medical education, escape rooms reinforce knowledge while cultivating soft skills: communication, teamwork, and decision-making (Rafi et al., 2025; Zhang et al., 2018). A narrative review by Rafi et al. (2025) identified 25 studies demonstrating that VR and gamified escape rooms enhance clinical decision-making, improve teamwork and collaboration, increase knowledge retention and engagement, and reduce stress in high-pressure scenarios across emergency medicine, pharmacy, radiology, internal medicine, and psychiatry.

Notably, virtual escape rooms developed using low-cost tools such as Google Forms and Zoom have shown effectiveness comparable to traditional lectures in promoting knowledge gains among emergency medicine residents (Dimeo et al., 2022). Educational escape rooms focused on sepsis management in pediatric residents yielded significant knowledge improvement with sustained retention after three months (Alejandre et al., 2022). These findings establish that escape room mechanics – puzzle-solving, time pressure, and collaboration – effectively support learning outcomes in healthcare contexts, providing a foundation for AR-enhanced versions.

3. Augmented Reality for Cognitive Rehabilitation

Augmented reality offers distinct advantages over fully immersive VR for certain neurocognitive applications. By overlaying digital content onto the user's physical environment, AR maintains spatial orientation and allows interaction with real-world objects (Bakker et al., 2020). In visuospatial neglect (VSN) – a common cognitive deficit after stroke affecting 30–90% of patients – AR has been explored as a tool for Visual Scanning Training (VST), the recommended treatment in clinical guidelines (Bousché et al., 2024; Cappa et al., 2005).

Bakker et al. (2020) used a design research approach with co-creation involving seven VSN patients, eight occupational therapists, and healthcare professionals to develop an AR game for scanning training. Fundamental design choices included: extrinsic motivation (critical for patients with reduced self-awareness), nostalgia and metaphors, direct feedback, independent movement, object contrast, search elements, and competition. Therapists evaluating VR and AR serious games for VSN rehabilitation reported that 54% considered them suitable for neglect rehabilitation, with 23% noting motivational benefits for VST practice (Bousché et al., 2024). However, therapists emphasized requirements for clear instructions, adaptive difficulty, feedback and reward features, and performance metrics.

The Environment-Integrated Adaptive Cognitive Training System developed by Zhang et al. (2025) extends this paradigm to elderly cognitive maintenance. The system employs a Q&A assessment to estimate cognitive abilities, requests users to photograph their

environment, and uses a fuzzy system to determine suitable game programs. Empirical experiments demonstrated that the adaptive AR escape game could customize cognitive tasks, adapt to environmental context, and maintain high engagement. VR simulations for nursing students improved satisfaction, self-confidence, and performance (Salameh et al., 2024), while VR with 360° video outperformed conventional simulation in mental health nursing (Lee et al., 2024).

4. Design Principles and Implementation

Synthesis of the reviewed literature yields several design principles for AR escape rooms as neurocognitive training environments. First, motivation design is paramount. Extrinsic motivation structures – badges, points, leaderboards – provide feedback and accomplishment (Maheu-Cadotte et al., 2021). For populations with reduced self-awareness, extrinsic motivation may be essential to sustain engagement (Bakker et al., 2020). Second, feedback and rewards must be carefully calibrated. Therapists called for more specific and frequent feedback, positive reinforcement of correct trials, and flexible timing (Bousché et al., 2024).

Third, adaptability and personalization are critical. The fuzzy logic approach of Zhang et al. (2025) demonstrates that matching game difficulty to estimated cognitive ability and environmental context improves engagement. Therapists stressed the need for games adaptable to patients with cognitive or motor disabilities, sensory hypersensitivity, and varied interests – suggesting theme selection and adjustable audio/visual parameters (Bousché et al., 2024). Fourth, ecological validity can be enhanced through environmental integration. Implementation requirements include: clear protocols and manuals for therapists and patients; hardware management protocols; cost evaluations for equipment and software licensing; and performance tracking systems (Bousché et al., 2024).

5. Findings

First of all, the reported evidence across medical education, cognitive rehabilitation, and adaptive learning was compared, since the application domain and target population are main antecedents of design choices. In medical education settings, VR and gamified escape rooms demonstrated significant improvements in knowledge retention, clinical decision-making, and teamwork. In visuospatial neglect rehabilitation, AR games were rated suitable for training by the majority of therapists, with motivational benefits noted. The adaptive AR escape game of Zhang et al. (2025) maintained high engagement through personalization. A characteristic feature of the reviewed studies is that engagement and satisfaction were consistently high across formats, though sample sizes were often small. Further, design elements including extrinsic motivation, direct feedback, adaptive difficulty, and environment integration were repeatedly identified as critical across domains. In all cases, the evidence suggested that AR escape rooms represent a promising paradigm, though rigorous efficacy trials are needed.

6. Conclusions

The results of this review demonstrate that AR escape rooms represent a promising paradigm for neurocognitive training that synthesizes gamification, immersive technology, and scenario-based learning. Evidence from medical education demonstrates that escape room mechanics enhance clinical decision-making, teamwork, knowledge retention, and stress management. Applications in cognitive rehabilitation – particularly visuospatial neglect – show that AR can support visual scanning training with design elements including extrinsic motivation, direct feedback, and environment integration.

Not surprisingly, implementation requirements and design principles differ between application contexts, since medical education emphasizes knowledge acquisition while rehabilitation emphasizes compensatory strategy training. It seems that extrinsic motivation, feedback calibration, and adaptability are the areas where design choices make the largest influence. The findings raise a reasonable question: Do the positive outcomes arise from the escape room format, the AR technology, or their combination? Specific features such as environment integration may

Table 1
Key design elements for AR escape rooms in neurocognitive training

Design element	Rationale	Source
Extrinsic motivation	Essential for populations with reduced self-awareness	Bakker et al., 2020
Direct/delayed feedback	Reinforces correct strategies; therapists request frequent feedback	Bousché et al., 2024
Adaptive difficulty	Match tasks to cognitive ability; fuzzy logic for personalization	Zhang et al., 2025
Environment integration	Ecological validity; AR overlays content in physical space	Zhang et al., 2025
Theme variation	Motivation through personal interest	Bousché et al., 2024
Performance metrics	Accuracy, duration, search strategy for tracking	Bousché et al., 2024

offer unique advantages for transfer to daily life. Future research directions include multicenter studies with larger samples, head-to-head comparisons of AR versus VR versus traditional training, longitudinal follow-up for skill transfer, and economic evaluations for clinical implementation.

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