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In-game photography

Annet Dekker in Conversation with Marco De Mutiis

Dekker, A.; De Mutiis, M.

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*Annet Dekker in Conversation with
Marco De Mutiis*

Game art has been around since the early days of gaming. On the one hand, there is modding and machinima in which artists from the 1990s, such as Orhan Kipcak and Reini Urban (*ArsDoom*, 1995), JODI (among others, *Untitled Game*, 1996–2001 and *Max Payne Cheats Only*, 2004), Thomson & Craighead (*Trigger Happy*, 1998) or Natalie Bookchin (*The Intruder*, 1999), were really dissecting and reappropriating the technical medium of game software at the core. This type of game art is still going strong and is being recognised more and more within the art world. For instance, the ‘Open World: Video Games & Contemporary Art’ exhibition at the Akron Art Museum (19 October 2019–2 February 2020) and the Machinima Film Festival in Milan are two recent examples. Adding to game art is the phenomenon of in-game photography. Here, instead of changing the game mechanisms or aesthetics, specific elements from the game or the game play are documented, so, unlike mere screen captures, in-game photography is a way of interacting with the media from the inside. While some icons in in-game photography have emerged, their relation to documentation practice beyond the game world has been given little attention. Usually seen as mere advertisement to highlight the realism of the game¹ or as part of the game play, I wondered not only what the value of in-game photography could be for the documentation of games and their future history (i.e., preservation) but also how their methods could be useful to capture and preserve digital art more broadly. Discussing in-game photography with Marco De Mutiis, Digital Curator at Fotomuseum Winterthur and a PhD researcher at London South Bank University who is interested in photography as and against game, we want to explore not only how in-game photography provides and limits the documentation potentials but also how in-game photography can expand documentation practices.

Can you explain what in-game photography is and how it evolved?

In-game photography is an umbrella term that emerged in the early 2010s to define practices of screenshotting game worlds with an artistic and photographic approach. Aside from the simple screenshot function, more recently games have implemented ‘photo modes’. These are dedicated softwares that pause the game and simulate the camera function, allowing players to compose and take pictures. These functions emerged most prominently in 2014 when *The Last of Us* (Naughty Dog, 2013) was remastered for the newly launched PlayStation 4 to feature improved

graphics and the introduction of a photo mode. Since then, most AAA game titles with photorealistic graphics feature a photo mode. These functions have become so popular and taken for granted, that players would put pressure on the developers to introduce photo modes in their games – like it happened with *Death Stranding* (Kojima Productions, 2019) for PlayStation 4. In-game photography has seen many players focusing on the photographic quality of the game. Currently, there are entire communities who take pictures of landscapes, cars, portraits and other photographic genres in games. All these approaches are creating images that only marginally document the gameplay, but they do tell us something about games and their players, the relationship between them, as well as the relationship between the game industry and the value of player generated screenshots.

What has changed is the development of photorealistic simulations. With the boom of the game industry that has seen millions of players living within game worlds the boundaries blurred between the dichotomy of virtual/real that was perceived in the nineties and early noughties. At the moment, simulations and physical worlds live in a feedback loop where they influence each other. This can be witnessed in a game such as *Grand Theft Auto V* (Rockstar Games, 2013) that has been used to train systems for self-driving cars deployed in actual cities, and the way gamification has been affecting commerce, social interactions and basically everything else. Perhaps that's one of the reasons why in-game photography became so popular – it blurred the boundaries between screenshotting the screen and taking pictures of the phenomenic world.

However, I believe the introduction of photo modes paradoxically restricted the kind of images that are being taken in games, or at least encouraged a more narrow definition of photography. In comparison to the screenshot, which could be considered the perfect photo in the sense that it is a 1:1 exact replica of what the screen shows, photo modes introduced tools that simulate the analogue camera and cinematic effects: it provided depth of field, aperture, vignetting, zoom and removed the game interface. Photo modes invite the player to think through a nostalgic idea of analogue photography, capturing emotions and beauty, and eventually really focusing on the standardised aesthetics (and content) of what could be called Instagram influencer photography. This way of capturing and aesthetic standardisation has accelerated when PlayStation 4 introduced a SHARE button directly on the console controller, thereby encouraging players to share their images directly to social media platforms, such as Facebook and Twitter. In the game, players can access photo modes and create the composition of their image, and then they hit the SHARE button on the controller to upload their image online. Photo modes, in connection with PlayStation's SHARE button, create a dedicated game space and infrastructure that facilitates the creation of photographic simulations and the distribution of these images on the networked spaces of the attention and sharing economy. In other words, this feature merges the photographic act of capture with the circulation of the image on social media, equating taking a picture with sharing a picture, and it allows game companies to use the free labour of players to create more content that fuels online commercial platforms based on attention economy.

Rather than a way to simply document the game object, in-game photography privileges an artistic creation that shows the game world in a new light, and can be reread and experienced through the lens of 20th-century analogue photography. In terms of documentation, an unmodified screenshot, which shows the interface and the game HUI, can be considered a more objective representation of the game world, while photo modes create a documentation of the in-game photography phenomenon instead of the gameplay. They document the attempt of photo modes to hide the software, and to appear as an analogue photograph instead. A good example of this is ‘gamifications of street photography’ where players can score points based on the aesthetic evaluation of their ‘decisive moments’ in the game. Here photography is simulated in the core mechanisms of the game, and the camera transforms into an apparatus endowed with time traveling and supernatural features, photo-safari simulations, paparazzi role-plays, sports photo reportages gameplay and games that employ photography as evidence within game missions. This not only shows the diverse approaches used by game developers to try and incorporate different definitions of photography, but also reveals the significant lineage of photography in games.² Yet, an example of a practice that does not mod or break the game is Alan Butler’s project *Down and Out in Los Santos* (2016–present). Butler turns the attention on the process of simulation performed by game developers by taking screenshots of the simulated homeless non-playable characters (NPCs) in *GTA V*. He documents how Western game companies ‘see’ the world and understand society. These homeless NPC have no game functions and are merely there to provide realism just like extras or props in a movie. In this sense, the project seems like a traditional photographic work but actually opens up the layers of mediation and the ideologies that these images carry within themselves.

You seem to make a connection between games and art that happens on the level of documentation through the creative use of in-game photography. While this happens in a digital realm it still largely follows the conventions of analogue photography, that is positioning the camera, the specific framing, etcetera.

Yes, indeed, at times these worlds can be seen to collide with documentation practices. For example, Roc Herms’ photobook *Postcards from Home* (2015) documents his experience in Sony’s now defunct virtual world *PlayStation Home*. The book not only captures a meaningful social space, the lives and the interactions of players through a photojournalistic approach, but is now also a document that preserves a world that has disappeared when Sony pulled the plug on the project on 31 March 2015. The book follows a linear narrative, taking the reader from encounter to encounter. It feels similar to the tradition of the ‘Fotoroman’, but it can equally be seen as a printed documentary created to survive the disappearance of the online space. Herms spent five years documenting different communities and practices of players of *PlayStation Home*, until the day the platform was taken offline – or what the users of Home called ‘the end of the world’. While technically more of a social media platform than a game, Herms’ photographic interventions break with the normative ways in which players would interact in

PlayStation Home. I find the tension between gameplay and photographing very interesting.

Games always impose rules and as a player you always have to deal with the authority of the game, embodied in the game obstacles and goals. The game is not a free space of play, but a structured and regulated place that pushes the player towards a specific path. In that sense, to decide to go and take pictures of landscapes or NPCs in games is an act of resistance, or even rebellion. In some games, your character might risk being attacked and ultimately die if you try to take screenshots instead of following the rules of gameplay. While screenshotting is not altering its source like modding practices, conceptually it can be seen as a form of transformative play, which is an act of re-appropriation of the game to enable creative expression.³ It could also be considered a form of counterplay, which Alan F. Meades defines as play that goes against ‘the general expectation of compliant conventional play’.⁴ Early forms of in-game photography might endanger the player’s character and get in the way of the goal of winning. In other words, the gameplay is in contrast with the photographic activity: shooting the screen versus being shot in the game screen. That’s why I think photo modes tame and even nullify the resistance of in-game screenshotting. They bring back the photographic act within the safe boundaries of the game, they pause the gameplay and negate the risks. They standardise the aesthetics of the images that can be produced, and they remove the friction between the player-photographer and the gameplay.

Similarly, I became really interested in the intertwined relation of the different actors and power relations that unfold in this networked media ecology around photography and gaming. On the one hand, there is the computer game industry that has been obsessed with the creation of photorealistic graphics. Unlike Indie developers and smaller creative studios, big game companies have pushed the development of computer-generated imagery (CGI), attempting to achieve lifelike simulations and images that are indistinguishable from photography and cinema. By introducing these photo tools into the game, they have reached an ambiguous state of representation that mimics photographic quality. On the other hand, there are many images circulating on social media platforms that are ‘gamified’: this ranges from gamers who post their score points, to Instagram influencers whose images are part of a ‘game’ of metrics and quantifications in the forms of likes and followers, thereby turning photographic practices into a game of scoring the highest number of likes. All of these are based on models of quantified attention and point systems, each uses at their core a game mechanics and they connect through photography practices.

You mentioned in the beginning that there are many communities capturing elements of gaming worlds, while you alluded to some specific interest in topics and aesthetics of in-game photographers, have you recognised whether these groups also document for the sake of posterity – to capture something of the game before it disappears, as a legacy document?

There are many communities of self-defined in-game photographers and virtual photographers with different approaches and on different platforms. At the

beginning most groups would be on Flickr, which was always presented and considered a platform for photography. One of the most prominent communities of in-game photographers formed around the professional capture artist⁵ Duncan Harris aka *Dead End Thrills* and his now defunct forum. His Flickr group *Undead End Thrills* (www.flickr.com/groups/deadendthrills/) was set up in 2010 and enforced strict photographic principles: ‘No huds, letterboxing or watermarks, No cut scene shots, No photoshopping, Lightroom edits or colour grading in post, Full camera control is crucial to the process, Choose your aspect ratio and framing carefully, Use the description field’.⁶

Another popular Flickr group that was created in 2013 is *Landscape photographers of In Game Worlds* (www.flickr.com/groups/landscapesoflossantos/). This group started with posting images of the landscape photographers of the fictional setting of the game *GTA V*, Los Santos and Blaine County, but later also accepted other game landscapes and hence changed its name. Their rules state: ‘No “selfies”. No crotch shots. No dead animals. No shootings or killings. There are plenty of places for those! This is a place for landscape pictures only. They can be rural or urban’.⁷ The discussions on in-game photography Flickr groups are also telling of the photographic mindset that player-photographers share in their game experience. They discuss lighting and compositions of the images, remind other members to submit pictures that align with the style of the group, propose creative projects and exchange (real and in-game) camera tips.

In both cases, the rules of the groups show the photographic approach and the rigor that underline the difference between simple game screenshotting and in-game photography in the eyes of these communities. Interestingly, the *Dead End Thrills* group has a Photoshop ban, which resonates the rules that the World Press Photo award have put in place (www.worldpressphoto.org/contests/2021/photo-contest/verification-process/what-counts-as-manipulation). Similarly, there are artistic communities with a strong knowledge of the history of photography, like the group *INGAME* on the Russian social media platform VK (<https://vk.com/ingameph>), where they even created a recontextualisation of Japanese photographer Daido Moriyama’s work and methods: https://vk.com/wall-122046911_1508. Moriyama’s practice in the 1960s and 1970s was often moving away from the polished European style of the time, to experiment with the photographic medium through grainy, out of focus and blurry found images. Konstantin Remizov of the *INGAME* group attempted to recreate this style within the car racing game *Driv3r*.⁸ So, you can see how these photographers and their communities are very much looking at the models and methods of the established photography institutions, and how they refer to the history of the medium.

At the same time, many games have their own social media platforms, where players can upload pictures and videos straight from the game. While these are usually created by the game companies, they mimic the logics and mechanics of social media platforms. *Rockstar Social Media Club*, for example, employs the image grid interface as well as likes and followers like Instagram and similar platforms (<https://socialclub.rockstargames.com/photos>).

All these examples can be seen as documentations of games, yet they also acquire value as potential advertisement for the games, produced by a form of players' 'free labour',⁹ or 'playbour'.¹⁰ At the same time, and precisely because they are more valuable for marketing purposes than long-term documentation of computer game worlds, these images rely on the circulation on corporate platforms which are extremely fragile in terms of preservation, as they are connected to business models that do not value archival efforts or long-term preservation.

As part of a workshop on the preservation of digital art and games I once interviewed someone who was involved in developing and teaching games, and he mentioned the importance of preserving the gameplay rather than the game elements.¹¹ How do you see the tension between keeping the gameplay functioning versus the documentation of (part of) these worlds?

Games require players, so I agree that the core experience of gameplay cannot be properly documented through images. There are a lot of efforts to preserve games through emulation strategies,¹² but at the same time many games that were dependent on a specific platform have disappeared and continue to live on unstable infrastructures – think of early iPhone games and Apple's recent Arcade platform.

Pictures of game screens are more interesting in documenting specific moments during gameplay and of course the looks and feel of the game world. For example, in the 1980s Polaroids were used to take photographic proof of high scores. The results were submitted to companies like Activision who would reward the player with a fabric patch. Ironically, David Crane, the co-founder of Activision, reported in an interview that these pictures were not archived and preserved, and are now lost.¹³ Screenshots in the nineteen nineties were mostly taken to commemorate funny moments or glitches, in a way that Betsy Book compared to tourist snapshots.¹⁴ One could say that, paradoxically, the photographic prints which were created with a clear intention to document a fact did not survive a few decades, while the digital screenshots of personal game memories had better chances of survival thanks to the properties of circulation of networked images.

So, even though I think that a game is a work that needs to be experienced, to be played and not just contemplated, at the same time these images give us insight into the ways other players have experienced the game, subverted its gameplay or submitted to it. Interestingly, I think in-game photography serves a double function: it not only documents the social and cultural context that games live in, but it can also serve as a political act of refusal or reinforcement of specific image economies and politics.

Another platform that may be relevant in this respect is Twitch, which launched in 2011 initially as a general video live streaming site but it became also important to gamers who started to livestream their gaming sessions. Although the hope of the start-up was to make money from people watching others play, for me it became interesting as a documentation platform where I could watch the gameplay evolving.

It's funny to think of Twitch through the lens of preservation, because the platform was born very much with the idea of live streams that would disappear.

Having said this, the emergence of *Let's Play* videos on YouTube and Twitch is very interesting because indeed it makes the case for a way to experience gameplay through spectatorship and interaction with the player, rather than directly with the game. *Let's Play* videos are a universe in themselves, and showcase the many different ways you can play. From Walkthroughs to Speed Runs, from power players with no voice commentary who collect all achievements to casual gamers who entertain the viewers narrating their experience, *Let's Play* videos visualise what kinds of subjects games create.

At the same time, game arcades in the nineteen eighties and nineties already had that social aspect of people standing around players, watching someone else's gameplay and interacting with each other. Also consoles and pc-gaming created very social spaces in the pre-networked multiplayer era – gathering at a friend's house, taking turns to play and watch, for example. I think Twitch brought back that aspect in contemporary networked society, adding more layers of entertainment labour of the influencer age. The figure of the Twitch streamer privileges a monetary transaction in which viewers can give donations, on top of the quantification of popularity through followers and live view counts. Twitch streamers and YouTubers are often depending on the content they create to earn their income, which is a significant difference from other forms of offline gameplay spectatorship.

Sometimes I look at the Twitch channels of so-called 'virtual photographers'. They stream their in-game photography activities, going through photo modes in real time, and taking pictures in games. I'm interested in the way they understand photography and how they go into these spaces with a photographic mindset, showing the process of creating the images. I enjoy witnessing the interaction with the viewers in the chat and how they negotiate the composition with the player. I was just watching a stream where someone in the chat was writing instructions to the streamer, who was taking pictures of a car: 'Get the car when it's just coming into the light and use a long focal length for compression. This way the car is in the sun but the tunnel lights look closer behind' (www.twitch.tv/deadeyesunny/video/1146570951 at about 1:04:50). I really enjoy the idea of a shared participation and the collective effort behind a photograph, rather than the traditional romantic notion of the photographer as the sole author. Obviously, this stream has disappeared, which proves my earlier point of live streams and how tech and preservation is at odds with each other.

In general, I think the network still offers a participatory approach that allows communities to come together and create, appropriate and preserve content in a collaborative way. They can be alternative to institutional blind spots, and detached from the logic of authorship that regulate the art market. While these spaces are far from being neutral places for social encounters and disconnected from the corporate logics of platform capitalism, it's important to recognise these practices from the point of view of institutions. How can we rethink and expand museum collections through a shared network of 'care', rather than isolated ivory towers, hoarding artworks in storage rooms? How can museums support artistic and cultural processes that take place through a network of stakeholders, rather

than the individual artist as sole author? And finally, most preservation and collection strategies in museums (especially in photography at least) mostly focus on final physical objects organised around concepts of scarcity and numbered according to editions. How can institutions preserve contexts, processes and discourses that are inseparable from the final works?

What in your opinion is the best documentation strategy you have seen in gaming from which institutions could learn about the preservation of digital art?

I think the game Doom can offer interesting insights for ideas of documentation, while simultaneously challenging some notions of preservation and the relation between original and copy. Doom was released in 1993 and was purposely created to make it easy for players to modify it and extend it. The game was developed with the ideals of copyleft and hacker culture at its core, and basically singlehandedly spearheaded the modding phenomenon of re-appropriating and transforming video games. This means that Doom has survived through the decades, but it has also been transformed tens of thousands of times through different mods. In some ways, Doom modding has become a form of using the game to create social commentaries, like in the latest NFT Doom mod¹⁵ where you take pictures of NFTs instead of monsters, or Selfie Doom¹⁶ where a game weapon has been swapped for a selfie stick. And yet, they are also all 'still' Doom, with the original code still needed to run every mod. Finally, Doom has also become famous for running on any machine, surviving the updates of all current computational technologies. 'It runs Doom' has become a meme because the game is so ubiquitous, re-released many times both officially and not, on the most unusual platforms, almost 30 years later. These include DSLR cameras,¹⁷ office phones,¹⁸ oscilloscopes,¹⁹ mp3 players²⁰ and even pregnancy tests.²¹

Doom shows how culturally meaningful digital and networked media can circulate via all kinds of devices, adapting and surviving through the decades, thanks to communities of individuals who re-appropriate technologies. It also shows what is possible when ideologies of free distribution and modification of intellectual properties are incorporated in the production of cultural objects, rather than exploiting open source efforts for corporate gains and keeping content locked in black boxes and proprietary systems.

Concluding remarks by Annet Dekker

Games are conducive to photography, if only because they have a camera that can be controlled by a player. As a result, and due to the close relation and at times integration of games and social networks and at times integration of social networks into gaming platforms (such as Steam), game players actively share their achievements and impressions. Documenting particular moments and spaces within games, such as screenshots of game glitches and 'fail' moments, collection of found digital artworks decorating the locations of First Person Shooters and photographic reportages of specific game characters and landscapes, transformed the role of in-game photography into artistic works of appropriation and

commentaries on the political and social layers embedded in the creation of computer games. While it could be said that these images only marginally document the gameplay, they convey fragments about games and their players, the relationship between them, as well as the relationship between the game industry and the value of player generated screenshots. As such, in-game photography can be understood as a vernacular practice of documentation of digital content and artworks. On the one hand, such images and interventions challenge the notions of the conventional aesthetics of documentation in particular of interactive and participatory art. On the other hand, these practices show how audience documentation that is not made with the purpose of preservation can still be considered to be valuable for future (re)presentation of vernacular culture. Moreover, it emphasises how documentation from a functional perspective changes into a potential aesthetic form in which re-appropriation challenges the boundary between the role of the player and the artist.

The aesthetic quality of in-game photography can be connected to the realism of the game world or the decisive moment in the gameplay, but also more trivial aspects such as a mouse pointer or other elements of the interface in the image can provide contextual information of how the game was played (or the image was made). Yet, next to looking at the aesthetics of what in-game photography depicts it is important to understand their operational or functional aesthetics. Unlike memes that are copied and modified and shared everywhere, in-game photography has inherited the authorship model of the analogue photograph of the 20th century. Similarly, many game companies still hold on to their power of proprietary owners. However, when inserting creative possibilities into the game and relinquishing some control over their product shows the transformative dimension of in-game photography and how such documentation can expand beyond the game itself. Here, as mentioned by De Mutiis, the act of in-game photography is no longer attached to the creation of a fixed image, whether in the form of impressed film or of a screenshot saved file on a computer, but it also is merged with the immediate act of sharing. As a circulatory and mostly amateur-based practice in-game photography can be regarded as 'resistant' or as counter examples of documentation practices currently undertaken in museums. At the same time, and despite their circulation in various platforms or getting thousands of likes, these images are part of a 'poor image' ecology of networked images in which they cannot be saved or downloaded easily. In their natural habitat, they lead precarious lives; once a platform or a company decides to stop their activities, the images are likely to end up in the dark corners of the web or are deleted altogether. Clearly, our discussion merely touched upon some of the more general aspects of in-game photography, more should be explored about the specific conditions under which these images are created to better comprehend their value and potential influence. In the meantime, the role of the museum or archival institution could help to secure long-term survival of in-game photography while acknowledging their 'amateur' and distributive characteristics as well as their potential evolving nature.

Notes

- 1 Sebastian Möring and Marco De Mutiis, “Camera Ludica: Reflections on Photography in Video Games,” in *Intermedia Games – Games Inter Media: Video Games and Intermediality*, eds. Michael Fuchs and Jeff Thoss (New York: Bloomsbury Academic, 2019), 69–94.
- 2 In 2018 The Photographers’ Gallery commissioned *Camera Lucida*, a video essay about in-game photography in which De Mutiis showed several in-game examples, see <https://thephotographersgallery.org.uk/whats-on/camera-ludica>.
- 3 Katie Salen and Eric Zimmerman, *Rules of Play: Game Design Fundamentals* (Cambridge, MA: The MIT Press, 2004).
- 4 Alan F. Meades, *Understanding Counterplay in Video Games* (London: Routledge, 2015), 1.
- 5 Capture artists are people who screenshot games for game companies. They are usually given early access to games, and they create images for the marketing and communication of the game.
- 6 Group rules of Undead End Thrills Flickr group. www.flickr.com/groups/deadendthrills/.
- 7 Group rules of Landscape photographers of In Game Worlds Flickr group, www.flickr.com/groups/landscapesoflossantos/.
- 8 For more information, see https://vk.com/wall-122046911_1508.
- 9 Tiziana Terranova, “Free Labor. Producing Culture for the Digital Economy,” *Social Text*, 18, no. 63 (2000): 33–58.
- 10 Julian Kücklich, “Precarious Playbour: Modders and the Digital Games Industry,” *The Fibreculture Journal*, 25, <https://five.fibreculturejournal.org/fcj-025-precarious-playbour-modders-and-the-digital-games-industry/>.
- 11 Annet Dekker, “Serious Archiving. Annet Dekker in conversation with Jeroen van Mastrigt,” in *Archive 2020: Sustainable Archiving of Born Digital Cultural Content*, ed. Annet Dekker (Amsterdam: Virtueel Platform, 2010), 7.0–7.10.
- 12 Emulation technology uses software to replicate a game hardware environment. The Internet Archive has preserved thousands of Flash, PC and MS_DOS games through emulation. Emulation has also been used officially by Nintendo and PlayStation to offer games from older consoles. Free ROMs are also available for download by many independent websites.
- 13 Mikael Jakobsson, “Achievements,” in *Debugging Game History: A Critical Lexicon*, eds. Henry Lowood and Raiford Guins (Cambridge, MA: The MIT Press, 2016): 22–35, 27.
- 14 Betsey Book, quoted in Cindy Poremba, “Point and Shoot: Remediating Photography in Gamespace,” *Games and Culture*, 2, no. 1 (2007): 49–58. <https://doi.org/10.1177/1555412006295397>.
- 15 “NFT Doom,” www.moddb.com/mods/nft-doom/downloads/nft-doom-a11.
- 16 “Selfie Doom,” <https://doomwiki.org/wiki/InstaDoom#:~:text=Selfie%20Doom,-InstaDoom%20includes%20a&text=It%20consists%20of%20a%20single,popular%20on%20social%20media%20sites>.
- 17 Raccoon, “Playing Doom on a Canon EOS RP,” *YouTube* (19 January 2022), www.youtube.com/watch?v=zytIWGzpoSk.
- 18 Neil Bostian (@NeilBostian), Twitter (2 August 2021), <https://twitter.com/NeilBostian/status/1422014712326279171>.
- 19 Stephen English, “Doom on a Scope,” *YouTube* (1 December 2006), www.youtube.com/watch?v=GTApvwqZ_TM.
- 20 tony na, “Playing doom on a mp3 playe,” *YouTube* (14 March 2016), www.youtube.com/watch?v=op843cRGkNU.
- 21 Caroline Delbert, “This Programmer Figured Out How to Play Doom on a Pregnancy Test,” (11 September 2020), www.popularmechanics.com/science/a33957256/this-programmer-figured-out-how-to-play-doom-on-a-pregnancy-test/.