Computers in Human Behavior Reports 11 (2023) 100304

Contents lists available at ScienceDirect

Computers in Human Behavior Reports

journal homepage: www.sciencedirect.com/journal/computers-in-human-behavior-reports

Older adults' motivations in game based systems: Heuristic definition and its connection with fun

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ARTICLE INFO

Keywords:
Older adults
Motivations
Game bases systems
Player experience
Learning
Fun

ABSTRACT

Efforts are currently being made to generate wellbeing in the elderly population in order to achieve a good quality of life through the improvement of health, social interaction and psychological health. This is achieved, in addition to other options, through the application of game-based systems, presenting positive results that have been evidenced in several studies. These types of approaches are not only applied for entertainment and leisure, but also for learning and generating positive feelings, as a means of escape from loneliness, isolation, health improvement and support in daily life. Although these experiences are gradually being applied to the older adult population, they have usually been oriented to a young population with different characteristics, needs and motivations, where technological mastery is taken for granted. This makes an older adult feel limited when initially interacting with this type of experiences, which prevents them from fully using and enjoying these technological solutions. In this article, different motivational aspects that encourage older adults to use game-based systems (for learning, fun, health, etc.) were identified and characterized in order to increase the use of this type of technologies, and to improve the design and evaluation of these experiences to obtain greater enjoyment from the end users. These aspects were represented by a motivational model and then established as a set of heuristics. These heuristics were evaluated by means of an expert judgment focused on the design of game experiences, obtaining positive results for the use of these elements as guides in the design and construction of Game-Based Systems oriented to older adults. This set of heuristics and their application were published in the PL/PX web platform for detailed explanation, access and use by the academic community.

1. Introduction

Older adults are a representative group in the digital gamers (Entertainment Software Association, 2022, pp. 1–25). These numbers, although positive, could be better, due to the fact that in many occasions the older population sees in digital games a waste of time as a leisure and entertainment center, which is not oriented to their particular motivations. This mistaken vision is given, among other things, by the existing technological gap of a non-digital native population, in addition to a reduction of the functional capacity of the natural state of the human being as a result of the aging process (Ling et al., 2023). Just as this population has its physical and cognitive particularities, they also have their own personal motivations that lead them to achieve a state of interaction with this type of experiences, being necessary their identification and full understanding in order to design engaging and attractive experiences, achieving states of wellbeing, learning, fun and experiencing positive emotions.

Older adults have different motivations than the younger population because human beings change their social orientations and goals during their lifetime (Carstensen, 1995). The older population perceives future time as something limited, prioritizing emotional objectives, avoiding experiences with aversive effects, such as time pressure to complete challenges or the frustration of not achieving some challenges due to their high complexity. In contrast, young people perceive time as

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https://doi.org/10.1016/j.chbr.2023.100304
Received 8 May 2023; Received in revised form 31 May 2023; Accepted 1 June 2023
Available online 9 June 2023

unlimited, prioritize learning new things and do not mind aversive experiences with duration limitations and high difficulty; on the contrary, this drives and motivates them to play (Carstensen, 1995; Possler et al., 2017).

Although the elderly population is a heterogeneous population group (D'Haeseleer et al., 2022), there are some behavioral patterns that allow a characterization of the motivations of this population. Like all human beings, older adults have intrinsic and extrinsic motivations. Intrinsic motivation" is the one that comes from the person himself, motivating the person to perform different activities without the need to receive external stimuli such as a reward. Extrinsic motivation" is that which is generated through stimuli that come from outside the individual, such as rewards and incentives for the performance of tasks and activities, regardless of whether they are really to their liking or not (Sansone & Harackiewicz, 2000).

Traditionally, game experiences have been related to fun contexts in response to the given leisure and entertainment approach. Currently, there has been a change in this concept due to the dependence between the game-based system presented and its purpose. It is possible to find benefit-oriented game experiences such as learning and health where entertainment and fun are treated as an optional aspect, being this applied in all generational groups (Figueiredo & García-Peñalvo, 2022; Padilla-Zea et al., 2022; Sein-Echaluce et al., 2022). From this it is concluded that fun and game motivation are independent concepts that in an ideal state can be together. However, this is not always the case, since one can be motivated to play because of the rewards to be obtained, even if the game experience is not fun during its execution. Motivation generates satisfaction when performing a set of activities in a specific context. On the other hand, fun generates joy in the participant. When these elements are found in a game experience, a state of enjoyment is generated, achieving relaxation, wellbeing and good mood in the older adult (Kari, 2020). To explain this, we have constructed the following image. (see Fig. 1).

Based on the above, this paper proposes a model of motivational aspects in older adults to improve their interaction with different types of game-based systems (GBS). In addition, the proposed model was taken to a set of heuristics, with their respective specifications along with a set of checklists. This was done to facilitate the creation of GBS and provide better experiences through their design, oriented to the different motivations of the population under study, which can generate a positive impact on learning processes, active aging, etc.

The paper is organized as follows: Section 2 provides a contextualization of current GBS, models of diversion and motivation not oriented to the older population. In addition, we describe our previous work on which we followed up to arrive at the results presented here. Section 3 describes the proposal on the model of motivational aspects in the elderly population for their interaction in GBS; Section 4 describes the entire methodological process applied for the definition of this model of motivational aspects and its definition as a set of heuristics; Section 5 gives a detailed description of the results obtained in the process of validation of the proposal through expert judgments, as well as the entire set of heuristic specifications made with their checklists; finally, Section 5 presents the discussion, conclusions and future lines of work; Section 6 presents the results obtained in the process of validation of the proposal through expert judgments, as well as the entire set of heuristic specifications made with their checklists; finally, Section 6 presents the discussion, conclusions and future lines of work.

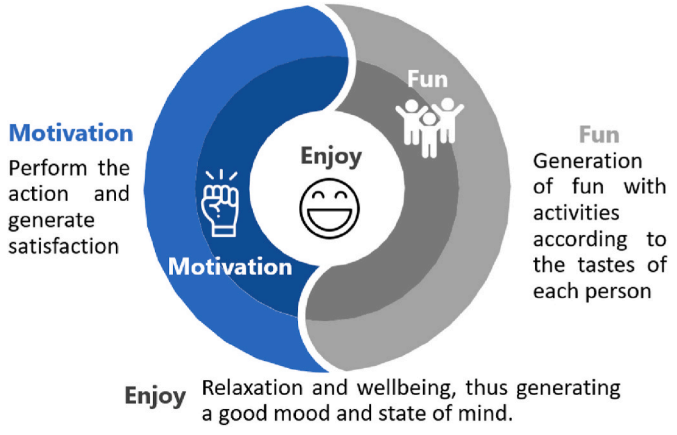

Fig. 1. Motivation and fun in older adults.

2. Background

The universe of education and digital games requires, like other areas of knowledge, motivation of the participants. This applies to serious games with a specific purpose as well as any other type of game-based system. The definition of game and its integration with all types of systems is becoming more and more widespread. Being relevant the incorporation of Gamification for the increase of motivation for the realization of activities that do not necessarily have a leisure and entertainment orientation (Salazar Cardona et al., 2021). One of the most relevant proposals that classifies the different GBS is called "Game Thinking" (Marczewski, 2015a). It defines 5 types of GBS according to their purpose: Serious Games (games that do not focus on fun, but on deeper purposes such as learning, health or similar), Gamification (use of game elements in non-game contexts), Simulation (virtual world with high similarity to the real world that allows learning, practicing and testing in a safe way), Playful Design (ideas such as designs and illustrations that are inspired by games or the way they should be written) and Game (games with the purpose of entertaining).

The field of Human-Computer Interaction (HCI) is used, among other things, to evaluate the game experiences of older adults with GBS, using techniques and tools designed for a general population to determine the impact of games on older adults (Rienzo & Cubillos, 2020). Although there are many means to evaluate this type of experiences (Sánchez et al., 2012), for the older population, their particularities must be considered through the adjustment of these means of evaluation in order to evaluate the game experiences in an objective way. However, these adjustments or adaptations are insufficient to evaluate the context of games due to the specific and subjective elements of the area (González & Gutierrez, 2010; Salazar Cardona et al., 2021), and even more so when the traditional concept of usability is used instead of the concept of playability.

It has been identified that some of the techniques and tools applied in the older adult population to evaluate these experiences are the Game Experience Questionnaire (GEQ) (Ijsselsteijn et al., 2013), Player Experience Need Satisfaction (PENS) (Rigby & Ryan, 2004), System Usability Scale (SUS) (Brooke, 1995), Technology Acceptance Model (TAM) (Davis, 1989), among others (Salazar et al., 2022). These, although they offer good results, could be better, since it is necessary to fully adjust them to the context of the older adult population, not only to evaluate the experiences offered, but also to provide support for the design of GBS more suited to this population.

When evaluating the experience of GBS, the "Playability" property has been used for this type of technology products because of its ability to adapt the usability property to game systems, being a more accurate measure of how much fun a game is. Here, it should be understood that playability offers two points of view: First, the game is considered as a software product that needs to be analyzed in depth to determine its quality. Secondly, there is the quality of the "Player Experience" (PX), which is directly related to the concept of User Experience (UX), but which, referring to the context of games, must be treated differently, resulting in PX. Although the difference between the two is based on the experience that the game offers players, this should be addressed using more subjective and personal measures such as "emotion", "satisfaction" or "engagement", which are key to describe and improve the interactive

experience that humans enjoy when playing a game (Lazzaro, 2004; Salazar Cardona et al., 2021).

Therefore, it is necessary to identify the particularities and motivations of older adults in order to address the above-mentioned problem in digital games on an objective and solid basis. In order to respond to this, a preliminary process of identification of works in which game experiences were used in older adults was carried out. This identification process was carried out through a systematic review of the literature (Salazar et al., 2022) in which detailed information was obtained on the different motivational elements of GBS for this population.

This process was oriented to answer different research questions directed to older adults, among which was their acceptance in the use of games through technology, and which game mechanics/dynamics were the most used and accepted by this population. Dynamics and mechanics concepts are closely related, and because of this they tend to be confused. The dynamics in GBS establish in a general way how the mechanics and the player interact in real time. Mechanics are the various actions, behaviors and control mechanisms, thus defining how the GBS will work (Salazar Cardona et al., 2021).

To carry out this research, the methodology established by Kitchenham and Charters (Kitchenham & Charters, 2007), which defines a series of steps or phases for the application of systematic reviews in the software field, was applied. For the selection of papers, a search string was defined using logical operators and relevant words to efficiently filter the results to be obtained. Following the basic methodology, a series of inclusion and exclusion criteria were defined in order to reduce the total number of articles to be treated for the definition of what is proposed here (see Fig. 2).

Subsequently, a proposal was made on the analysis of playability in GBS (Salazar Cardona et al., 2021), which allowed not only the updated definition of the analysis of this particular field, but also identified different models and theories that would be taken as a basis for the definition of the model of motivational aspects in older adults. It was necessary to adjust them since they were not oriented to the older adult population. The theories in question are the types of enjoyment established by Lazzaro (Lazzaro, 2004) and the "Model of Intrinsic Motivation" (RAMP) (Marczewski, 2013).

The proposal made by Lazzaro on the types of fun establishes that players find fun in some characteristics and particularities that, although they should not be fulfilled in detail due to their subjectivity, give a basis on the possible elements to be taken into account to satisfy the needs in a game experience. The characterization of fun used in the proposal presented here consists of 4 types of fun: Hard fun, Easy fun, Serious Fun and People fun (Lazzaro, 2004). "Hard fun" is the fun gained through overcoming obstacles, accomplishing goals and overcoming challenges through strategy. "Easy fun" is the pleasure of experiencing game experiences emphasizing capturing the player's attention over winning. "Serious fun" is the enjoyment gained through the feelings of wellbeing offered by participating in game experiences using them as therapy. These generate emotional changes during and after the game, producing sensations such as excitement, relaxation and relief passing from one mental state to another, avoiding boredom, distracting the player, being used as therapy. Finally, "People fun" is the fun obtained through the social experiences offered by playing with other participants, interacting with them, sharing with friends, generating rivalry, cooperation and Recognition (Salazar Cardona et al., 2023).

The RAMP model (Marczewski, 2013) states that there are 4 key intrinsic motivation drivers which are relatedness, autonomy, mastery, and purpose. "Relatedness", refers to the basic human drive to connect with others, as healthy social connections are relied upon for survival. "Autonomy" refers to the human ability to influence one's own direction, as lack of freedom or voice produces stress and overwhelm. "Mastery" is the basic need to dominate and be worthy of admiration. Finally, "purpose" is the innate need to know the "why" of things. Likewise, understanding the reason why actions are performed gives clear objectives, giving importance to these and a means to measure the results This model is based on the Self Determination Theory (SDT) (Ryan & Deci, 2000) and what is established in the book "Drive" by Daniel Pink (Pink, 2009).

3. Motivation model in older adults

The following is a characterization of aspects that have been identified as highly motivating in game experiences for older adults, in order to provide a basic guide in the design of different GBS and in the experience of the older adult in relation to the game, taking as input the intrinsic and extrinsic motivations of this particular population (Salazar Cardona et al., 2023) (see Fig. 3). To consult the different theoretical references used for the identification of these motivating aspects, please review the "Appendix A".

Based on the different motivations identified in older adults that lead them to play, and based on existing reference models, the following model of motivation in older adults has been established in order to cover the specific needs of this population (see Fig. 4). In the process of defining the model, it was identified that the motivational aspects found relate smoothly to the human motivations established in the RAMP model and to the fun base approaches in a balanced way. Autonomy, mastery (which will be renamed Achievement because they do not seek mastery in specific), relationships and purpose are reflected in older adults, but with a very different focus than that presented for gamers in general.

It should be clarified that the way in which the motivational aspects of older adults with respect to the human motivations established in the RAMP model are given in the following way: the motivation and human need to relate is reflected in motivational aspects of the older adult such as participation, the need for recognition and to interact with close relatives, children and grandchildren as an intergenerational experience. At the level of autonomy, the processes of interaction, adaptation/personalization and the use of the game lead the older adult to fully experience such independence in their actions within the GBS. In

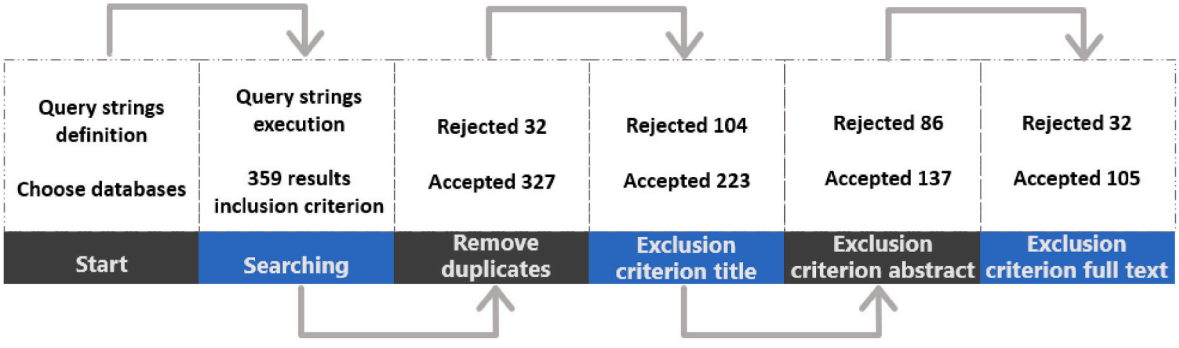

Fig. 2. Systematic literature review process.

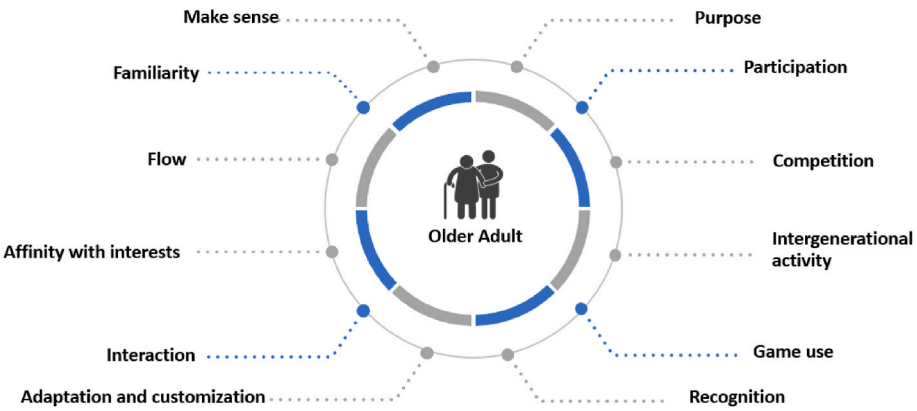

Fig. 3. Characterization of motivational aspects in older adults.

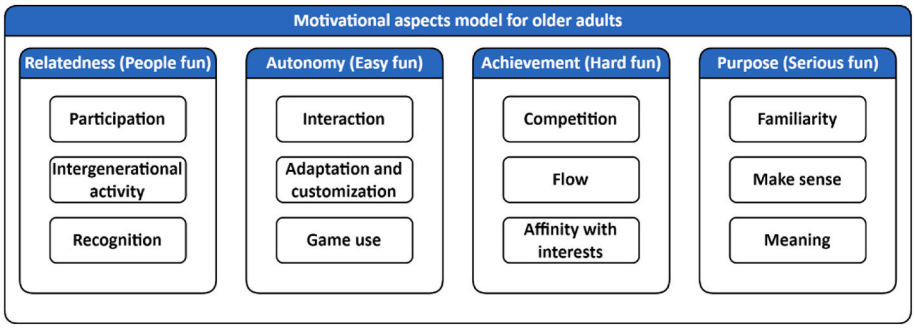

Fig. 4. Motivational aspects model in older adults.

relation to achievement, it can be achieved through competition, the flow of the game and affinity with their tastes or interests. Finally, purpose can be given to the older adult through narrative that gives a make sense to actions, utility or benefit that gives meaning, and familiarity to further entrench meaning.

3.1. Achievement

Achievement motivation in older adults is given by the need to win in a particular field, demonstrating it to oneself and to others. This is achieved by accomplishing goals in a given environment, experiencing a sense of accomplishment and victory by overcoming the different obstacles presented. Although they like to feel this type of sensation, they do not like to make others feel bad. For this reason, leaderboards and public display of results are at the bottom of motivational trends.

3.2. Relatedness

Older adults may be motivated by the need to socialize, interacting with other people and sharing with them. For this they prefer face-to-face rather than online games, because they do not want to acquire additional obligations such as connection time or waiting for other players to perform the actions corresponding to their turn. For this type of experience, cooperation/collaboration predominates as a means of socialization. They are motivated by having to work together with others in order to achieve goals, but this does not completely exclude the sense of competition regardless of victory. Additionally, older adults prefer games on the same screen shared with their counterpart, experiencing the same field of vision and thus avoiding confusion.

3.3. Purpose

The purpose in older adults is important because it gives a make sense and relevance to the use of a game-based system. If they not only have an entertainment purpose, but for example see a benefit in their daily life such as health or the acquisition of useful knowledge, it will give an added value to the experience obtained. This purpose is not only for self-benefit through external rewards as an extrinsic approach, but also at an intrinsic level in the empathy felt with an external being and the internal desire to help them. This should not be confused with "epic meaning" as the latter refers to the motivation of feeling that one is working to achieve something great, something much greater than the player himself. This is not to say that the older adult does not experience this type of motivation, but it is less frequent.

3.4. Autonomy

The motivation for autonomy in older adults comes from the need to be independent in their activities. And to achieve this, they require feedback, support and guidance to achieve such independence. In addition, autonomy is also sought due to the need of older adults to feel useful in an environment where, due to different socio-cultural factors, they may be isolated at the family and social level. Another relevant aspect is the need for recognition of the older adult in the process of achieving autonomy and independence, which is an element that strengthens the permanence of the experiences in a game-based system. This leads the older adult to become an independent user in the use and mastery of Information and Communications Technology (ICT), exploring and describing by himself what technology can offer through the confidence it generates.

4. Materials and methods

An exhaustive process of validation and definition of an instrument was carried out to put into practice the theoretical model proposed to evaluate the experience of the older adult gambler and his motivation.

To achieve this, we used the methodology for defining heuristics proposed by Quiñonez et al. (Quiñones et al., 2018), in which they establish in detail how to perform a formal process of heuristics definition with their respective validation. This proposal is composed of a total of 8 stages, which direct the process with inputs and outputs. The stages in question are the following: Exploratory, experimental, descriptive, correlational, selection, specification, validation and refinement stage (see Fig. 5). As a result of the application of this methodology, a set of heuristics was developed and validated through expert judgment. This developed process, although its results are mainly focused on the second iteration of the methodology, will detail all the steps executed for the generation of the final set of heuristics. In the first version of this only 10 heuristics specifically oriented to its application in serious games were identified (Salazar Cardona et al., 2023), but this second iteration contemplates GBS in a general way.

4.1. Exploratory stage

This exploratory process is composed of a systematic review previously conducted (Salazar et al., 2022), where information related to the enjoyment of older adults in game experiences, application focuses, acceptance, game mechanics and dynamics was obtained. In addition, the consolidation of motivations of this population and all the theoretical references that support our proposal can be consulted in "Appendix A", resulting in a motivational model oriented to older adults and their interaction with GBS. In the process of information collection, sets of heuristics of usability, playability (product evaluation), UX, and properties of these heuristics were identified. The objective of the proposed heuristics is the specific evaluation of motivational aspects to be considered for the evaluation of PX and enjoyment in older adults in GBS. That is why, although they are named in the document and are taken as a reference to determine whether this proposal contemplates elements previously raised, the proposed heuristics will have their own names and specifications seeking to be taken as a basis in the extension of playability analysis proposed by Gonzales (González & Gutierrez, 2010). This is currently the most complete and detailed proposal on playability analysis.

4.2. Experimental stage

This step has been omitted because the information was obtained from the systematic review process and, therefore, it was not necessary to perform an experimental process.

4.3. Descriptive stage

In the systematic review process carried out (Salazar et al., 2022), an approach was established to identify the different experiences applied to older adults at the physical, cognitive and wellbeing levels. In addition, the analysis focused on the identification of motivational aspects through the finding of metrics and indicators of fun, focus of attention, acceptance, game structures, playability and PX oriented to older adults. These allowed the identification of different particularities of older adults and characteristics of elements that motivate or demotivate this population in relation to game experiences. In addition, the study is based not only on our research, but also on a systematic review of interest carried out by Rienzo and Cubillos (Rienzo & Cubillos, 2020). The latter focused on game experiences, playability, motivations, metrics and game recommendations in older adults.

With respect to existing research on the game factors that motivate older adults to experience this type of experience, it is found that there is no formal model proposal that attempts to characterize these aspects. However, there are documented cases on specific particularities according to the case studies. In this, they coincide in that they are a varied population group, with interest in connecting, relaxing with friends, in obtaining a feeling of wellbeing and a taste for intellectual challenges quickly and without commitment (Rienzo & Cubillos, 2020; Salazar et al., 2022).

Regarding heuristics oriented to PX, there is the work done by Salgado et al. (de Lima Salgado et al., 2019) oriented to older adults but only in applications for mobile devices. Also the work done by Aker et al. (Aker et al., 2020, pp. 123–161) on different platforms and the work done by Marco (Marco, 2017) on PX evaluation in First Person Shooters (FPS) type games, but the latter focused on the general population. Regarding attributes and playability properties, the set defined by Gonzales and Gutiérrez (González & Gutierrez, 2010) was taken because they are the most complete and of greater reference at present. In addition, since PX is a particular case of UX, the facets defined by Morville (Morville, 2004) will be considered due to their high relevance as a general knowledge base. Similarly, the 10 usability heuristics of Nielsen (Neilsen, 1995) are considered for the same reason and their possible application to the field of digital games (Joyce, 2019).

Although there is no formal proposal of motivations in older adults that direct them to play the game experiences, the application of the Octalysis framework applied to older adults is highlighted (Gellner et al., 2021; Kappen et al., 2019; Tondello et al., 2016). As in the work of Havukainen (Havukainen et al., 2020), where they identify some general purpose motivational elements that can be applied to older adults. In addition, it was found that the Hexad player type classification model defined by Marczewski A (Marczewski, 2015b). uses the RAMP motivational model as a basis for its classification, being taken as input for the distribution of motivational aspects in older adults.

The following is a summary of the elements considered for the correlation of the model defined on motivational aspects in older adults in game experiences and their vision from the motivations (see Table 1), usability – playability (see Table 2), and PX - UX (see Table 3). The elements considered of high importance (valued at 3), are those that are applied to the context of older adults or that are the knowledge base of the area. The documents that are considered of interest (valued at 2) are those that either do not completely cover the motivations, are oriented to the evaluation of the game as a product and are not a knowledge base and/or are oriented to UX and not to PX. Finally, the documents considered unimportant (valued at 1) are those that are based on theories already taken as a reference and that were not applied to older

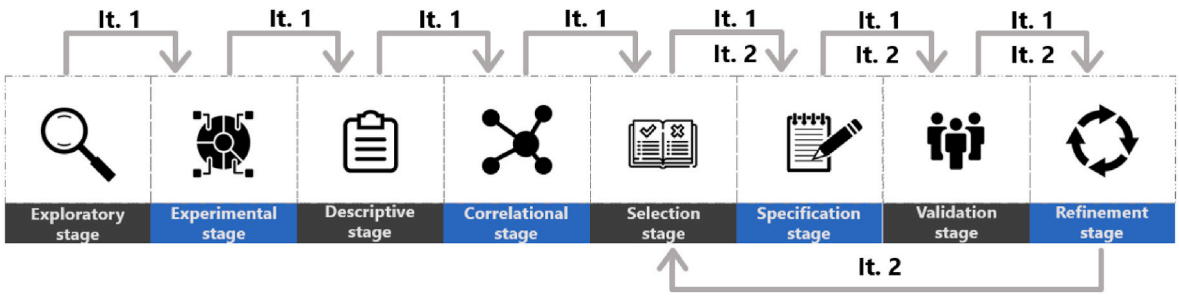

Fig. 5. Stages performed to establish motivational aspects heuristics.

Table 1
Prioritization of information obtained from motivational aspects.

ID	Value	Thematic	Information source
M01	3	Findings of our own systematic review	Systematic review conducted on a self-directed basis (Salazar et al., 2022).
M02	3	Motivation model for game experiences	RAMP Motivation Model (Marczewski, 2013).
M03	3	Octalysis Framework oriented to older adults	Evaluation of motivations oriented to the general population applied to older adults (Gellner et al., 2021; Kappen et al., 2019).
M04	2	External systematic review findings	External systematic review (Rienzo & Cubillos, 2020)
M05	2	Identification of intergenerational motivational elements	Applied case study in collaborative design between seniors and children (Havukainen et al., 2020).

Table 2
Prioritization of information obtained from playability (product) - usability.

ID	Value	Thematic	Information source
PL01	3	Playability	Attributes of playability oriented to the evaluation of the game as a product. (González & Gutierrez, 2010).
PL02	2	Usability	Nielsen heuristics as a knowledge base for the identification of potential problems in information systems, but with possible application to digital games (Joyce, 2019).

Table 3
Prioritization of information obtained PX - UX.

ID	Value	Thematic	Information source
PX01	3	Player experience (PX)	Player experience-oriented playability attributes (González & Gutierrez, 2010).
PX02	2	User Experience (UX)	User experience facets (Morville, 2004).
PX03	2	User Experience (UX)	Heuristic definitions on mobile devices, applied as a practical guide to UX evaluation (de Lima Salgado et al., 2019).
PX04	1	Player experience (PX)	Review of heuristics for evaluating player experience on different game platforms (Aker et al., 2020, pp. 123–161).
PX05	1	Player experience (PX)	PX evaluation in First Person Shooter (FPS) games (Marco, 2017).

adult contexts.

4.4. Correlational stage

Motivational characteristics of older adults in game experiences that have been documented were identified and grouped into 15 main motivational aspects. These aspects identified were usefulness/benefit, social interaction, collaboration/cooperation/coactivity, competition, intergenerational activity, type of game, recognition/feedback/support, ease of use, type of device, affinity with interests, achievement and victory, technological mastery/previous experience, familiarity, variety, and narrative. Each of these aspects were rated following the same weights as in the previous section and in turn, were assigned to each of the categories offered by the RAMP motivation model which are relatedness, autonomy, mastery and purpose. The distribution and assignment process are described in detail in "Appendix B, Table 1".

In order to demonstrate that these motivating aspects offer completeness in the areas to be addressed, they were correlated with each of the selected heuristic proposals and properties. This correlation evidenced that the proposed elements have sufficient scope to address the reference characteristics, as well as the fact that more elements are addressed that have not been taken into account in the existing definitions (see Appendix B, Table 2). The information with ID ″M01" and "M04" (see Table 1) were excluded because they were information obtained for the generation of the motivational aspects model through systematic reviews, which included application cases, but not heuristics. The information obtained with ID ″M02" (see Table 1) was excluded because it was taken as a reference for the structuring of the proposed motivational aspects model and therefore will only serve for the categorization of the defined motivational aspects. Finally, the information from "PL01" (see Table 2) will be evaluated together with "PX01" (see Table 3) because they are from the same source of information, but have different approaches.

4.4.1. Selection stage

No were found specific heuristic sets oriented to the motivation of older adults in GBS, but general-purpose playability and motivation heuristics were found. Also, user experience and usability heuristics were found, but oriented to transactional systems. As no were found specific base heuristics, it was decided to build a new set taking as reference the findings previously described. As indicated above, the nomenclature of the RAMP model and its descriptions had to be adjusted to fully adjust to the motivations of the older adult population. Autonomy, relationships and purpose are reflected in older adults, but with a different focus than that presented in a younger population. Regarding the category "mastery", it was necessary to rename it to "achievement" because this population does not seek to achieve a specific domain.

In addition, redundancy was identified in some of the characteristics previously identified, making it necessary to integrate some of these, as well as to adjust the names assigned to cover more precisely the characteristics of each aspect. With this, the number of motivating aspects was reduced from a total of 15 to only 12. "Social interaction" was eliminated as it is part of "Utility - Benefit" because it is part of the wellbeing of the human being. "Technological mastery and previous experience" were integrated to "familiarity", since it is part of familiarity at a technological level. "Variety" was integrated to "Flow", because variety generates the flow of the game in the older adult. Finally, each of the motivational aspects identified were related to the playability attributes found in the exploratory and descriptive stages, as a means by which the completeness of the identified aspects could be evidenced in "Appendix B, Table 3".

Regarding the new names assigned to some motivational aspects, we find that "Collaboration - Cooperation - Coactivity" was renamed to "Participation", because all these types of games seek to encourage the participation of the older adult in the game. The aspect "Types of game" was named as "Use of game", due to the fact that more than a typology of game, they are the characteristics themselves that make up the game and its use by the older adult. "Recognition, feedback and support" was simplified to "Recognition", as this term encompasses all the others. "Ease of use" was renamed to "Adaptation/customization" due to the fact that ease of use actually refers to adjusting the game to the particularities unique to the older adult population. "Device types" was renamed to "Interaction" because interaction is achieved in multiple ways, not just through the peripherals offered. "Achievement and victory" were renamed to "Flow" because this is the technical concept traditionally used to refer to the feeling of achievement and victory in GBS. Finally, "narrative" was renamed to "make sense" since narrative is not the only means of making sense of the game.

4.5. Specification stage

Each of the 12 motivational aspects identified was organized according to the guiding methodology, structuring them as follows: An identification code was assigned for each heuristic generated. The category of the RAMP motivational model to which each heuristic corresponds was specified (Marczewski, 2013). Also, a specific type of amusement was associated with the reference model (Lazzaro, 2004), a

name was assigned to the heuristic, a priority and a basic definition. Then, the purpose of the heuristic, the characteristic of the game-based system it affects, was explained in detail. In addition, an example application was given and the benefits of the heuristic for the older adult population were explained. Finally, possible interpretation problems of the heuristic were addressed, a checklist for the heuristic is proposed, then it was associated with a defined motivating aspect(s) and it was indicated to which attribute and playability facet it corresponds according to the reference model (González & Gutierrez, 2010). All these established heuristic specification elements were refined after the validation process, thus generating a second iteration. A total of 15 heuristics were defined from the 12 motivating aspects (see Table 4). For the detail definition of each heuristic, see the "Appendix B, Table 4".

4.6. Validation stage

Based on the guiding methodology, after defining the heuristics, we proceeded to validate them, using different means such as heuristic evaluation, expert judgment and user testing. Due to the objective of having a refined set of heuristics to be used by evaluators and users in later stages, we initially proceeded to perform an expert judgment and thus find possible improvements to the proposal made. Expert judgment is a method to evaluate a methodology, artifacts or heuristics at a qualitative and quantitative level. This in order to validate the proposal and make adjustments and improvements to the proposal if necessary.

Fourteen evaluators were recruited to apply the evaluation, the majority of whom were academics with graduate training at the master's or doctoral level. In addition to being expert researchers in the field of HCI, they had experience in the field of education and heuristic evaluation. Also, many of them had experience in the field of digital games and were familiar with design principles and needs. The participating evaluators were associated with Pontificia Universidad Católica de Valparaíso (Chile), Universidad de Caldas (Colombia), Universidad de Granada (Spain), Universidad de la Frontera (Chile), Universidad de Medellín (Colombia), Universidad Antonio José Camacho (Colombia) and Universidad San Buenaventura (Colombia). The set of evaluators included 2 experts in the care and technological interaction of older adults and 2 anthropologists in order to offer an evaluation from the approach of human motivations. Both the experts in the care of older adults and the anthropologists had no previous experience in the subject of heuristics, being necessary a previous training process in order to carry out the process in an adequate way.

Based on the heuristics defined, a questionnaire was created to be answered by the expert evaluators according to the guiding methodology (Appendix C). This questionnaire consisted of a total of 79 questions, with 4 questions for each heuristic focused on evaluating them individually with respect to the dimensions of usefulness, clarity, ease of use and the need for a checklist as a complementary element. These questions used a 5-point Likert scale where a value of 1 indicated that the heuristic did not comply with its dimension and a value of 5 indicated that it fully complied. Each heuristic had an optional question to obtain additional qualitative information that the evaluator wanted to provide. Three additional questions were added to analyze the heuristics as a whole, asking about their ease of use, intention of use by the evaluators, and completeness. Finally, 1 optional question was added to complement the missing information and to obtain qualitative results. For each heuristic, the dimensions evaluated from D1 to D4 are described below. The questions focused on evaluating the heuristics as a group from Q1 to Q3. The question available for each heuristic to obtain qualitative information from H1 to H15. Finally, the question set to obtain qualitative information about additional heuristics is included in C1 (see Table 5).

Table 4
Defined heuristics oriented to motivational aspects of the older adult population.

Id	Heuristic
AM01	Participation in the game experience
AM02	Intergenerational activity in the game experience
AM03	Providing recognition in the game experience
AM04	Pleasant interaction in the game experience
AM05	Adaptation and customization of the game experience
AM06	Use of the game experience
AM07	Offer competitiveness in the game experience.
AM08	Achieving the flow of the game experience
AM09	Affinity with personal tastes and interests in the game experience
AM10	Familiarity with the context presented in the game experience
AM11	Technological familiarity presented in the game experience
AM12	Make sense in the game experience.
AM13	Social interaction in the game experience.
AM14	Improved health in the game experience.
AM15	Offer learning in the game experience.

5. Results

Responses were obtained from the 14 experts who participated in the process (see Table 6). The results of their responses were focused on the individual analysis of the heuristic with respect to the usefulness, ease, clarity and necessity of a checklist. The results of D1 - Usefulness, showed that the mean of this is high (4.72). Heuristics 4,5,8 were considered the most useful of all. The overall standard deviation was low (its range is 0.27–0.85). As for the results of D2 - Clarity, its mean was also high (4.54), with a range between 4.29 and 4.79 where heuristics 5 and 7 were the clearest of all. Its standard deviation was also low, with the minimum value in heuristic 5 (0.47). As for the results of D3 - Ease, although the mean was the lowest of all, it is still an acceptable value (3.81). Heuristics 8 and 9 were the least easy to use (3.29 and 3.36 respectively) and heuristics 3 and 4 were the easiest. Their variance is one of the most significant with a range of 3.29–4.21. Its smallest standard deviation occurred with heuristic 1 (0.62).

Finally, regarding the need for a checklist to obtain more details, it was high (4.41), which is understandable due to the results obtained in ease, this being a point to improve in order to address the ease of use of the heuristics. All heuristics acquired a high average value with a minimum value of (4.14). Furthermore, it stands out that heuristics 8 and 9 were the highest scores with 4.71 and 4.57 respectively. Being directly proportional to their ease, coinciding with the lowest ratings in this aspect. The heuristic with the lowest value was heuristic 10, but with a high standard deviation, with a value of (0.92). The perceptions of the experts were similar for all dimensions, except the need for a checklist for heuristic 14 and 15. This occurred, due to the participation of some evaluators without much experience in the field of the application of expert judgment and the use of heuristics, such as anthropologists and experts in the care of older adults. In addition, it is evident that

Table 5
Evaluation questionnaire.

Id	Question
D1	How useful are heuristics as a motivating factor in older adults to interact with game-based systems?
D2	How clear are the heuristics to be applied in the design of game-based systems oriented to older adults?
D3	How easily do you think this heuristic can be implemented in the design of game-based systems targeted at older adults?
D4	How necessary is it to supplement the heuristics with a checklist?
H1–H15	What elements do you think are missing or should be included in this heuristic?
Q1	How easy was it to perform this heuristic evaluation?
Q2	Would you use this set of heuristics for the design of game-based systems targeted to older adults?
Q3	Do you think that the set of heuristics presented covers all the aspects that can motivate older adults with respect to their participation in game-based systems?
C1	Do you think that more heuristics should be included to those already defined and for what purpose?

Table 6
Survey results for dimensions D1, D2, D3 and D4.

	D1 Useful		D2 Clarity		D3 Ease of use		D4 Checklist	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Heuristic AM01	4,71	0,47	4,64	0,50	4,07	0,62	4,36	1,01
Heuristic AM02	4,57	0,76	4,57	0,85	3,86	1,10	4,36	0,84
Heuristic AM03	4,79	0,58	4,50	0,85	4,21	0,89	4,43	0,65
Heuristic AM04	4,93	0,27	4,57	0,51	4,14	0,86	4,21	1,12
Heuristic AM05	4,86	0,36	4,71	0,47	3,64	1,28	4,50	0,65
Heuristic AM06	4,71	0,47	4,43	0,65	3,93	0,92	4,50	0,65
Heuristic AM07	4,43	0,85	4,79	0,58	4,07	0,73	4,43	0,85
Heuristic AM08	4,86	0,36	4,36	0,63	3,29	0,73	4,71	0,47
Heuristic AM09	4,57	0,76	4,29	0,83	3,36	1,22	4,57	0,65
Heuristic AM10	4,79	0,58	4,50	0,85	3,50	1,09	4,07	0,92
Heuristic AM11	4,71	0,47	4,57	0,65	4,00	0,96	4,29	0,91
Heuristic AM12	4,79	0,43	4,57	0,85	3,93	0,83	4,29	0,73
Heuristic AM13	4,43	0,76	4,57	0,51	4,00	0,78	4,36	0,84
Heuristic AM14	4,57	0,51	4,43	0,65	3,71	0,91	4,21	1,42
Heuristic AM15	4,36	0,63	4,50	0,85	4,00	0,88	4,14	1,17
Mean	4,72		4,54		3,81		4,41	

heuristics 2 and 9 do not show that they are easy to apply, so a revision of this heuristic was made to make it easily applicable regardless of the area of expertise, through checklists, recommendations and interpretation problems.

The general perception of heuristics with respect to ease, completeness and intended use can be seen in the Table 7. Perceived intention to use the heuristic was the highest rated item with a mean of 4.64, making the application of the set of heuristics presented attractive to the evaluators. For both ease of use and completeness of the heuristics, positive results were obtained with a mean of 4.29 and 4.43 respectively, and a standard deviation of 0.47–0.51.

All of the above reflects a completely positive result with respect to the heuristics presented as a whole, although as will be seen in the qualitative results there are elements that can be improved.

In relation to the questions optionally asked for each of the heuristics, only one evaluator provided an opinion on heuristic 4. The evaluator expressed confusion regarding the inclusion process indicated in the heuristic, relating it to the disability of older adults and not to a process of inclusion in social interaction based on cooperation and collaboration. Once the process was completed, we proceeded to clarify to the evaluator the true intention of the inclusion of this population. Regarding heuristics 8 and 9, which were rated as the most difficult to use, additional information was obtained on these heuristics, with repetitive comments from the evaluators who offered feedback. All comments obtained during the different iterations of the process will be shown below (see Table 8).

Finally, the answers obtained in the final question on the heuristic or missing elements presented by the experts made some observations.

Table 9 shows all the observations made during the iterations and specifies whether they are accepted for the revision of the heuristics as appropriate.

It should be noted that one of the expert evaluators was satisfied with the completeness of the elements contemplated in the heuristic.

Based on all the comments and results of the evaluations carried out, a refinement was made in the process of specifying the heuristics according to the base methodology. The heuristic specifications contain different elements such as their nomenclature, their name, their priority, their definition, their detailed explanation, the characteristics of the game they affect, the benefits of their application and their possible interpretation problems. Their priority was established in three levels: (1) useful, (2) important, (3) critical. A heuristic set as (1) indicates that the heuristic, although useful, can be improved. Ranking (2) indicates that the heuristic is important and should be taken into account, but is not mandatory because it depends on the context of the application. Finally, priority (3) establishes a key heuristic that must always be met. The entire set of heuristic specifications can be found in "Appendix D".

It is important to highlight the fact that from the whole process of refinement of the heuristics and in search of greater ease in the application of these regardless of the area of expertise of those who make use of them, a detailed set of checklists was generated for each heuristic proposed, with a total of 90 different recommendations, which are found in the specification formats located in "Appendix D". To see the total number of items for each heuristic, see the "Appendix B, Table 5".

Finally, the set of checklists, detailed explanation of each heuristic and application templates for identifying potential problems based on them can be found on the platform https://plpx.johnnysalazar.net/. In this platform, in the evaluation process section, in the motivation evaluation stage, there is a detailed description of how to use these heuristics. In addition, in the tools option of the stage, there are 3 formats that facilitate the use of this heuristic application process for any interested person.

Table 7
Survey results for questions Q1, Q2, and Q3.

	Q1 Easiness	Q2 Intention of future use	Q3 Completeness
Mean	4,29	4,64	4,43
Std. Dev.	0,47	0,50	0,51

6. Discussion, conclusions and future work

The GBS, regardless of whether they are oriented to learning, fun, health or similar, are oriented to a young audience with different needs, tastes and motivations than those found in the older adult population. This leads to older adults encountering a barrier when interacting with this type of solutions, not only in terms of content but also in terms of interaction with them, thus increasing the technological gap. Due to this, this research resulted in advances in the design of game experiences for the older adult population, in order to facilitate the design and evaluation of this type of experiences, adjusting them to the particularities of this target population and increasing their use.

The model proposed in this research, was evaluated through a process of expert judgment, by different evaluators with extensive experience in the field of education, HCI, digital games and interaction with older adults, not only with academic profile, but also engineering, social and anthropological. This group of experts indicated that the proposed model represented through a set of heuristics was easy to use, useful and showed their interest and intention to use it in their professional fields. In general, the evaluation results were uniform with some exceptions, obtaining qualitative and quantitative results. With these results, a process of adjustment and refinement was generated to the set of heuristics presented, improving their specifications, interpretation

Table 8
Individual heuristic comments.

Heuristic	Comment	Action performed
Heuristic #3	This part of recognition is complex because it depends on each person, what one person likes, another does not.	It was explained to the evaluator that, having a priority level 2 (Important), this is not mandatory, therefore, its implementation is optional. In addition, it was added in the heuristic specification at the feature level of the game-based system, that the possibility of deactivating this recognition in the game must be provided.
Heuristic #5	I think it is a relatively difficult thing to do because of the variation from person to person.	It was explained that heuristics are recommendations, in many cases they may not be applied. To give more clarity to this and all other heuristics, the specification documents were adjusted.
Heuristic #6	Maybe it contradicts intergenerationally a bit.	The heuristic specifications document was adjusted to clarify the comment made. It is explained that, although the game mechanics and dynamics recommended here may vary with respect to generational environments, this is due to the fact that the game approaches are very different, but for each context it was possible to identify which game features should be included.
Heuristic #7	Although the demotivating factor is explained in the event that the user has a disability, it is not made explicit how to act in these scenarios, nor how this may conflict with other heuristics. Some information could be included in this regard.	The recommendation of how to act in this type of cases when the older adult suffers some type of disability was added to the heuristic specification formats.
Heuristic #8	Does inclusion refer to disability? If so, then implementing it would be very difficult without knowing what is expected for each type of disability that exists.	The correct purpose of the inclusion of heuristic #8 was explained to the evaluator.
Heuristic #9	This heuristic is complex, as people's preferences and tastes are very diverse.	It was explained to the evaluator that, although personal preferences are entirely subjective, the heuristic is intended to provide a series of recommendations to guide the design and evaluation of the game, but is not mandatory.
Heuristic #9	From the social sphere, it is possible to confuse personal preferences and the context in which the person finds themselves.	The heuristic specification format was refined to provide clarity on the specific differences addressed by each, as well as a specific field of interpretation problems in which this issue is clarified.
Heuristic # 10, 13 and 14	It is recommended to change the priority of these heuristics from 2 (Important) to 3 (Critical).	The recommendation was reviewed and it was explained to the evaluator that this was not possible, because the heuristics rated 3 (Critical) are mandatory, and the elements proposed in these heuristics are not, they are recommendations and ideal states.

Table 9
Heuristics group comments.

Comment	Action performed
I think it covers many aspects. For all of them, in general, I would like to comment that perhaps an example could be given.	Application examples were indicated in the heuristic specification formats to guide the correct understanding and application of each heuristic.
Elements should be included to the existing heuristics such as ergonomics, activity time, activity adaptation, heuristics focused on individual activities, type of mechanics towards the type of target population.	These aspects were included in the heuristic specification document as appropriate. This was incorporated transversally into the descriptions or features of the game-based system.
The different special needs, disabilities of the elderly should be included in the existing heuristics.	Although taking into account all the disabilities that older adults may have is too complex a task, some recommendations for implementation were included as appropriate.
It should be defined whether these games are digital or include fully physical versions.	This comment was not accepted, because it was explained that the use of these heuristics was specifically for digital games.
I believe that the heuristics presented cover all the necessary aspects, however, I consider heuristic 9 to be complex, since people's preferences and tastes are very diverse.	It was explained to the evaluator that, although personal preferences are entirely subjective, the heuristic is intended to provide a series of recommendations to guide the design and evaluation of the game, but is not mandatory.

problems, application examples and generation of a comprehensive checklist covering the different heuristics presented.

Although heuristics are traditionally defined through the application of non-formal processes, the use of a standardized methodology for the definition and objective evaluation of these heuristics facilitated the definition of the proposal presented. An important result was the difference of opinions regarding the need for checklists in some heuristics as a complementary element in the design and implementation process of GBS. This was due to the different profiles involved. People with experience in interacting with older adults and anthropologists had no previous experience with the heuristic concept, affecting only this aspect of the evaluation.

If you wish to design and implement a game-based system that motivates, entertains and facilitates learning for the older adult population, the different motivational aspects raised could be addressed. For this, the game experience should be oriented on the 4 main categories of motivation identified. This would include elements such as obtaining benefits, enjoyment, recognition and the sensation of victory in competition, social interaction in the game, positive emotions, feeling of usefulness, and means by which the older adult can surpass themselves. Similarly, if it were necessary to define a set of specific heuristics for a different population, the proposed process could be replicated, executing each of the explained stages but focusing the review process on the target population.

Although an empirical validation was not carried out with older adults through a functional prototype, the results obtained will facilitate and guide a future construction of this prototype with the help of experts and end users. These results drive and encourage a construction more focused on the needs and particularities of older adults. Future extensions of this research should include tests applied directly on end users with the support of a functional prototype. In addition, the possibility of establishing a possible typology of players in the older adult population based on the different motivations identified is left open. Thus, seeking an additional means to facilitate the understanding of this population, having less complexity in the design and implementation of game experiences, and offering more motivating and fun GBS.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Johnny Alexander Salazar reports financial support was provided by MINCIENCIAS of government of Colombia.

Data availability

Data will be made available on request.

Acknowledgements

This work was supported by the FCT – Fundação para a Ciencia e a Tecnologia, I.P. [Project UIDB/05105/2020].

Appendix A

Motivating aspects description is available at: https://drive.google.com/file/d/1lp0BzVkMu1Fl0KZgw5XdVARAFQVaRazA/view.

Appendix B

Assignments of the methodological application for the generation of heuristics is available at: https://drive.google.com/file/d/1_fXc-WmGyFoy7HJqOxp2r-1BZ45J79wc/view.

Appendix C

Evaluation form is available at: https://docs.google.com/spreadsheets/d/1TpNgu2SucWDAOvpqdtrGOOc5QrfSquix/htmlview.

Appendix D

Heuristics specifications is available at: https://drive.google.com/file/d/1tk0vkz8wTqxn4kvikHWFkQzFVfOhzrb4/view.

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