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Research Progress on Game-Based Interventions for Children with Speech and Language Disorders

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Abstract: ***Speech and language difficulties during childhood can extend beyond problems with speaking or understanding language and may also interfere with learning, school performance, and everyday communication. Management often involves repeated practice over relatively long periods, yet maintaining sufficient training can be difficult when children lose interest or when professional and family resources are limited. Game-based approaches have emerged as one way to make this practice easier to continue. They include simple interactive activities as well as digital serious games and newer systems that use automatic speech recognition or adaptive feedback. This review examines how these approaches have been used for speech sound and phonological disorders, pronunciation and motor-speech-related training, language delay, and other communication difficulties in children. Particular attention is given to their role in sustaining participation, extending practice beyond clinical sessions, and providing individualized feedback. Although early findings are encouraging, the literature is still dominated by small and heterogeneous studies, and evidence for long-term retention and transfer to everyday communication remains limited. More rigorous clinical research is needed to determine where game-based intervention offers meaningful benefit in pediatric speech and language therapy.***

Keywords: Children, Speech and language disorders, Game-based intervention, Serious games.

1. Introduction

Speech and language abilities are fundamental to children's communication, learning, and social participation. Language involves semantic, morphological, syntactic, and pragmatic functions, whereas speech refers to the spoken production of language through articulation, fluency, voice, and intelligibility [1]. Difficulties in these domains may occur separately or coexist, and persistent problems can affect literacy, academic performance, peer interaction, and everyday participation [2-3].

Effective intervention often requires repeated and sustained practice, particularly for speech sound and motor speech difficulties [4]. In routine care, however, treatment intensity may be restricted by limited access to speech-language therapists, insufficient opportunities for home practice, and reduced motivation during repetitive exercises [5-6]. These practical limitations have encouraged the use of game-based approaches, in which therapeutic tasks are delivered through structured activities involving goals, feedback, rewards, and progressive challenge.

Digital technology has further expanded this model. Mobile serious games, automatic speech recognition, and adaptive systems can support home-based practice, immediate feedback, and individualized training [7-8]. Nevertheless, the current evidence is uneven. Most studies focus on speech production, phonological training, feasibility, or system usability, while evidence for broader language outcomes remains less developed [8]. Direct comparisons with equivalent non-game interventions are also limited.

This review summarizes the main forms and clinical applications of game-based interventions for children with speech and language disorders, and discusses their potential advantages, current limitations, and priorities for future research.

2. Main Forms of Game-Based Interventions

Game-based intervention is not a distinct therapeutic technique in itself. Instead, it offers a different way of delivering established speech or language exercises by embedding them within activities that contain game elements. According to how the intervention is delivered, current approaches can be broadly grouped into conventional interactive games, digital serious games, and more recent intelligent systems supported by automatic speech recognition or artificial intelligence.

Conventional interactive games are usually carried out face to face and depend on direct participation between the child and a therapist, parent, or peer. Activities such as turn-taking, imitation, picture naming, role play, and message exchange can provide repeated opportunities for verbal production without presenting practice as a formal drill. Khoiriyah and Purwanta, for example, used a chain-message game with children aged 5–6 years with speech delay and reported improvements in pronunciation clarity, message coherence, social communication responses, and speaking confidence [9]. These findings suggest that even simple, non-digital games may support communication practice, although the small sample and classroom-based design limit the strength of the evidence.

Digital serious games extend this idea by placing therapeutic tasks directly within the game structure. Progress is linked to the completion of speech- or language-related activities rather than to play alone. Madeira et al. developed Super-Fon for children aged 3–8 years with phonological disorders, using the Metaphon approach to organize training from sound-related concepts to phoneme- and word-level activities [10]. Animations, virtual rewards, and other game features were added to sustain participation while the therapeutic sequence remained central. Badkook et al. later proposed the eGLD design framework for children with language delay,

highlighting the need to consider therapeutic goals, interaction design, usability, and child-specific language needs instead of relying mainly on entertainment features [11].

A further development has been the incorporation of automatic speech recognition and artificial intelligence. These systems can respond to children's speech, provide feedback, and adjust task difficulty according to performance. A systematic review of 45 studies identified pediatric digital speech applications using speech recognition, phoneme-level exercises, multimodal feedback, adaptive difficulty, and intelligent tutoring [8]. Another review of AI-assisted speech therapy tools also reported growing use of mobile and gamified platforms, while noting that direct comparisons with conventional speech-language therapy were still uncommon [12]. Taken together, current developments indicate a gradual shift from games used mainly to support engagement toward systems that combine therapeutic tasks with automated feedback and individualized training.

3. Clinical Applications

3.1 Speech Sound, Phonological, and Motor Speech-Related Training

Among the different clinical applications of game-based intervention, speech sound and phonological training has received comparatively greater attention. Children with these difficulties often need repeated practice in discriminating speech sounds, producing specific targets, and using them at word or sentence level. Because repetition is an essential part of treatment, these tasks can be incorporated into games without substantially changing the underlying therapeutic goal.

The available evidence, however, remains mixed in quality. Furlong et al. reviewed 14 studies involving 11 computer-based programs for childhood speech sound disorders and found improvements in speech production in several studies, together with generally favorable responses from children and caregivers [5]. The authors also noted considerable variation in treatment procedures and outcome measures, and most studies included relatively small samples [5]. Similar concerns were raised by Hajesmaeel-Gohari et al., whose review showed that digital games had been used for training at phoneme, word, and sentence levels, but only a limited number of studies met the inclusion criteria and their designs were highly heterogeneous [7]. Thus, current findings support the feasibility of game-based speech training more clearly than they establish its superiority over conventional intervention.

Super-Fon provides a useful example of how therapeutic content can be incorporated into gameplay rather than simply surrounded by entertaining features. The program was developed for children with phonological disorders and follows the sequence of the Metaphon approach, progressing from awareness of sound properties to phoneme- and word-level activities [10]. Game elements such as animations and rewards are used to maintain participation, but the clinical task remains central to progression through the program. This distinction is important because adding points or visual rewards to an exercise does not, by itself, make the exercise more therapeutically effective. The game structure needs to encourage repeated production of the speech behavior that treatment is intended to change.

More individualized approaches have also been explored. Hair et al. developed Apraxia World, a tablet-based game that allowed children aged 5–12 years with speech sound disorders to practice clinician-selected target words at home [13]. Participants completed two 4-week treatment blocks, and their productions were evaluated either by caregivers or through an automated system. Preliminary findings indicated treatment gains, although the study was small and the results were intended as early evidence rather than confirmation of clinical efficacy [13]. An additional contribution of this work was the collection of more than 25,000 child utterances, which may support the development of automated assessment methods for disordered child speech.

Other systems have taken this idea further by making pronunciation performance directly influence events within the game. Nicolaou et al., for example, described games in which machine-learning-based speech evaluation was used to connect children's target-word production with rewards and game progression [14]. This design can make speech practice an integral part of gameplay rather than a separate exercise. At the same time, it introduces a technical concern: automated feedback is only useful when the system can reliably evaluate atypical child speech. Reviews of digital and AI-assisted speech therapy have identified recognition accuracy and clinical validation as continuing challenges, particularly for children with speech disorders [8-12].

A final issue is whether improvement during the game persists beyond the training task. Motor-learning principles distinguish immediate performance from learning that is retained and transferred to new contexts [4]. A child may become more accurate on repeatedly practiced words without showing the same improvement in untrained material or spontaneous communication. For this reason, future studies should not rely solely on in-game accuracy or immediate post-treatment scores. Retention, generalization to untrained words and connected speech, and use of the acquired skill in everyday communication are more clinically meaningful indicators of lasting benefit [4].

3.2 Language Delay and Other Communication Difficulties

Evidence for game-based intervention in broader language domains is still much thinner than that for speech production. Relatively few studies have examined vocabulary, sentence construction, receptive language, or expressive language directly, and many of the available reports involve small or clinically diverse samples.

Lan et al. investigated a three-dimensional virtual environment for Mandarin vocabulary and sentence-structure learning in four special education students aged 8–9 years with language delay and additional neurodevelopmental conditions [15]. Both the children and their parents responded positively to the learning environment, and the authors reported potential benefits for oral language learning. Even so, the small sample, mixed clinical profiles, and qualitative

design limit how far these findings can be interpreted as evidence of a treatment effect. The study is more useful as an early example of how immersive technology can be incorporated into language practice than as proof of clinical efficacy.

The evidence from autism research also needs careful interpretation. Language abilities in autism vary considerably: some children show relatively preserved structural language, whereas others have difficulties involving semantics, syntax, phonology, or functional communication [16]. This heterogeneity matters when game-based interventions are evaluated, because gains in social interaction or broader communication behavior do not necessarily indicate improvement in language itself.

Gao et al. addressed this issue in a meta-analysis of 24 randomized controlled trials involving 1,801 children and adolescents with autism spectrum disorder [17]. The pooled results showed significant benefits for social skills, social behavior, and cognition, whereas the effect on language expression was small and not statistically significant [17]. The findings highlight the need to keep different outcome domains separate. A program may improve social engagement or cognitive performance without producing a comparable change in structural language, and combining these outcomes under a general label of "communication improvement" can obscure that distinction.

The way treatment benefit is measured is equally important. Standardized scores and task accuracy remain useful, but they capture only part of a child's communicative functioning. Alons et al. found that communication difficulties varied according to the person involved, the topic, the pace of interaction, the setting, the timing, and the mode of communication [3]. For game-based interventions, this raises an important question: does progress within the training environment carry over into ordinary conversation?

For this reason, evaluation should not stop at performance on practiced vocabulary or sentence tasks. Retention of gains and their use in home, school, and peer interactions are likely to provide a more meaningful indication of clinical benefit than improvement within the game alone.

4. Advantages and Current Limitations

One important advantage of game-based intervention is that it may make repetitive practice easier for children to sustain. Goals, rewards, feedback, choice, and graded challenges can increase interest and provide a clearer sense of progression during treatment [18, 19]. However, engagement should not be treated as equivalent to therapeutic improvement. Kober et al. found that a game-based condition increased positive affect and frontal activity related to attention and reward, while behavioral performance was not clearly superior to that of a non-game condition [22]. This suggests that games may support participation, but their clinical value still depends on whether the game repeatedly elicits the intended speech or language behavior.

Game-based systems may also increase opportunities for practice outside formal therapy. This is relevant because treatment intensity is important for children with speech sound disorders, whereas the frequency available in routine services may be lower than recommended [6]. Digital games can extend practice into the home, but successful implementation depends on more than access to technology. Leafe et al. identified child participation, parent training, therapist collaboration, and actual practice intensity as important factors in digital home intervention [6]. Pritchard et al. similarly emphasized individualized guidance, clear expectations, parental knowledge, and therapeutic relationships [2]. Game-based home practice should therefore complement therapist-led intervention rather than replace professional involvement.

Remote service delivery may further support this model. Wales et al. reported limited but encouraging evidence that telehealth-delivered speech and language intervention can achieve outcomes comparable with face-to-face treatment in some school-age children [20]. A combined model of therapist supervision and game-supported home practice may therefore help extend training beyond the clinic while preserving clinical guidance.

Digital systems also provide rapid and relatively standardized feedback. Automatic speech recognition can respond immediately to children's productions and record performance across sessions [8-12]. Yet feedback must be carefully designed. Bakker et al. noted that its timing, frequency, detail, and modality can influence learning [21]. Excessive immediate correction may improve performance during practice but can also increase dependence on external feedback. In addition, automated recognition remains less reliable for disordered child speech, multilingual users, and children with multiple disabilities [8-12]. Incorrect recognition may therefore lead to inappropriate reinforcement, particularly during unsupervised practice.

Individual differences should also be considered in game design. Liu et al. argued that meaningful engagement requires both an enjoyable user experience and achievement of the intended task outcome, rather than the simple addition of points or rewards [23]. Badkook et al. likewise showed that games for children with language delay require child-specific therapeutic and interaction design [11]. Sensory characteristics may also influence usability. Björelius et al. found increased sensory-processing difficulties in some children with speech sound disorders, suggesting that highly complex audiovisual interfaces may not be suitable for every child [24]. The effectiveness of a therapeutic game therefore depends on how well its design matches both the clinical target and the child's individual profile.

Despite these advantages, the evidence base remains limited. Many studies involve small samples, heterogeneous diagnostic groups, short intervention periods, and different outcome measures [5-12]. A considerable proportion of the literature focuses on feasibility, usability, or prototype development rather than comparative clinical effectiveness. Studies directly comparing game-based and non-game interventions with similar therapeutic content and treatment dosage are still uncommon. This makes it difficult to determine whether reported gains arise from the game itself or simply from additional practice.

Long-term outcomes also remain insufficiently studied. Motor-learning research distinguishes improvement during practice from retention and transfer after training [4]. For game-based intervention, better in-game performance does not necessarily mean that children will retain the skill or use it in everyday communication. Future studies should therefore pay greater attention to follow-up, generalization to untrained tasks, and communicative participation in real-life settings [3, 4].

5. Conclusions

Game-based intervention has begun to find a clear place in pediatric speech and language therapy, particularly in areas that rely heavily on repeated practice, such as speech sound, phonological, and pronunciation training. Its usefulness lies less in making therapy "fun" than in changing how practice is delivered. Repetitive exercises can be built into structured activities that are easier for children to continue, and digital platforms can create additional opportunities for practice outside the clinic. For this reason, game-based intervention is better regarded as a delivery format for established therapeutic content than as a separate alternative to conventional speech-language therapy.

The key question is not whether children enjoy these games, but whether the skills practiced within them are retained and used beyond the training setting. A child may perform well during a game without showing the same improvement in spontaneous speech or everyday communication. This is an important limitation of the current literature, which still places considerable emphasis on short-term performance, usability, and satisfaction. Clinical value will be more convincingly demonstrated when improvements persist after training and generalize to untrained tasks and real-life communication.

There is also little reason to expect a single game format to work equally well for every child. Age, disorder profile, severity, attention, language ability, and family involvement can all shape the response to treatment. Flexible systems that allow therapists to modify task difficulty, practice content, feedback, and training frequency are therefore likely to be more useful than fixed programs. Artificial intelligence and automatic speech recognition may support this level of adjustment, but their role should remain secondary to clinical judgment. More sophisticated technology is not necessarily better if feedback is inaccurate or if game features draw attention away from the therapeutic goal.

The next stage of research should focus on how game-based approaches can be integrated into routine care rather than on adding more game elements. Their strongest role may be as a bridge between therapist-led treatment and structured home practice, particularly when the system can support repeated training, individualized progression, and monitoring over time. Larger controlled studies and longer follow-up remain necessary, but the available evidence already points to a practical direction: well-designed games may strengthen pediatric speech and language therapy when they support, rather than replace, established clinical practice.

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