Universal Access in the Information Society
https://doi.org/10.1007/s10209-025-01231-5

LONG PAPER

How to create video games with cognitive accessibility features: a literature review of recommendations

Miguel Ángel Oliva-Zamora[1] · **Carme Mangiron**[1]

Accepted: 14 May 2025

Abstract
Video games have become one of the most relevant audiovisual products in the entertainment industry. However, they are still not fully accessible to an important part of the population: people with disabilities, who often encounter barriers when attempting to play. Among the different barriers, people with cognitive disabilities or learning difficulties may struggle to determine the appropriate responses required to progress in the game. The objective of this paper is to map the current state of cognitive accessibility in video games and provide a set of recommendations for developing cognitively accessible video games. To this end, we conducted a literature review in which we examined both academic articles and non-academic guidelines related to cognitive accessibility. After defining *game accessibility* and *cognitive accessibility*, the methodology for the systematic search and the analysis are explained in detail. Out of the two hundred twenty five documents that were originally retrieved, eighteen met the inclusion criteria, such as language or date of publication. These documents were analysed to extract their recommendations for cognitive accessibility, the type of video games they mention, and the cognitive disabilities or learning difficulties they address. The findings are then presented and discussed, resulting in a list of fourteen key recommendations for developing video games with cognitive accessibility features. Finally, the main contributions of the paper are highlighted and future research avenues are suggested.

Keywords Game accessibility · Cognitive disabilities · Learning difficulties · Literature review · Accessibility guidelines · Recommendations

1 Introduction

Video games play an important role in the entertainment industry, with more than three billion players all over the world and a three hundred billion revenue [1]. These audiovisual products have undergone several changes with the development of new technologies, from the simplicity of *PONG* [2] to the intricacy of the *The Last of Us Part I* [3]. The former was depicted as lines and a marker, its controls entailed moving up and down, and its sound effects were minimal. The latter, however, uses motion capture to show realistic characters in a well-recreated environment, has a rich and overarching narrative, and includes an elaborated soundtrack.

This increase in complexity, in turn, has an impact on the player. Technological advances in interactive entertainment software offer an array of possibilities, but they might also generate obstacles [4]. For example, Kinect technology, which allows players to interact with games using their bodies as controller, is not accessible for players with reduced mobility. In this context, persons with disabilities are constantly expressing their will to play video games. A study by Anderson [5], who analysed different definitions of *accessibility*, showed that persons with disabilities consider game accessibility not only a want, but a need.

Among the visual, auditory, physical, or cognitive barriers users may encounter, cognitive ones are the least explored [6]. This paper aims to map the current state of cognitive accessibility and propose a set of recommendations for developing cognitively accessible video games. To that end, the Primary Research Question (PRQ) is the following:

✉ Miguel Ángel Oliva-Zamora
miguelangel.oliva@uab.cat

Carme Mangiron
carme.mangiron@uab.cat

[1] Universitat Autònoma de Barcelona, Barcelona, Spain

Published online: 29 May 2025

- **PRQ**: What guidelines are present in existing literature in order to ensure cognitive accessibility in video games?

To answer this question, we conducted a literature review to compile a series of guidelines from the academia, the industry, and the users. Furthermore, we examined how and where these recommendations are actually implemented in video games and what types of cognitive disabilities or learning difficulties they address. These analyses can be framed as Secondary Research Questions (SRQ):

- **SRQ1**: What types of video games include accessibility features for cognitive accessibility?
- **SRQ2**: What types of cognitive disabilities or learning difficulties are addressed by the recommendations?

The paper is organized as follows: first, we define *game accessibility* and *cognitive accessibility*, and describe a preliminary search that justifies this literature review. Then the methodology for the systematic search and the analysis of the data are explained in detail. Findings are presented and discussed, resulting in a list of fourteen recommendations to consider when developing video games with cognitive accessibility features. Finally, the main contributions are highlighted and future research avenues are suggested.

2 Game accessibility

Game accessibility falls under the umbrella of *media accessibility*, which aims to ensure that everyone is able to use and enjoy all audiovisual products [7]. Although *accessibility* has always been associated with disability, implying that people might find it difficult to access something due to the presence of a physical, sensory, or mental impairment [8, 9, 10], its definition is growing to include everyone [11], since barriers can also appear because of the environment [12]. For example, playing with the Nintendo Switch in a car could entail sensory obstacles: the daylight could not allow seeing the image properly and the surrounding noise could not allow hearing dialogues.

Thus, *game accessibility* can be understood as the avoidance of situations in which someone's abilities are not matched with the barriers of the video game they are interacting with [13]. According to Yuan et al. [14], these barriers can be found when interacting with a game in three steps: (a) receiving the stimuli (e.g., seeing the events on the screen, hearing an enemy that approaches from behind); (b) determining a response (e.g., finding the solution to a puzzle); and (c) providing input (e.g., pressing buttons to move or attack).

In recent years, attention has been devoted to barriers arising in the first and the third step. For motor accessibility, companies such as Microsoft and Sony have developed accessible controllers, such as the Xbox Adaptive Controller [15] or the Access controller [16]. For visual and auditory accessibility, games such as *The Last of Us Part I* [3] and *God of War: Ragnarök* [17] implement audio description and subtitles for the deaf and hard of hearing. These two video games include a variety of accessibility features for all types of barriers, more than 60 each, demonstrating the extent to which access can be facilitated for a diverse range of players. However, while both games include presets for visual, auditory, and motor accessibility, they have none for cognitive accessibility, which exemplifies how this type of accessibility is lagging behind. Research regarding cognitive accessibility is still scarce and requires attention in order to improve game accessibility for neurodivergent players [18].

3 Cognitive accessibility in video games

Cognition is an umbrella term referring to "mental tasks, including conceptualizing, planning, sequencing thoughts and actions, remembering, interpreting subtle social cues, and manipulating numbers and symbols" [19]. Therefore, *cognitive accessibility* intends to ensure that people do not find barriers because of a limitation in any of these cognitive tasks. From the perspective of game accessibility, cognitive accessibility is the most challenging to address, since players who might benefit from it represent a heterogeneous group that ranges from people with autism or Down syndrome to people with learning difficulties [20, 21]. Such variety of users is also mentioned in guidelines from the industry and the player community, e.g., Microsoft's Xbox Accessibility Guidelines [22], which are further described in Sects. 5 and 6, Results and Discussion respectively.

There are also a number of serious games developed for people with cognitive disabilities or learning difficulties [23]. These are games that serve other purposes beyond entertainment [24], such as *educational games*, which combine education and video games to make learning more interactive and fun [25], and *games for health*, which deal with the phases of illness and healthy habits, among other things [26]. In this type of video games, accessibility is so essential that it is embedded in the development by default. When creating a video game such as *Junk-Food Destroyer* [27], whose sole purpose is to aid adolescents with Down syndrome to have healthy eating habits, developers will take all necessary measures so that this group can have access to it.

Additionally, academic works analysing or describing the development of serious games target people from different ages and with different needs, for example, children with special educational needs [28] and elderly people with cognitive decline [29]. In fact, several games for health are used for analysing the effect of gaming in the mental state of elderly people with cognitive decline [30], which evidences that cognitive accessibility is not only concerned with birth impairments.

However, players with cognitive disabilities and learning difficulties would also benefit from efforts that favour their social interaction and their autonomy [31]. They should have access to commercial games, so that they can play what most people play, thus fulfilling their need of inclusion [32]. Therefore, while the educational and therapeutic approach to cognitive accessibility can have a positive impact on neurodivergent users, the social approach, which aims for inclusion by facilitating access to mainstream games, should also be fostered.

As regards academic literature on the topic of cognitive accessibility, a preliminary search in databases such as Google Scholar revealed a lack of literature reviews focusing on cognitive accessibility in video games. Dutra et al. [33] performed a systematic literature mapping to seek guidelines for the development of accessible video games and, by the end of the study, proposed some guidelines that could specifically help players with cognitive disabilities. Nonetheless, their search included all types of disabilities (visual, auditory, motor, and cognitive) and their corpus only included academic articles.

This paper, however, focuses on game accessibility in a broader way by searching for guidelines about cognitive game accessibility from a variety of sources. The intention is to combine the two fronts in which recommendations for game accessibility emerge: academia, on the one hand, and industry and community, on the other hand [34]. The search was performed accordingly, including not only research articles but also guidelines that developers and players are creating, sharing, and using, as further detailed in the next section.

4 Methodology

The PRQ of the study, "what guidelines are present in existing literature in order to ensure cognitive accessibility in video games?" is answered via a literature review. This method entails reading and assessing an array of information sources that gather what is known about a certain topic [35]. Part of the structure of the study follows the PRISMA-checklist [36], which offers a series of steps that can be easily followed: searching databases, selecting documents, and extracting data.

Since we are interested in both papers and guidelines from different sources, we refer to *academic documents* as those written by researchers, and *non-academic documents* as those created by developers or the player community. Given the different nature of the documents to be retrieved, we performed a two-step systematic search. The first step involved selecting databases in which to apply a search string. This step is restrictive since it aspires to be replicable, but leads to results whose quality has been ideally appraised [37]. Therefore, it works for finding academic articles, but it will probably lead to the exclusion of other types of evidence, such as non-academic guidelines. The latter cannot be found in databases, but are, as mentioned before, an important source of information about game accessibility. To consider them in our analysis, we included a second step, which entailed scanning the results gathered in the first step for references to non-academic documents.

We began by designing a search string with only two terms and a Boolean operator in order to retrieve as many documents as possible:

"game accessibility" AND cogniti*.

The first term, *game accessibility*, ensures that results are related to the area of interest, that is, it seeks to avoid the emergence of documents dealing with other types of accessibility, such as web accessibility. The second term, *cogniti**, is truncated in order to include variances such as *cognitive* or *cognition*, and it delimits the type of barriers that players may encounter. Terms were searched for in all parts of the document: title, abstract, and full text.

The systematic search was performed in the following databases: Web of Science (WOS), Scopus, SAGE Journals, and ProQuest. WOS and Scopus were chosen because of the quality of their content, and SAGE Journals and ProQuest because of their importance in social research, which is the area where accessibility studies fall into. To limit the results according to the inclusion criteria, which are explained in detail below, the following three filters where applied when possible: (a) published within the last 15 years (referred to as "Date"); (b) written in English or Spanish, the working languages of the authors (referred to as "Only English and Spanish"); (c) peer-reviewed (referred to as "Evaluated by experts"). The total number of retrieved documents was 140, as seen in Table 1 below.

Once we obtained the 140 results, references to non-academic guidelines were looked for. This scanning led to a list of 85 development guidelines [38] that had been gathered by the Inclusion, Diversity, Equality and Accessibility (IDEA) working group. This list was found in a study by Larreina-Morales [39], who used it in the development of a tool to measure game accessibility. Following in her

Table 1 Results by database

Database	Filters	Results
WOS	Date, Evaluated by experts	2
SAGE	Date, Evaluated by experts	6
ProQuest	Date, Evaluated by experts, Only English and Spanish	48
Scopus	Date, Evaluated by experts, Only English and Spanish	84

footsteps, the present study included the 85 documents as results of the search. All references to development guidelines we found in other papers were already included in this list, so we considered it was representative of the work in the industry and the community.

Therefore, the two-step systematic search led to a total of 225 documents. To begin with, duplicates were looked for and erased (24). Next, the remaining documents (201) were examined to assess their relevance for the present study. For academic documents, two rounds were applied. In the first round, the title and the abstract were read in order to extract some basic information. In the second one, the discussion and conclusion were also analysed in order to have a clearer sense of the objectives of the research. For non-academic documents, one round to examine the objectives and the target audience were usually enough.

Figure 1 shows an extract illustrating how documents were recorded in an Excel sheet. Sorted by the database they were found in, we noted relevant information such as the title, authors, and year of publication, followed by a column for comments in case they contained useful information or references. When the documents included recommendations for cognitive accessibility, the last columns were filled in with the specific quote and page number.

As stated in the criteria above, only documents that offered a recent overview of the landscape and that were in an understandable language for the authors (English and Spanish) met the inclusion criteria. For academic documents, quality was guaranteed by including only those that had been evaluated by experts, a criterion that could not be applied to non-academic sources. Documents that could not be accessed, that were not related to the topic, and that did not include guidelines for cognitive accessibility were excluded. Tables 2 and 3 summarize the inclusion and the exclusion criteria.

Database	Title	Comments	Author	Journal	Year	Recommendations	Method	Page
WoS	Challenges of Developing a Mobile Game for Children with Down Syndrome to Test Gestural Interface	Down syndrome	Sancho Nascimento, L., Zagalo, N., & Bezerra Martins, L.	Information (Basel)	2020	About the rules: Must b	Reception study	4
	Integrating Health Behavior Theory and Design Elements in Serious Games	Design elements for depressive adolescentes, serious game	Cheek, C., Fleming, T., Lucassen, M. F., Bridgman, H., Stasiak, K., Shepherd, M., & Orpin, P.	JMIR mental health	2015	Perceivable: Content is	Reception study	9
SAGE Journals	Video Game Accessibility Defined Through Advocacy: How the Websites AbleGamers.org and CanIPlayThat.com Use the Word Accessibility	Justifies game accessibility	Anderson, S. L.	Games and Culture	2024			
	How Accessible is This Video Game? An Analysis Tool in Two Steps	Metaanalysis	Larreina-Morales, M. E.	Games and Culture	2024			
	Assessing Video Game Satisfaction of Gamers with Disabilities	Literature review	Van Ommen, C., & Chaparro, B. S.	Proceedings of the Human Factors and Ergonomics Society Annual Meeting	2021			
	Designing for Disability: Evaluating the State of Accessibility Design in Video Games	Not specific of cognitive accessibility	Brown, M., & Anderson, S. L.	Games and Culture	2021			
	Disability and Video Games Journalism: A Discourse Analysis of Accessibility and Gaming Culture	Interesting: "Currently, the majority of the work on gaming and disability comes in the form of research on games' utility as medical or therapeutic interventions (Balan et al., 2015; Chang et al., 2011; Kato, 2010; Stendal, 2012; Wästerfors, 2011)."	Anderson, S. L., & Schrier, K.	Games and Culture	2022			

Fig. 1 Data extraction excerpt

Table 2 Inclusion criteria

Inclusion criteria
Published less than 15 years ago
English or Spanish
Evaluated by experts (for academic documents)

Table 3 Exclusion criteria

Exclusion criteria
No access to full text
Not including recommendations
Not related to cognitive accessibility

Table 4 Excluded results

Reason for exclusion	No. of documents
Duplicates	24
Without access	8
Not including recommendations	96
Not related to cognitive accessibility	79

After applying the criteria to the 201 documents, only 18 were accepted. Documents that could not be accessed (8) or that dealt with game accessibility but did not include recommendations (96) or cognitive features (79) were excluded, as illustrated in Table 4.

All accepted documents were carefully read. Having noted all recommendations for cognitive accessibility (PRQ), we completed the Excel sheet by analysing the video games in which they were implemented (SRQ1) and the disabilities or learning difficulties they addressed (SRQ2).

From the documents, a corpus of guidelines for designing video games with cognitive accessibility was compiled. Given the size and the heterogeneity of the data, it was coded to look for similarities [40]. Two cycles of coding were performed via the qualitative data analysis tool ATLAS.ti. The first one consisted of choosing a word or two, usually a noun, to summarise or define the content, while the second one consisted of re-reading each recommendation to remove redundancies. The resulting list of codes is presented in Table 5, together with their description.

Table 5 Coding list

Code	Description
Interface	Elements on the user interface
Controls	Hardware used by players to interact with the game
Channels	Methods of transmitting information to players
Time	Pace and rhythm of the game
Help	Hints or features that aid players
Text display	Textual representation of information
Objectives	Instructions to progress in the game
Difficulty	Level of challenge in progressing through the game
Repetition	Possibility of replaying parts of the game
Sensitivity	Elements that might trigger seizures or similar conditions
Sound	Volume adjustment of auditory components
Multiplayer	Communication between players
Engagement	Player motivation and involvement
Language	Understandability of the text
Graphic style	Visual characterisation of the game
Rewards	Feedback and incentives given after an adequate progression
Saving	Mechanism for tracking game progression between playthroughs
Choices	Options available to interact with the game
Tutorials	Introduction of rules and guidance to players
Failure	Consequences for inadequate progression
Mental health	Issues related to emotional or suggestive content
Motion sickness	Stimuli that might cause dizziness
Narrative	Storyline and contextual background
Practice	Opportunities for players to learn the rules
Documentation	Information on the accessibility features of the game
Navigation	Movement through the game world
Skip	Bypass of certain parts of a game
Identity	Representation of player traits within the game

5 Results

The documents retrieved during the two-step systematic search that contain recommendations for cognitive accessibility in video games are listed in the following tables, sorted by ascending date order. Results are divided into two broad categories, depending on their origin. The papers in Table 6 were extracted by systematically searching databases, and those in Table 7 were extracted from references to industry or community guidelines in academic articles.

The analysis of the selected documents revealed that most academic documents focus on serious games, specifically nine of the twelve that were retrieved: D2, D3, D4, D5, D7, D8, D10, D11, and D12. They are presented according to their methodology, which ranges from a literature review to the development of a game or a reception study. For example, D3 performs a literature review of five reception studies dealing with the game *SPARX* to elucidate design elements that are important for children with depression, while D5 gathers information about post-operative education for the elderly. D2 uses the development of the video game *My First Day at Work* as a case study to analyse the effort and the cost of the decisions that must be taken during the development of an accessible serious game. On the other hand, D11 takes *Liberi*, a collection of video games whose controls and gameplay are based on exercise (known as *exergames*), and describes a reception study performed with five participants with autism during six weeks to analyse

Table 6 Selected papers from academic sources

ID	Ref.	Name	Year
D1	[14]	*Game accessibility: a survey*	2011
D2	[41]	*Towards a low cost adaptation of educational games for people with disabilities*	2014
D3	[42]	*Integrating Health Behavior Theory and Design Elements in Serious Games*	2015
D4	[43]	*Design, implementation, and wide pilot deployment of FitForAll: An Easy to use exergaming platform improving physical fitness and life quality of senior citizens*	2016
D5	[44]	*Considerations for the design of online gaming interventions for the frail elderly: A short communication*	2016
D6	[45]	*A guide for making video games accessible to users with cerebral palsy*	2019
D7	[46]	*Challenges of Developing a Mobile Game for Children with Down Syndrome to Test Gestural Interface*	2020
D8	[47]	*A Method to Develop Accessible Online Serious Games for People with Disabilities: A Case Study*	2020
D9	[48]	*Factors Affecting the Accessibility of IT Artifacts: A Systematic Review*	2022
D10	[49]	*Method for the Development of Accessible Mobile Serious Games for Children with Autism Spectrum Disorder*	2022
D11	[50]	*Design and Evaluation of an Exergaming System for Children With Autism Spectrum Disorder: The Children's and Families' Perspective*	2022
D12	[51]	*A device-interaction model for users with special needs*	2022

Table 7 Selected papers from non-academic sources

ID	Ref.	Name	Year
D13	[52]	*Game Accessibility Guidelines*	2017
D14	[53]	*Accessible Player Experience*	2018
D15	[54]	*Cognitive accessibility guide*	2019
D16	[55]	*Improving Games for Those with Cognitive Disabilities| Designing for Disability*	2019
D17	[22]	*Xbox Accessibility Guidelines*	2023
D18	[56]	*IGDA Game Accessibility SIG - On Cognitive Disabilities*	–

what design solutions should be considered to make the game accessible to them.

However, most of the papers focus on the development and testing of a video game. D4 describes the creation of the exergame *FitForAll* and the tests performed with 116 elderly users to explore usability and efficacy. D7 focuses on the creation of *Parque das Galáxias*, conducts a heuristic evaluation via a usability test, and presents a cognitive walkthrough with designers and specialists. D8 explains how *PC TRAVEL* was developed in Roblox and gathers feedback from 10 players via surveys. D10 describes the implementation of a user-centered design for *SimpleTEA* and the results of interviews to five therapists for feedback. D12 outlines the development of a device-interaction system and the use of a cognitive walkthrough with four experts as well as an experiment with 12 students to assess it.

The other three academic papers are not dedicated to serious games specifically, but also use one of the aforementioned methodologies: a literature review (D1 and D9) and the description of the development of a game (D6). D1 examines a series of accessible video games to see what strategies are implemented, and D9 performs a systematic review to examine the problems found in making accessible IT artifacts, i.e., web applications, web sites, or user interfaces, including video games. D6 focuses on the creation of three games, *Footb-all*, *Formula Chair*, and *Fisio Run*, in collaboration with an association of people with cerebral palsy. These games cannot be considered serious games, as their primary purpose is pure entertainment, but they were made accessible with the help of the target users.

On the other hand, guidelines from the industry and the community have very different origins, thus making their classification more complex. D13 is probably the most ehxaustive, since it has thirty recommendations for cognitive accessibility. However, not all of them are to be implemented at the same time, since they are grouped in three levels (basic, intermediate and advanced) depending on the reach (number of people who benefit), the impact (the difference made to those people), and the value (cost to implement). In any case, all recommendations are accompanied by examples of good practice and testimonies.

D14 has been written with the help of the game community and it has probably the most divergent approach, since its recommendations are divided into access patterns (which allow players to play the game) and challenge patterns (which focus on how players with disabilities can progress in the game). They associate each of their so-called *patterns* to a type of player and then give examples of video games where the pattern can be found.

Both D15 and D16 use different barriers in video games as a starting point for their recommendations, with the difference that D15 bases them on player experience and D16 on obstacles steming from certain disabilities or difficulties.

D17 has been written solely by developers and has a set of twenty-three guidelines with examples of video games and specific data about the implementation of different accessibility features, e.g., the convenient size of the text. D18, on the contrary, advocates for simplicity and presents nine general recommendations, including a set of nine questions to evaluate their implementation.

As can be seen, all selected documents present different approaches to cognitive game accessibility, hence the diversity of their recommendations. Generally speaking, the selected academic documents have a more fixed structure and are more concerned about the validity of their results,

whereas non-academic documents focus on providing practical tips for developers. Other differences and similarities are addressed in the following section.

To analyse the data, codes are displayed in a frequency table. Figure 2 illustrates the distribution of the different accessibility features across the accepted documents. The rows represent how the recommendations were coded, such as "Controls" or "Interface," while the columns correspond to the documents (D1–D18). Shaded cells signify the presence of a feature in the respective document. On the last column, the percentage indicates the relative frequency of each feature across all documents (e.g., recommendations about controls appear in 77% of the accepted documents). These percentages reflect how commonly each feature appears within the dataset, providing insight into which accessibility aspects are most frequently addressed.

The same approach was applied to SRQ2. Fig. 3 presents an overview of various cognitive disabilities and learning difficulties mapped across the accepted documents, all of which are discussed in Sect. 6.

In order to create a set of recommendations that could summarise the findings, codes were grouped under broader categories. The following table (Table 8) links the different codes to each category, which then served as the foundation for our recommendations, described in detail in Sect. 7.

6 Discussion

The literature review carried out to answer the PRQ of this paper, "what guidelines are present in existing literature in order to ensure cognitive accessibility in video games?" has

	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11	D12	D13	D14	D15	D16	D17	D18	%
Controls	■		■	■	■	■	■	■	■		■		■	■	■		■	■	77%
Time	■			■	■	■	■	■		■			■	■	■	■	■	■	72%
Interface	■		■	■	■	■	■	■					■	■	■		■	■	66%
Channels			■		■		■	■	■			■	■	■			■	■	55%
Help				■	■		■		■		■		■	■		■	■	■	55%
Text display			■		■				■				■	■	■	■	■		44%
Difficulty				■	■		■	■		■						■	■	■	44%
Objectives		■		■			■			■			■		■		■		38%
Sound							■			■			■	■	■		■		33%
Language			■		■			■	■				■			■			33%
Multiplayer				■			■				■		■	■			■		33%
Engagement			■	■			■			■	■								27%
Repetition								■		■			■		■	■			27%
Saving							■	■					■	■		■			27%
Sensitivity													■		■	■	■		22%
Graphic style				■		■	■			■									22%
Rewards				■			■	■		■									22%
Choices							■			■	■			■					22%
Tutorials							■						■		■	■			22%
Practice													■	■				■	16%
Narrative		■					■						■						16%
Failure			■				■				■								16%
Motion sickness															■	■	■		16%
Mental health													■	■			■		16%
Navigation															■	■			11%
Identity						■					■								11%
Skip				■										■					11%
Documentation																	■	■	11%

Fig. 2 Frequency table with codes per document

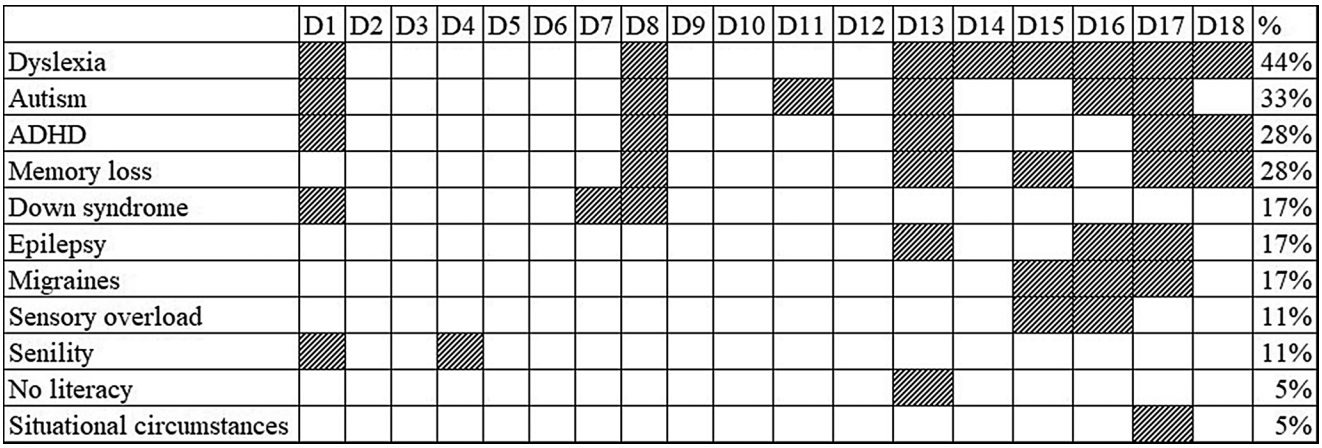

Fig. 3 Frequency table with cognitive disabilities and learning difficulties per document

Table 8 Codes grouped under wider categories

Codes	Category
Interface	Unclattered interface
Controls	Adaptive controls
Channels, Sound, Multiplayer	Several channels
Time, Repetition, Skip, Choices	Slow pacing
Help, Navigation	Helping guidance
Text display, Language	Suitable texts
Objectives, Narratives	Simple progression
Difficulty	Adjustable difficulty
Sensitivity, Motion sickness, Graphic style	Reduced stimuli
Engagement, Rewards, Identity	Enhanced motivation
Saving	Safe playthrough
Tutorials, Failure, Practice	Practice spaces
Mental health	Mental healthcare
Documentation	Complementary documentation

shown that most of the documents are very recent. In total, 12 of the 18 selected documents were published or updated, in the case of some of the guidelines, after 2019. This confirms that efforts in game accessibility, particularly in cognitive accessibility, are very contemporary.

Through the qualitative analysis, it can be seen where these documents intersect regarding cognitive accessibility. The recommendation that appears in most documents is related to *controls*, which should be easy to memorise, implemented in a single device as per the user's preference, and available at any point in the game. This is closely followed by recommendations related to *time*, which aim to ensure that players can adequately read texts, interact with the interface, and pause the game when necessary to check previous information or think about future actions. The *interface* is another aspect that receives considerable attention: everything should be as simple and uncluttered as possible; there should be a clear contrast between interactive and non-interactive elements, which can be achieved by having a configurable background; all screens with menus should be easy to navigate, and a quick start mode is recommended.

A feature that also appears in many documents is related to *channels*. Information should be delivered through as many channels as possible (audio, visual, haptic…), so services such as subtitles, audio description, or screen narration are encouraged, as well as speech-to-text and text-to-speech technologies. The way the game provides *help* to the player is also important, which implies having contextual information of the controls, objectives, or narrative, automating functions such as aiming or centering, and warning the player before taking irreversible actions. Additionally, academics, developers, and players emphasize the importance of *text display*, including appropriate size, font, colour, and customisation options. It is also advisable to present the text in an easy structure, like a list, and highlight important words.

The *difficulty* should progressively increase through evolving tasks, and remain adjustable to the player's preferences at all times. *Objectives* should be as clear as possible and not numerous; in fact, having just one is desirable. It is also important to provide separate sliders for volume settings for different *sound* effects, such as music and dialogues, to use a simple and easy *language* with consistent terminology and short sentences, and to allow a *multiplayer* mode so that users can benefit from the help of another person or interact via voice chat. Developers should include an intriguing plot and dynamic sensory stimuli to keep *engagement*, allow the *repetition* of challenges, tutorials, or information in text or voice, and ensure that *saving* is consistent throughout the playthrough, providing manual save slots with thumbnails and personalised titles.

With regard to *sensitivity*, flashing lights or flickering images should be avoided as much as possible. Concerning the *graphic style*, it should be minimalist and allow the expression of emotions. In relation to *rewards*, the player

should be offered visual or auditory feedback when completing challenges or gaining new abilities. Regarding the player's *choices*, users should be able to personalise as many aspects of the game as possible. In relation to *tutorials*, they should be available every time the player needs them.

In addition, video games should include a training ground in which players can *practice* without consequences, should have an easy-to-follow *narrative*, and should minimize the effects of *failure* or avoid it completely. They should also avoid *motion sickness* caused by head bobbing or content that scrolls and blinks, and refrain from strong emotional content to prevent negative impacts on *mental health*.

Some features that are barely mentioned but could also be implemented are an easy overworld *navigation* with waypoints, mini-maps, and objective markers; the display of the player's *identity* with avatars to avoid barriers in group play; the option to *skip* certain parts of the video game before becoming frustrated, and some kind of *documentation* stating available accessibility features.

In relation to the secondary research question about what types of video games include accessibility features for cognitive accessibility (SRQ1), there is a double trend. On the one hand, many documents mention serious games, which are designed with certain target users in mind, and are, therefore, accessible. Examples include *Shared Interfaces to Develop Effective Social Skills* (D1), a four-player puzzle game for people with Asperger's syndrome to practice group work; *Parque das Galáxias* (D7), a recreational park game with five activities based on the touchscreen to test these types of interfaces for children with Down syndrome, and *SimpleTEA* (D10), an application with exercises aimed to improve the communication skills of children with autism.

There are also several approaches to exergaming, such as *FitForAll* (D4), which includes several physical exercises that use the remote controller and the Wii Balance Board to improve the physical condition of the elderly. Another example is *Liberi* (D11), a collection of seven pedalling-based minigames designed for children with autism. All of these examples are mentioned in academic articles, evidencing that such papers tend to focus on a user-centered approach and on the creation of games tailored to people with cognitive disabilities or learning difficulties.

On the other hand, many other documents mention commercial games that have accessible features for a variety of users. This is the case of *Street Fighter IV* [57] (D13), which includes a black background with high contrast that emphasizes the fighters. Similarly, *Civilization V* [58] (D13 and D16) allows simplifying the interface by blurring or darkening non-interactive elements and can be quickly started with the option "Play now." *Overwatch* [59] (D13 and D14) includes a "Practice Range" with no failure to test out controls and abilities, and allows adjusting the volume of the music and the in-game voice, among other things. *Mass Effect: Andromeda* [60] (D14) allows changing controls from holding a button to just tapping it to aim or sprint; includes the option "Auto Level" to easily manage abilities and skills, and allows players to keep track of their progression with saves that have proper names and a thumbnail.

Gears 5 [61] (D17) allows pausing motion videos at any time and for as long as needed with a single button, turning off notifications of kills to avoid distractions, and adjusting the amount of time that chat messages stay on the screen. The game also has a dedicated website that provides an overview of each accessibility feature and setting.

Grounded [62] (D17) is one of the most recent games and it has several options for cognitive accessibility:

- Font size and contrast can be adjusted;
- Text is accompanied by symbols in some parts of the interface, such as tab menus ("tools" has a hammer, "meal prep" has a burguer and a drink);
- The rate of the auto-saving is modifiable from 1 min up to 20, as well as the amount of autosavings that are stored;
- A "Creative" mode serves as a training ground without threats;
- The objectives are shown at all times in the interface;
- Multiple channels provide information: audio and visual, but also haptic;
- Warning notifications help avoid losing settings or data;
- An "Arachnophobia safe mode" is included as a mental health measure.

All of these mainstream games are mentioned in non-academic guidelines, which imply that their accessibility features have been implemented and tested during the development process, with the objective of reaching the widest possible audience. In any case, all the above-mentioned video games, whether serious or mainstream, are examples of games that people with cognitive disabilities or learning difficulties might have access to.

Regarding the secondary research question about types of cognitive disabilities or learning difficulties that are addressed in academic literature and non-academic guidelines (SRQ2), the most commonly mentioned are *dyslexia*, *autism*, *attention deficit hyperactivity disorder* (ADHD), and *memory loss*. For *dyslexia*, academics and developers suggest using text with a high-contrast background (D13) and a dyslexic friendly font (D15). These features are easy to implement, which might explain why this learning difficulty appears so widely in the selected documents. For *autism*, most authors advocate for not having too many elements in the interface to accommodate users' sensitivity (D16), and also for fostering physical activity and social interaction

(D11). For *ADHD*, objective indicators and directional arrows can be a big help (D18). Something similar is suggested for *memory loss*: contextual information about goals and controls can be very helpful (D17).

There are other disabilities mentioned in the documents, such as *Down syndrome*, or impairments directly related to sensitivity, such as *epilepsy* or *sensory overload*. Some non-academic guidelines mention *migraines* and some academic articles refer to *senility*, which exemplifies the broad view there is of cognitive accessibility, since neither chronic headaches nor cognitive decline are usually considered disabilities or learning difficulties. There are also mentions to *no literacy* and *situational circumstances*, two cases that fall under the current definition of *accessibility*, as mentioned in the Introduction, despite not being related to neurodivergence.

Many of the recommendations previously gathered are common accessibility features in current commercial video games. The most frequently mentioned, key remapping, is particularly common in action games such as *Nier: Automata* [63] or *Gears of War 4* [64], which include fighting sequences heavily based on motor skills. Applying different levels of difficulty is also a common feature, and games have explored several ways to implement it. For example, *The Elder Scrolls V: Skyrim* [65] modifies the damage dealt and recevied across its six difficulty levels, and *Resident Evil 4* [66] has adaptive difficulty, where the level of challenge changes according to the player's failures and successes. Other games, such as *Assassin's Creed Origins* [67] or *The Outer Worlds* [68], include story or exploration modes that allow players to experience the narrative or discover the world without harm. Most video games include tutorials to facilitate initial immersion in the game, although some might work better than others. An example of a good tutorial can be found in *Jamestown* [69], which allows players to test every action dynamically. Another widely used feature in video games is subtitles. This method of transmitting the information represents a way of accompanying voiced dialogues, usually in adventure games with several characters and a meaningful narrative such as *Uncharted 4: A Thief's End* [70] or *Detroit: Become Human* [71].

There are other features, however, that are less common in video games. Sometimes they might be difficult to implement due to their ambiguity, such as those related to *engagement*. These recommendations only appeared in papers on serious games, where learning is intrinsically related to motivation. In other cases, the recommendations may conflict with the desired effect of the game, such as when a game is intentionally overstimulating, like *Post void* [72]; has a macabre narrative, such as *The Walking Dead* [73], or uses mental disorders to portray enemies, such as *Outlast* [74]. Another feature that is yet to be properly implemented is the display of a game's accessibility features. *Gears 5* [61] and *The Last of Us Part I* [3], for example, have websites detailing their accessibility features, but the key challenge is ensuring that this list of options is available to players before purchase and is easily accessible within the game.

To end the discussion, there are some limitations to this research that are worth mentioning. Firstly, as can be seen, more academic documents were selected in comparison with non-academic ones. However, we consider that there is a balance between them, since some of the articles include very few recommendations compared to the exhaustiveness of some of the guidelines from the industry and the community, which mostly have between 20 and 30 recommendations. Secondly, some decisions taken during the search process, such as including Spanish publications and non-academic sources that might change or disappear over time, while excluding documents that did not reference any recommendations, may have resulted in overlooking relevant aspects of the game accessibility landscape. Thirdly, not all selected documents include recommendations that have been tested with users. As previously mentioned, the research described in documents such as D2, D3, D5, and D9 did not involve a reception study. Therefore, it might be necessary to assess their validity by means of questionnaires or experiments with users. Despite these limitations, we consider that all of the above-mentioned accessibility solutions provide an indication of the current trend in cognitive accessibility in video games.

7 Recommendations

Using the data gathered in the discussion, we compiled a set of recommendations, which could be taken into account when designing cognitively accessible video games. They have been ordered according to the prevalence of the codes in the analysed documents, but they are all equally important in order to ensure accessibility for the widest possible spectrum of users:

1) **Unclattered interface**: Limit the elements displayed on the screen or allow the player to choose their size or layout. Design menus that are easy to navigate and make sure interactive elements can be easily distinguished from non-interactive ones, for example, with a high-contrast background;
2) **Adaptive controls**: Reduce the combinations of buttons and allow them to be remapped. At the same time, ensure compatibility with as many control devices as possible;
3) **Several channels**: Present information through visual (video, images), auditory (dubbing, cues), and textual

(descriptions, subtitles) channels whenever possible. Allow players to use screen readers and other speech-to-text and text-to-speech technologies, as well as voice chat for communication with other players. Offering haptick feedback can also be useful, but players should be able to customise its intensity. Provide independent sliders for music, dialogues, and other effects;

4) **Slow pacing**: Let players pause and rewind the game at any moment. When possible, provide settings to adjust the overall speed. Allow players to rewatch, reread, and replay all parts of the game, such as videos, dialogues, or challenges. Allow players to skip or bypass parts of the game in which they cannot successfully progress. Limit the impact of failure and ensure mistakes do not block progress or impede restoring a previous status of the game. Ensure choices can be confirmed or reversed at any moment;
5) **Helping guidance**: Design the game to assist the player when necessary, with functions such as auto-aim, auto-centering, or lock-on target. Provide reminders of controls and objectives, and create a space where it is possible to revisit previous instructions and narratives. When necessary, provide a minimap and easy navigational directions, such as glowing breadcrumb trails, 3D arrows, objective markers, or waypoints;
6) **Suitable texts**: Include options to customise the type and the size of the text font. Use a sans-serif font and include a dyslexia-friendly font, provide enough spacing, and highlight important words. Ensure there is good contrast between the background and the text. Use short sentences and consistent terminology for simple language;
7) **Simple progression**: Present the overall purpose of the game as soon as possible. Whenever possible, have a single objective but allow the player to achieve it in multiple ways. Do not make a narrative more complex than necessary or avoid making it the basis of progression;
8) **Adjustable difficulty**: Create a simple-to-complex progression with evolving tasks but provide several levels of difficulty that can be adjusted at any time;
9) **Reduced stimuli**: Diminish visual activity, particularly bright lights, flickering images, and flashing lights. Avoid sudden movements or sounds, and try not to include unexpected mechanics. A simple and minimalist graphic style is preferred. Let players turn off motion blur, head bobbing, screen shake, or other features affecting camera movement or depth of field;
10) **Enhanced motivation**: Engage players through constant new discoveries. Design a story and characters that are emotionally compelling. Add stimulating and dynamic sensory effects. Offer rewards after a good performance or after overcoming a challenge, such as upbeat music or animations. Create environments and avatars that players can identify with. Encourage social interaction through competition or cooperation between players;
11) **Safe playthrough**: Allow players to manually save the progress or include many strategic save points. Add screenshots and thumbnails in save slots;
12) **Practice spaces**: Include interactive guided tutorials that mimic original gameplay. Offer areas or modes where players can learn gameplay concepts and gain skills without failing;
13) **Mental healthcare**: Avoid strong emotional content or make players aware of its existence in advance. Include an option to disable blood;
14) **Complementary documentation**: Provide information on the accessibility features of the game on the game's website, the packaging, and any other easily accessible place.

8 Conclusion

Game accessibility involves taking the necessary measures to prevent players from finding barriers while playing video games. These barriers can appear when receiving the visual or auditory stimuli of the game, when trying to determine the required actions to progress, and when providing input through a controller or another device.

Among these barriers, those related to determining a response are the ones that have been less explored. Such barriers are related to cognition and were the focus of our study. To date, cognitive accessibility in video games has predominantly been present in serious games designed for specific groups, but players also want access to well-known commercial games.

To analyse the existing recommendations for developing video games with cognitive accessibility features, we conducted a literature review. We implemented a two-step systematic search to extract data from the two main sources of recommendations for game accessibility: academic articles and non-academic guidelines. The search resulted in more than two hundred documents dealing with cognition in video games. Of these, eighteen met the inclusion criteria and were analysed.

During the analysis, we identified some differences between the selected documents. Academic articles, for example, cannot be modified once they are published, whereas non-academic guidelines can be constantly updated. Furthermore, academic research tends to focus on serious games and the cognitive effects of video games on specific groups, while developers and players prioritise having mainstream games that are accessible to the widest

possible audience. Despite these differences, the selected documents share common aspects in their recommendations. These similarities form the core contribution of this study: a list of recommendations for incorporating cognitive accessibility in video games.

As seen in the analysis, a wide range of people might benefit from cognitive accessibility, not only people with disabilities such as Down syndrome, but also people with learning difficulties such as dyslexia and mental health conditions such as anxiety. People who are illiterate or young, as well as novice and elderly players, could also benefit from this type of accessibility. Therefore, this set of recommendations has the potential to make video games more inclusive for many users.

The next step of this research will be to conduct a reception study, applying a number of these recommendations to a video game to assess whether they enhance users' gameplay experience. Ultimately, future studies that involve collaboration between users, academics, and development companies are essential for advancing cognitive accessibility in video games and ensuring that everyone, regardless of cognitive disabilities or learning difficulties, can enjoy any video game.

Acknowledgements This research is part of the R&D project PID2022-137058NB-I00 funded by MICIU/AEI/10.13039/501100011033 and ERDF/EU. The authors are members of the TransMedia Catalonia research group funded by Secretaria d'Universitats i Recerca del Departament d'Empresa i Coneixement de la Generalitat de Catalunya, under the SGR funding scheme (ref. code 2021SGR00077), and the corresponding author has been awarded a PhD grant from the Catalan Government (2022FI_B 00308).

Author contributions M.A.O.Z. and C.M. co-wrote the manuscript text.

Funding Open Access Funding provided by Universitat Autonoma de Barcelona.

Data availability No datasets were generated or analysed during the current study.

Declarations

Competing interests The authors declare no competing interests.

References

1. Clement, J. Video gaming worldwide - Statistics & Facts. *Statista*. (2022)., November 14 https://www.statista.com/topics/1680/gaming/#topicOverview
2. Atari: Pong. [Video game] (1972)
3. Naughty Dog. The Last of Us Part I. [Video game] (2022)
4. Mangiron, C. Panorama actual de la accesibilidad a los videojuegos. In: Reverter Oliver, B., Martínez Sierra, J.J., González Pastor, D., Fernado Carrero, J. (eds.). Modalidades de traducción audiovisual: Completando el espectro, pp. 85–94. (2021)
5. Anderson, S.L. Video game accessibility defined through advocacy: How the websites AbleGamers.org and CanIPlayThat.com use the word accessibility. Games Cult. (2023). https://doi.org/10.1177/15554120231170156
6. Mangiron, C. Game accessibility: taking inclusion to the next level. In Antona, M., Stephanidis, C. (eds.), Universal access in human-computer interaction. design methods and user experience– 15th international conference, UAHCI 2021, held as part of the 23rd HCI international 20 conference, HCII 2021, proceedings. lectures notes in computer science, vol. 12768, pp. 269–279. (2021). https://doi.org/10.1007/978-3-030-78092-0_17
7. Greco, G.M. The nature of accessibility studies. J. Audiov. Translation. **1**(1), 205–232 (2018). https://doi.org/10.47476/jat.v1i1.51
8. National Network. Information, Guidance, and Training on the Americans with Disabilities Act. (2020). https://adata.org/faq/what-definition-disability-under-ada
9. UK Parliament. The Equality Act 2010. (2010). https://www.legislation.gov.uk/ukpga/2010/15/section/6
10. Boletín Oficial del Estado. Real Decreto Legislativo 1/2013, de 29 de noviembre, por el que se aprueba el Texto Refundido de la Ley General de derechos de las personas con discapacidad y de su inclusión social. (2013). https://www.boe.es/buscar/act.php?id=BOE-A-2013-12632
11. Lidwell, W., Holden, K., Butler, J. Universal principles of design (2nd ed.). Rockport. (2010)
12. Greco, G.M., Jankowska, A. Media accessibility within and beyond translation studies. In: Bogucki, Ł., Deckert, M. (eds.), Handbook of Audiovisual Translation and Media Accessibility, pp. 57–81. (2020). https://doi.org/10.1007/978-3-030-42105-2_4
13. IGDA-GASIG. The IGDA game accessibility special interest group. (2022). https://igda-gasig.org
14. Yuan, B., Folmer, E., Harris, F.C. Game accessibility: A survey. Univ. Access Inf. Soc. **10**(1), 1–19 (2011). https://doi.org/10.1007/s10209-010-0189-5
15. Microsoft (n.d.). Xbox adaptive controller. https://www.xbox.com/en-US/accessories/controllers/xbox-adaptive-controller
16. Sony (n.d.). Access controller. https://www.playstation.com/en-us/accessories/access-controller/
17. SIE Santa Monica Studio: God of War: Ragnarök. [Video game] (2022)
18. Folmer, E. Virtual world accessibility: directions for research. (2011). http://ga.fdg2011.org/papers/6.pdf
19. LoPresti, E.F., Bodine, C., Lewis, C.: Assistive technology for cognition. IEEE Eng. Med. Biol. Mag. **27**(2), 29–39 (2008). https://doi.org/10.1109/EMB.2007.907396
20. Crabb, M., Heron, M., Jones, R., Armstrong, M., Reid, H., Wilson, A. Developing accessible services: understanding current knowledge and areas for future support. 2019 CHI Conference on Human Factors in Computing Systems (CHI '19), 1–12. (2019). https://doi.org/10.1145/3290605.3300446

21. von Gillern, S., Nash, B.L. Accessibility in video gaming: An overview and implications for english Language arts education. J. Adolesc. Adult Lit. **66**(6), 382–390 (2023). https://doi.org/10.1002/jaal.1284
22. Microsoft: Xbox Accessibility Guidelines. (2022). https://learn.microsoft.com/en-us/gaming/accessibility/guidelines
23. Anderson, S.L., Schrier, K. (Kat) (eds.) Disability and video games journalism: a discourse analysis of accessibility and gaming culture. Games Culture. **17**(2), 179–197 (2022). https://doi.org/10.1177/15554120211021005
24. Wilkinson, P. A Brief History of Serious Games. In R. Dörner, S. Göbel, M. Kickmeier-Rust, M. Masuch, and K. Zweig (eds.). Entertainment computing and serious games. Computer Science, 9970. (2016). https://doi.org/10.1007/978-3-319-46152-6_2
25. Kenwright, B. Brief review of video games in learning & education: How far we have come. Proceedings of the SIGGRAPH Asia 2017 Symposium on Education (SA 2017), 1–10. Association for Computing Machinery (ACM). (2017). https://doi.org/10.1145/3134368.3139220
26. Wattanasoontorn, V., Boada, I., García, R., Sbert, M.: Serious games for health. Entertainment Comput. **4**(4), 231–247 (2013). https://doi.org/10.1016/j.entcom.2013.09.002
27. Hatzigiannakoglou, P. Junk-food destroyer: helping adolescents with down syndrome to understand healthy eating through serious game. 7th International Conference on Games and Virtual Worlds for Serious Applications (VS-Games), 1–5. (2015). https://doi.org/10.1109/VS-GAMES.2015.7295778
28. Rocha, T., Barroso, J. Play for learning: serious games to assist learning of basic didactic concepts: a pilot study. In: Fang, X. (eds.) HCI in games: serious and immersive games. lecture notes in computer science, 12790(29), pp. 62–71. (2021). https://doi.org/10.1007/978-3-030-77414-1_6
29. Boletsis, C., McCallum, S. The smartkuber case study: lessons learned from the development of an augmented reality serious game for cognitive screening. In: De Paolis, L., Bourdot, P., Mongelli, A. (eds.) Augmented Reality, Virtual Reality, and Computer Graphics. Lecture Notes in Computer Science, 10324. (2017). https://doi.org/10.1007/978-3-319-60922-5_36
30. Webster, D., Celik, O. Systematic review of kinect applications in elderly care and stroke rehabilitation. J. Neuroeng. Rehabil. **11**, 108 (2014). https://doi.org/10.1186/1743-0003-11-108
31. Spiel, K., Gerling, K. The purpose of play: How HCI games research fails neurodivergent populations. ACM Trans. Computer-Human Interact. **28**(2), 1–40 (2021). https://doi.org/10.1145/3432245
32. Cairns, P., Power, C., Barlet, M., Haynes, G., Kaufman, C., Beeston, J. Enabled players: The value of accessible digital games. Games Cult. **16**(2), 262–282 (2021). https://doi.org/10.1177/1555412019893877
33. Dutra, T.C., Felipe, D., Gasparini, I., Maschio, E. A systematic mapping of guidelines for the development of accessible digital games to people with disabilities. In: Antona, M., Stephanidis, C. (eds.), Universal Access in Human-Computer Interaction. Design Methods and User Experience, 12768 pp. 45–63. Springer. (2021). https://doi.org/10.1007/978-3-030-78092-0_4
34. Porter, J., Kientz, J. An empirical study of issues and barriers to mainstream video game accessibility. ASSETS '13: Proceedings of the 15th International ACM SIGACCESS Conference on Computers and Accessibility, 1–8. (2013). https://doi.org/10.1145/2513383.2513444
35. Bryman, A. Social Research Methods, 4th edn. Oxford University Press (2012)
36. Page, M.J., McKenzie, J.E., Bossuyt, P.M., Boutron, I., Hoffmann, T.C., Mulrow, C.D., et al. The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. BMJ. **2021**(372), n71 (2021). https://doi.org/10.1136/bmj.n71
37. Davies, A. Carrying out systematic literature reviews: An introduction. Br. J. Nurs. **28**(15), 1008–1014 (2019). https://doi.org/10.12968/bjon.2019.28.15.1008
38. IGEA: Game development accessibility resources and guides. (2022). https://igea.net/wp-content/uploads/2021/03/IDEA-Working-Group-Accessibility-Pack-March-2022.pdf
39. Larreina-Morales, M.E. How accessible is this video game? An analysis tool in two steps. Games Cult. **19**(1), 75–93 (2023). https://doi.org/10.1177/15554120231154710
40. Saldaña, J.M. The Coding Manual for Qualitative Researchers, 4th edn. SAGE (2021)
41. Torrente, J., del Blanco, Á., Serrano-Laguna, Á., Pinto, V., Moreno-Ger, J., P., Fernández-Manjón, B. Towards a low cost adaptation of educational games for people with disabilities. Comput. Sci. Inform. Syst. **11**, 369–391 (2014). https://doi.org/10.2298/CSIS121209013T
42. Cheek, C., Fleming, T., Lucassen, M.F.G., Bridgman, H., Stasiak, K., Shepherd, M., Orpin, P. Integrating health behavior theory and design elements in serious games. JMIR Mental Health. **2**(2) (2015). https://doi.org/10.2196/mental.4133
43. Konstantinidis, E.I., Billis, A.S., Mouzakidis, C.A., Zilidou, V.I., Antoniou, P.E., Bamidis, P.D. Design, implementation, and wide pilot deployment of FitForAll: An easy to use exergaming platform improving physical fitness and life quality of senior citizens. IEEE J. Biomedical Health Inf. **20**(1), 189–200 (2016). https://doi.org/10.1109/JBHI.2014.2378814
44. Fredericks, S., Lapum, J.L., Policelli, J. Considerations for the design of online gaming interventions for the frail elderly: A short communication. Can. J. Nurs. Inf., **11**(3). (2016). https://cjni.net/journal/?p=4919
45. Compañ-Rosique, P., Molina-Carmona, R., Gallego-Durán, F., Satorre-Cuerda, R., Villagrá-Arnedo, C., Llorens-Largo, F. A guide for making video games accessible to users with cerebral palsy. Univ. Access Inf. Soc. **18**(3), 565–581 (2019). https://doi.org/10.1007/s10209-019-00679-6
46. Sancho Nascimento, L., Zagalo, N., Bezerra Martins, L. Challenges of developing a mobile game for children with down syndrome to test gestural interface. Inform. (Basel). **11**(3) (2020). https://doi.org/10.3390/info11030159
47. Jaramillo-Alcázar, A., Arias, J., Albornoz, I., Alvarado, A., Luján-Mora, S. Method for the development of accessible mobile serious games for children with autism spectrum disorder. Int. J. Environ. Res. Public Health. **19**(7) (2022). https://doi.org/10.3390/ijerph19073844
48. Mäkipää, J.P., Norrgård, J., Vartiainen, T. Factors affecting the accessibility of IT artifacts: A systematic review. Commun. Association Inform. Syst. **51**, 666–702 (2022). https://doi.org/10.17705/1CAIS.05129
49. Jaramillo-Alcázar, A., Cortez-Silva, P., Galarza-Castillo, M., Luján-Mora, S. A method to develop accessible online serious games for people with disabilities: A case study. Sustainability. **12**(22) (2020). https://doi.org/10.3390/su12229584
50. Graham, T.C.N., King, N., Coo, H., Zabojnikova, P., Gurd, B.J., Samdup, D. Design and evaluation of an exergaming system for children with autism spectrum disorder: The children's and families' perspective. Front. Virtual Real. **3** (2022). https://doi.org/10.3389/frvir.2022.817303
51. Ojeda-Castelo, J.J., Piedra-Fernandez, J.A., Iribarne, L. A device-interaction model for users with special needs. Multimedia Tools Appl. **80**(5), 6675–6710 (2021). https://doi.org/10.1007/s11042-020-10026-0
52. Ellis, B., Ford-Williams, G., Graham, L., Grammenos, D., Hamilton, I., Games, H., Lee, E., Manion, J., Westin, T. Game accessibility guidelines. (2017). https://gameaccessibilityguidelines.com/

53. AbleGamers. Accessible Player Experiences (APX). Retrieved July 7, 2022, from (2018). https://accessible.games/accessible-player-experiences/
54. Cassidy, R. Cognitive accessibility guide. Can. I Play. That? (2019). https://caniplaythat.com/workshops/basic-accessibility-options-for-cognitive-accessibility
55. Brown, M. Improving Games for Those with Cognitive Disabilities| Designing for Disability. [YouTube] (2019). https://www.youtube.com/watch?v=ObhvacflOg0
56. IGDA-GASIG: (n.d.). On cognitive accessibility guidelines. https://igda-gasig.org/get-involved/sig-initiatives/resources-for-game-developers/sig-guidelines/on-cognitive-disabilities/
57. Capcom: Street Fighter IV. [Video game] (2009)
58. Firaxis Games: Civilization V. [Video game] (2010)
59. Blizzard Entertainment: Overwatch. [Video game] (2016)
60. BioWare: Mass Effect: Andromeda. [Video game] (2017)
61. The Coalition: *Gears 5*. [Video game]. (2019)
62. Obsidian Entertainment: Grounded. [Video game] (2020)
63. PlatinumGames: Nier: Automata. [Video game]. (2017)
64. The Coalition: Gears of War 4. [Video game] (2016)
65. Bethesda Game Studios: The Elder Scrolls V: Skyrim. [Video game] (2011)
66. Capcom: Resident Evil 4. [Video game] (2005)
67. Ubisoft Montreal: Assassin's Creed Origins. [Video game] (2017)
68. Obsidian Entertainment: The Outer Worlds. [Video game] (2019)
69. Final Form Games: Jamestown: Legend of the Lost Colony. [Video game] (2011)
70. Naughty Dog: Uncharted 4: A Thief's End. [Video game] (2016)
71. Quantic Dream: Detroit: Become Human. [Video game] (2018)
72. YCJY Games: Post Void. [Video game] (2020)
73. Telltale Games: The Walking Dead. [Video game] (2012)
74. Red Barrels: Outlast. [Video game] (2013)