

Promoting social and collaborative language learning among older adults in the digital era: Development and evaluation of a smartphone app prototype using a design-thinking approach

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Abstract

Background: Older adults constitute a large and fast-growing segment of the population for whom language learning may be especially beneficial. However, current mobile applications (apps) for language learning overlook older users' needs and capabilities, resulting in low app uptake among them and eventually hindering their continued access to learning opportunities in an increasingly digitalized world.

Objective: We explored older adults' needs, behaviors, and learning goals to develop an innovative app prototype specifically designed to facilitate language learning among them.

Method: We followed a design-thinking process completed over three phases with 22 German-speaking older adults (aged 60+) as potential end-users. During phase I (needfinding), we conducted semi-structured individual interviews and identified the main themes that guided the generation of concepts in phase II (brainstorming). The best concept was implemented in phase III (prototyping) as a smartphone app prototype, which was subsequently pilot-tested with a subgroup of the interviewees in individual evaluation sessions.

Results: Our participants wished for language-learning tools that promote (i) face-to-face social interaction, (ii) an active lifestyle, and (iii) practice opportunities to achieve a variety of language-learning goals. Our concept covers those needs in a novel manner by allowing users to learn a language while practicing a hobby with matched partners or groups. It offers a learner-centered experience and promotes social and collaborative learning among peer users. The prototype was positively received and obtained high usability scores. The features of the app are discussed in the light of multiple dimensions of language learning, insights from social and educational gerontology, and human factors research.

Conclusion: Older adults can provide us with valuable insights into requirements for app-based innovations aimed at enhancing their learning experiences and social lives in the digital era. The developed concept and its features can serve as a model to better tailor language-learning apps to older users' needs.

Keywords: older language learners, user-centered design, app prototype, human factors, Germany

INTRODUCTION

The unprecedented global shift in demographic structure toward rapidly aging populations is coupled with a higher prevalence of age-related physical and cognitive health issues, for instance, neurodegenerative conditions such as dementia, Parkinson's, and Alzheimer's disease (Dorsey et al., 2018; Prince et al., 2016). Older adults are moreover confronted with changes in their social relationships and socioeconomic status, which may affect their ability to participate in society, increasing the risk of isolation, feelings of loneliness, and depression, all factors that have a negative impact on cognitive functioning and may contribute to early mortality (Waycott

et al., 2019; Wister et al., 2021). Learning a foreign or second language (L2) may be particularly beneficial for the aging brain, as it leads to improvement in cognitive abilities and can protect against memory decline. Speaking an L2 trains inhibitory control, conflict resolution, and attention, and may even delay symptoms of dementia or Alzheimer by several years (Klimova, 2018; Reifegerste et al., 2019). In addition, knowledge of a foreign language provides social and communicative advantages that can help against isolation in later life. For example, it can expand the social network, foster intercultural awareness, and communication, provide more opportunities for social engagement and support independ-

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ent traveling abroad (Pfenninger & Polz, 2018; Ramírez-Gómez, 2016; Ware et al., 2017).

In recent years, the pervasive use of increasingly powerful mobile devices like tablets and smartphones has led to an overwhelming and ever-increasing number of stand-alone apps specifically designed for language learning such as Babbel, Duolingo, Busuu, and many others, which are transforming the way we learn an L2 (Heil et al., 2016; Kukulska-Hulme et al., 2017; Puebla et al., 2022). Self-directed mobile-assisted language learning (MALL) through language-learning apps promises a self-regulated, accessible, and affordable learning experience for all ages. Apps such as Babbel or Duolingo have millions of users around the world and several evaluation studies on those apps conducted with younger learners – mostly ‘digital natives’ – have reported positive attitudes towards them (e.g., Loewen et al., 2020; Vesselinov & Grego, 2016). At the same time, however, concerns arise as to the apps’ actual effectiveness, pedagogical innovation, and universal accessibility. Several researchers have noted that current implementations of language-learning apps fail to exploit the full potential of mobile technology for socio-cognitive, constructivist, collaborative, and learner-centered instruction (e.g., Heil et al., 2016; Kukulska-Hulme et al., 2017; Rosell-Aguilar, 2018), attributes that are crucial for effective learning in older adulthood (e.g., Baschiera, 2019; Chiu et al., 2016; Formosa, 2019; Maulod & Lu, 2020). Furthermore, existing language-learning apps have not been developed considering older adults’ multiple needs, preferences, and capabilities, which may make those apps not fully suitable or accessible for older users, resulting in poor use or low acceptance of MALL among older adults.

In a recent study, Puebla et al. (2022) examined the extent to which older adults aged 60-92 residing in Germany engage in MALL voluntarily on their own, their use and perceptions of current language-learning apps, and the factors that may modulate their (non-)adoption of such apps. Despite the participants’ everyday use of mobile devices and online resources, and their interest and active engagement in L2 learning, they were found generally resistant to adopting language-learning apps to support their L2 learning practices. Many participants had prior experience with those apps but their opinions as users were rather negative. They missed personal face-to-face interaction, were dissatisfied with the learning materials or with the way content was delivered, and found the apps not suitable for their learning styles. Technologically savvy older adults who were open to new advancements were more likely to engage in MALL compared to their less tech-oriented peers. These results

underscore the need for developing language-learning innovations that integrate principles for effective learning in older adulthood while considering older users’ specific requirements to ensure their continued access to learning opportunities in the digital era.

A promising way to design suitable apps for older adults is by adopting user-centered design (UCD) approaches to product development. UCD involves end-users in the development process, incorporating their needs, wishes, values, and capabilities, and allowing them to influence the concept and shape of the final product (Franz & Neves, 2019). User involvement is currently common practice in the design of many gerontechnological innovations, particularly in the field of mHealth and assistive technologies (Boot et al., 2020; Köhler et al., 2021; ten Bruggencate et al., 2019). However, to our knowledge, no app intended to facilitate language learning among older adults has been yet developed following UCD approaches.

The current study

In the present study, we followed a specific type of UCD approach known as design thinking (DT) to develop an app prototype for older German-speaking language learners. DT provides an organic, bottom-up methodology to creative problem solving for economic and social innovation-focused on understanding the human needs involved (Brown & Wyatt, 2010; Nicolai et al., 2016, von Thienen et al., 2018). Our primary aim was to gain a deeper understanding of older adults’ needs and requirements to determine a set of principles and features that could inform technology providers in enhancing the suitability and accessibility of app-based language-learning products for older users.

Prior to initiating the DT process, we conducted a pilot evaluation study using Babbel to assess the suitability of current MALL for typically retired older adults. Six older German-native speakers (4 females, mean age: 69.7 years, SD: 5.4, age range: 65-77 years) learned English with Babbel for 12 weeks. Their individual progress and perceptions of the learning experience were elicited through usage questionnaires. Compared to the positive attitudes reported in previous evaluation studies on Babbel conducted with younger learners (e.g., Vesselinov & Grego, 2016), our results revealed only a partial satisfaction with the app in that only items concerning self-regulation and self-direction elicited high ratings. However, our participants considered that Babbel failed to provide an authentic learning experience and adequate exposure to the English lifestyle and culture and did not feel that the app had increased their opportunities to communicate with English-native speakers or to connect with peer learners.

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Table 1. *Persona's goals (phase I), and outcomes from the value propositions (phase II)*

Persona's goals	Value propositions: Products and services/features
#1: To lead an active lifestyle	<ul style="list-style-type: none">• Social network/platform to practice a hobby/L2 together• Facilitate face-to-face meetings• Adaptability/flexibility (e.g., self-paced, self-directed)
#2: To have fun without pressure	<ul style="list-style-type: none">• Discussion forum to share/expand common and new interests• User-friendly, easy to handle interface• Modular product to fit multiple interests/needs
#3: To avoid isolation & feel useful (social connectedness & participation)	<ul style="list-style-type: none">• Multimedia user-generated content• Self-organized collaborative learning, peer-teaching• Match-making among users based on age and interests• Instant messaging among users
#4: To practice/use knowledge of an L2	<ul style="list-style-type: none">• Less grammar, more talking• Less interaction with technology, more real-life L2 learning• Travel assistant app with basic L2 content• Oral communication with native speakers of the L2
#5: To maintain a previously learned L2 (keep knowledge alive over long time)	<ul style="list-style-type: none">• A product also suitable for proficient L2 learners• Social network to meet native speakers of the L2• Facilitate regular group meetings• Review topics based on interests and proficiency
#6: To refresh a previously learned L2 (revisit an L2 for a specific purpose)	<ul style="list-style-type: none">• A product also suitable for proficient L2 learners• Review topics based on interests and proficiency• Travel guide integrated into language-learning app
#7: To deeply explore an L2 (attain a higher level of proficiency)	<ul style="list-style-type: none">• A product also suitable for proficient L2 learners• Advanced content (literature, newspapers, local radios)• Engage also native speakers of the L2• Provide access to a variety of resources in the L2

Albeit limited by the small sample, these preliminary results confirm and extend previous findings reported by Puebla et al. (2022) and suggest that Babbel may not be as suitable for older learners as it appears for their younger counterparts.

METHODS

Study design

We adopted a 5-step design-thinking model (Köppen & Meinel, 2015; Stanford d.school, 2010) conducted in three phases that correspond to the three main stages (or ‘spaces’) of DT commonly distinguished in the literature with varying labels: (I) NEEDFINDING, (II) BRAINSTORMING and (III) PROTOTYPING (Seidel & Fixson, 2013; but cf. Boot et al., 2020; Brown & Wyatt, 2010). During phase I, we first conducted individual semi-structured interviews with a group of older adults to gain an empathetic understanding of our end-users’ mindset, needs, wishes, and requirements (step 1, empathize). The collected data was then analyzed and synthesized in a meaningful, manageable, and human-centered problem statement (step 2, define) that guided the generation of innovative concept ideas in the brainstorming sessions conducted during phase II (step 3, ideate). During phase III, a functional representation of the best concept was implemented as a smart-

phone app prototype (step 4, prototype), which was next tested with a subgroup of the interviewees in individual evaluation sessions (step 5, test).

Sampling and data collection

Older adults aged over 60 years who were typically retired and in principle interested in language learning were targeted for participation in this study. Participants were recruited via phone calls and e-mail invitations. They all had grown up monolingually with either German or English as their native language (L1), had completed at least secondary school, and had no diagnosed neurological impairments. At the time of data collection, they all were living in the Berlin/Potsdam area and were everyday users of at least a smartphone, a tablet, or a desktop computer. Smartphones were used primarily for communication, especially via phone calls, WhatsApp and Skype, and information search. Although half of the participants were presently or had been recently learning an L2, none was using a language-learning app.

A semi-structured ‘problem’ interview was constructed to determine older adults’ profiles and gain insight into their needs for an app-based solution within the language-learning context. The interviews were conducted during phase I (step

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Table 2. Results from the feedback questionnaire (participants, n=10)

	Mean rating (SUS score, out of 100)	SD (over subjects)
Overall (items, n=38)	4.43	0.35
Brooke's SUS (items, n=10)	4.47 (86.75)	0.45
Usability dimensions		
<u>Utility:</u>		
Do users find the app useful?	4.63	0.56
Does the app satisfy their needs?		
<u>Layout, visual elements & accessibility:</u>		
Is the app visually appealing?	4.63	0.52
Are elements visible/big enough?		
<u>Consistency:</u>		
Are the same words, colors, forms consistently used across screens?	4.60	0.52
<u>Communication efficacy:</u>		
Is the app well organized?	4.52	0.36
Are functions well integrated?		
<u>Learnability:</u>		
Is the app easy to use?	4.43	0.55
Is the functioning of the app easy to learn?		
<u>User control & freedom:</u>		
Are users able to control and fulfill their actions?	4.43	0.42
<u>Navigation & orientation in the app:</u>		
Do users know how to go back/move to another screen?	4.35	0.51
<u>Familiarity & conventions:</u>		
Do users recognize icons and terms from other apps/services?	4.30	1.25
<u>Satisfaction:</u>		
Are users satisfied with the app?	4.30	0.74
Would they recommend it?		
<u>Errors:</u>		
Do users notice when they tapped on the wrong button?	4.08	0.37
Can they recover from the error?		

Note: Individual statements were all positively worded (see Sauro & Lewis, 2011). Ratings were given through a 5-point Likert scale (1=trifft überhaupt nicht zu 'strongly disagree'; 5=trifft völlig zu 'strongly agree').

1, empathize) with 22 older adults (14 females, mean age: 72 years, age range: 64-85 years, SD: 5.71). Each session lasted approximately one hour and was audio/video recorded with the participant's consent. Additionally, notes and observations were taken during the session. Participation was rewarded with 10 euros.

Ten of the interviewees (9 females, mean age: 74 years, age range: 66-80 years, SD: 4.75) were randomly selected and invited via phone calls and e-mails to try out and evaluate the prototype in phase III (step 5, test). The tests aimed at assessing the usability of the app's interface design and information architecture, at detecting specific design/concept issues, and at collecting user feedback. During the sessions, participants interacted with the prototype via a smartphone according to a specific scenario while describing aloud what they saw, thought, and the actions they took (i.e., a 'think-aloud' method, see Franz & Neves, 2019). During the user-app interaction, participants attempted the completion of 10 tasks (Table 3) and answered questions aimed at obtaining instant feedback. The interaction was recorded using a screen recorder app (DU Apps Studio, 2016) with the participant's consent. Additionally, notes of the user's behavior were taken. At the end of the session, participants completed a

feedback questionnaire containing 38 statements related to the prototype and user-app interaction in terms of various dimensions of usability such as usefulness, learnability, accessibility, and satisfaction (Rubin & Chisnell, 2008; Table 2). Twenty-eight items evaluated the user-interface design following roughly the principles (or 'heuristics') put forward by Nielsen (1994). The remaining 10 items were modeled after the System Usability Scale (SUS; Brooke, 1996). The SUS is a popular 10-item questionnaire for measuring users' perceptions about the usability of a system and it has been validated as an effective and reliable instrument by multiple studies (Bangor et al., 2009), in settings involving also older adults (Alkawaldeh et al., 2020). Each session lasted for about 90 minutes. Participation was rewarded with 10 euros.

The interviews and the evaluation tests were held in person, with each participant individually, by two members of the team either at the participant's home or in a quiet room at our lab.

Design activities and analyses

Phase I: Needfinding

Phase I started with the 'problem' interviews. Data gathered during the interviews were carefully examined and summarized by each interviewer separately. All relevant information was then extracted,

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Table 3. Completion success rates to 10 main tasks performed by participants during their user-app interactions

#	Task	Success rate (%)
1	Complete registration as a new user (sign-up process)	60
2	Find information about 'Learner' and 'Tutor' participation roles	0
3	Browse through your matches and find a suitable learning partner or group	40
4	Search for fellow users according to the key term 'English'	20
5	Create your own group	70
6	Check messages with your partners and groups	60
7	Visualize your user profile and tell us how you would edit it	60
8	Change your participation mode from 'Learner' to 'Tutor'	80
9	Check who your partners are / which groups you joined	80
10	Go to account settings and change your email address / delete your account / modify your username / change your password	90

Note: Completion rates were calculated as the percentage of participants who completed the assigned task. A task was considered successfully completed when participants were able to accomplish it on their own before moving forward to the next task.

sorted into broad categories, and reformulated as short and concise insights. The team followed an affinity clustering process by grouping the insights into related themes and finding patterns and connections among them to identify key themes that could be translated into opportunities for design (Gumienny et al., 2015; IDEO, 2015).

In order to gain a deeper understanding of the aspirations of our target users and their goals in using our product, we constructed a goal-directed persona, a representation of our target group based on the things they want or need to achieve (Nielsen, 2019; Schäpers et al., 2017).

Phase I ended with the formulation of a problem statement, a concise expression of the problem we were aiming to address, which inspired the generation of solution ideas in phase II.

Phase II: Brainstorming

We used the value proposition canvas as a central tool for idea generation. This tool is useful to detect concrete points to tackle from both the user's and the designer's perspectives and allows the team to reflect on how the generated ideas may add value to the lives of the target users, ultimately ensuring that the final product is positioned around what the user values and needs (Osterwalder et al., 2014). Our value propositions were based on our persona's goals. A canvas was created per goal.

The creation of the value propositions resulted in a set of possible solution ideas. The concepts were closely examined and evaluated in terms of our problem statement and the outcomes of the value propositions until the team selected one of the solutions.

Phase III: Prototyping

We entered phase III by elaborating a service blueprint map of the selected solution. Service

blueprints represent the different components of a service or a product organized in a timeline (Sarvas et al., 2019). Next, we used Figma (www.figma.com), a web-based collaborative prototyping tool, to implement the graphic interface of a clickable simulation of the app that closely resembled our idea of a final product.

The evaluation sessions of the prototype involved the user-app interaction, including the completion of 10 tasks, and a feedback questionnaire. The recordings and notes taken during the interaction were carefully examined by each researcher separately. Completion success rates were first calculated for each task. To obtain a more fine-grained picture of the interaction, relevant insights were extracted, sorted into categories, and analyzed following an affinity clustering process. Special attention was given to the insights typified as issues (i.e., problems encountered by the participant during the completion of the tasks). For the questionnaire, participants rated how much each statement applied to their user experience with the prototype through a 5-point-Likert scale. A group mean score was calculated for the complete set of items and additionally for each of the usability dimensions individually. A mean score for the SUS items was obtained following the scoring procedure outlined by Brooke (1996).

RESULTS

Phase I: Needfinding

The key theme that emerged from the clustering process of the interview data was a wish for face-to-face 'SOCIAL INTERACTION'. This theme together with a need for an 'ACTIVE LIFESTYLE' and the search for 'PRACTICE OPPORTUNITIES' in the learning context was the most dominant among our interviewees and informed our problem statement. Our participants' goals are given in Table 1, 'Persona's goals'. Our focus was on goals related to language learning.

User actions What does the user do?	Launches app	Takes a tour	Enters e-mail & password to log in as new user	Creates own profile	Selects participation mode	Wants to learn with a partner	Gets matching individuals	Gets matching groups	Browses profiles	Finds a suitable partner	Explores/navigates app	Taps on 'Discover' and filters results to active search	Taps on 'Create a group' to start a new group	Taps on 'Messages' to chat with group members	Views/edits own profile & settings
Line of interaction															
Front office What does the user see in the system?	Welcome screen	Tutorial appears	Registration screen	Profile questions (set of screens)	Participation mode screen	Ideal partner (set of screens)	Matches screen (dashboard)		Suggested partners/ groups' profile screens		Bottom menu	'Discover' screen and users/groups matching the keyword	'Create a group' screens and related options	'Chat' screen	'My profile' screen and account options
Notes	Includes logo of the app	Optional and always accessible	Also includes a log-in button	Demographics, languages, interests...	User can also select both modes	Age, gender, L2 level, meeting frequency, nr. of members (group)...	If user selected both modes, suggestions for partners & groups are shown		Profiles include % of match with user	Matches are selected by tapping on a button	Always visible	Search by keyword or user name	1. Enter common activity/interest 2. Enter group's name & further details	Conversations with partners and groups in separated tabs	Account settings are accessed through button on 'My profile' screen
Line of viability															
Back stage What does the system do under the hood?			Save details and create account	Save answers and incorporate user's profile to database	Save selected option(s)	Save answers and incorporate to user's profile	Refresh matches from time to time	Retrieve users' data		Send invitation for partnership to selected user		Search in database for occurrences of the keyword	Save created group and add it to the database. Update matches	Retrieve messages	Retrieve user's data
App modules Sets of screens grouped by task			Register/ Log in screen	Profile questions	Participation mode	Questions about ideal partner	Matches				Bottom menu	Discover/ search	Create a group	Messages/ chat	My profiler/ settings

Figure 1. Central components and modules of the app

The key theme ‘social interaction’ permeated multiple areas of our interviewees’ lives. For example, over half of them were members of interest groups that organized regular meetings. Despite the group’s positive attitude towards digital technologies, language learners, in particular, expressed reluctance to use language-learning apps due to their strong wish for face-to-face contact. Our interviewees’ wish for social interaction was also manifested in their active engagement as volunteer workers in their communities, which relates to the common goal of avoiding isolation and feeling useful through social connectedness and participation (Table 1, goal 3). Our participants aimed at keeping themselves physically, mentally, culturally, and socially active by taking part in enjoyable activities of their choice, without external pressure (Table 1, goals 1,2). A common characteristic of the group was their perception of being continuously busy, which required them to carefully prioritize their activities. In general, our target group felt the need to put newly acquired knowledge into practice. In the context of L2 learning, this translated into a desire for using the target language in real-life situations, for example, to communicate when traveling abroad (Table 1, goal 4). Besides this common goal, we identified three specific goals among the language learners (Table 1, goals 5-7).

Based on the synthesized data, we defined the following problem statement: *“To create an app-based tool facilitating language learning among older adults, by offering practice opportunities in the target L2, promoting social interaction, and an active lifestyle”.*

Phase II: Brainstorming

Based on our persona, the team created seven proposition canvases in which we determined a variety of features, services, or components for a valuable solution; see Table 1, ‘Value propositions: Products and services/features’. Among the concepts generated during this phase, the team selected the one that integrated most features: an online platform bringing together older L2 learners with matched partners or groups based on their profiles, target L2, and a common hobby to practice in face-to-face meetings. The team considered that this solution fitted best with our problem statement while integrating crucial principles for effective learning in old-

er adulthood, and it was also flexible enough to cover our users' multiple language-learning goals.

Phase III: Prototyping

The brainstorming phase led the team to the concept of a smartphone app called *SprachenTanz*. The app combines human contact and technological innovation to offer users a completely personalized, social, and collaborative learning experience. *SprachenTanz* facilitates the creation of a self-organized community in which mutual empowerment is key, where L2 learning is shaped by the sharing of common interests, and where knowledge can be put into practice in a real-life setting. *Figure 1* shows the central components and modules of the app as defined in the service blueprint map.

SprachenTanz works as follows: after registering, new users create a profile by answering questions about themselves (e.g., gender, age, location, occupation, language background, target L2, and interests). Next, users decide between taking the role of a tutor – and transmitting their L1 or a fluent L2 to fellow users – or an L2 learner, and between working together with a partner or in a group. Depending on the selected modality, a set of questions follows about the ideal partner or group that *SprachenTanz* uses to calculate the best matches. Upon completion of the profile, a list of compatible fellow users or groups appears on-screen accompanied by the percentage of the match. The user can browse through their profiles and send invitations for partnerships or requests to join groups. Further functions (creation of a new group, active search via keywords, instant messaging with partners and/or joined groups, profile, and account settings) are available via a bottom menu bar. The prototype can be found at <https://bit.ly/sprachentanz>

SprachenTanz was positively received by our 10 test users. The results from the questionnaire are given in *Table 2*. Participants found the app easy to use and navigate, accessible, well organized, comprehensive, visually appealing, and very useful. The group SUS score was above 80 points (out of 100), which indicates a level of usability close to excellent (Bangor et al., 2009).

Table 3 shows the completion rates for the 10 tasks that participants were asked to perform during their interaction with the prototype. Success rates were generally higher for tasks performed later during the interaction, which confirms a good level of learnability. Still, none of the tasks was successfully completed by all participants, and tasks 3 and 4 yielded quite low success rates. In particular, task 3 (find a suitable learning partner or group), which required users to understand the purpose of the match-making

feature, was crucial for the proper use of the app. Moreover, none of the participants was able to complete task 2 (find information about participation roles), which required them to acknowledge and tap on help icons (question marks) to open explanations. Among the recurrent issues that hindered task completion were (i) difficulties grasping the match-making feature and understanding the meaning of the percentages indicating the amount of match; (ii) troubles navigating the app due to the lack of consistency in the location of the back arrows across screens and/or their small size; (iii) difficulties distinguishing interactive components such as clickable buttons from other graphic elements; (iv) difficulties acknowledging relevant elements due (e.g.) to their small size, the density of the screen, or lack of distinctiveness; and (v) the opaqueness of certain labels/terms, especially 'match'.

These and other minor issues will be addressed in the next iteration of the prototype. The modifications are not only driven by the issues identified as participants performed the tasks but also by their suggestions. For example, besides reformulating problematic terms, redesigning noisy screens, or including more environmental support, the participants' suggestions of including the option 'tandem' (i.e., language exchange) as a third participation modality and of distinguishing the app's modules through different colors will be implemented in the refined version.

DISCUSSION

SprachenTanz constitutes an innovative and integrative concept that addresses older language learners' social, cognitive, and affective needs, as well as their requirements as mobile users. In view of the positive evaluations obtained, the app shows potential as an alternative for older users to existing language-learning apps. Below, the key principles underlying the concept and how they are manifested in the app are first presented and discussed in light of insights from social and educational gerontology, second language acquisition (SLA), and human factors research. Next, a few implications for technology providers are highlighted. Finally, we point out the limitations of our study.

SprachenTanz's key principles and features

Social interaction and peer collaboration

At the center of the app is a collaborative and constructivist approach to learning (e.g., Baschiera, 2019; Kukulska-Hulme & Viberg, 2018), strongly based on social interaction and the building of social connections. Social interaction is not only crucial for healthy aging, as it can delay mental, cognitive, and even physical decline (ten Bruggencate et al., 2019; Waycott et al., 2019), but it also plays a critical role in lan-

guage learning (e.g., Pickering & Garrod, 2021). In *SprachenTanz*, users are encouraged to learn an L2 in a social-interactive and collaborative fashion while actively practicing an activity of their choice. For example, users can meet for a French wine tasting to talk in French, sharing with each other relevant vocabulary and expressions related to wine in an authentic context, or they can help each other in learning about gardening tools, techniques, or types of plants in their L2 while working together in the garden. In this way, learners cooperate in achieving their learning goals while taking advantage of their immediate surroundings and favorite activities, turning real-life contexts into learning contexts. At the same time, they are able to integrate multimodal information (i.e., auditory, visual, tactile) while interacting with their peers, manipulating the objects, and performing actions. Learners use their prior knowledge and real-life experiences as a base for learning and put the newly acquired knowledge into practice, which turns L2 learning into an authentic, meaningful, and contextualized experience. Recent evidence from cognitive neuroscience and SLA has shown that such a social L2 learning leads to greater neural activation, which enhances bilingual representation and long-term memory retention, ultimately improving learning outcomes (Li & Jeong, 2020). Given that memory declines with age, this approach may be especially beneficial for older adults. In addition, such a strategy fosters creativity, exploration, and an active lifestyle, and may as well increase motivation for learning an L2.

As a strongly social app, *SprachenTanz* supports the three interrelated dimensions for building social connections in older adulthood through digital technology identified by Waycott et al. (2019): (i) personal relationships are strengthened by providing means for meeting new people and establishing reciprocal virtual and/or face-to-face interaction among matched users, potentially leading to new friendships; (ii) community connections are encouraged by offering opportunities to engage in meaningful group-based social activities centered around language learning and shared interests; (iii) societal engagement is enabled by means of the tutoring role. Tutors take a leadership role within a group or partnership and actively shape the learning experience, helping peer users to develop their L2 skills and competence. Through the tutoring option, users have the chance to engage in a meaningful activity that can foster a sense of purpose.

In sum, the app's social and collaborative focus contributes to the creation of a learning community where knowledge is constructed together, fostering a sense of belonging and engaging socio-affective dimensions of L2 learning (Baschi-

era, 2019; Maulod & Lu, 2020).

User-centeredness and self-direction

Older adults display greater variability than younger adults in terms of needs, capabilities, digital literacy, attitudes towards technology, learning styles, and goals (Boot et al., 2020; Franz & Neves, 2019; Liu & Joines, 2020). *SprachenTanz* allows for a completely user-centered and customized experience that takes into account older adults' heterogeneous profiles. One of the innovative aspects of the app is the conceptualization of a match-making feature, similar to that used in dating apps such as Tinder or OkCupid, which exploits the individual user's characteristics and preferences to facilitate the search and selection of suitable peers. Besides offering a personalized experience, the match-making feature directed to older people can reduce the anxiety of interacting in an L2 thanks to the compatibility of the users. For example, some users may feel more comfortable learning with age-matched people for a safe and non-threatening atmosphere and peer support or mentoring (e.g., Chiu et al., 2016; Ramírez-Gómez, 2019). The integration of a match-making feature in an app targeted at older adults poses certain challenges, though. These will be discussed below. Two more assets of the app in terms of adaptability are that users can select (i) their preferred participation modalities (i.e., learner and/or tutor; partnership and/or group) and (ii) their preferred learning activities (i.e., a digital-based approach, suited for more tech-oriented users and/or users with mobility constraints, or a blended approach including regular face-to-face meetings). Users can interact synchronously or asynchronously with their partners and/or groups anytime and anywhere via the chat/messaging function, which looks and works similarly to WhatsApp, an app widely used by our participants. The chat serves as (i) a discussion forum where communication in the target L2 is possible without the eventual anxiety associated with face-to-face interactions and (ii) a platform for exchanging relevant materials and user-generated multimedia content (e.g., photos, audio, texts, videos).

Ideally, the learning experience for older adults should be created by older adults; it should include materials reflecting the learners' interests and meaningful activities in an informal environment (Maulod & Lu, 2020). *SprachenTanz* fosters autonomy, self-direction, and a self-reflective practice by leaving users full responsibility and control over their learning/tutoring. The user decides with whom, when, where, and how to learn or facilitate a language and co-creates the learning experience (e.g., selection or construction of materials, activities, structure, pace, format) in collaboration with peer users in a self-

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regulated and self-organized environment.

These features ensure the creation of an ideal learning environment where users feel comfortable discussing their ideas, thus activating emotional responses and increasing cognitive processing, performance, and motivation to learn (Li & Jeong, 2020).

Usability

Even though usability testing is an integral part of UCD approaches, it is especially necessary when designing products for older adults. Due to their heterogeneity, it is difficult to foresee the exact usability or accessibility issues older users will encounter (Franz & Neves, 2019; Liu & Joines, 2020). During the evaluation tests, we detected a few issues that should be addressed to avoid frustration and achieve a more accessible and inclusive design. For example, most users were not familiar with the match-making procedure and consequently found the feature confusing and difficult to grasp on their own. In addition, the term 'match' and the percentages indicating the amount of compatibility with fellow users were not clear to many despite the explanations provided. These issues made it difficult for users to browse through their matches and find suitable partners or groups, and indicate the need for well-designed and unambiguous environmental support. To reduce task demands and improve performance, the next iteration of the prototype will contain readily available and visible support in the form of instructions, visual/graphical aids (e.g., help icon), and screen information. Other problems identified (e.g., the small size of visual elements or text, some screens too noisy, troubles navigating the app) might not even affect older adults only; designing apps for older adults can also provide valuable insights into designs that benefit all users, making end-products more flexible and universally accessible, and ultimately increasing their market penetration (Boot et al., 2020).

Implications for technology providers

Based on the principles and features of *Sprachen-Tanz* discussed above, we summarize below a few implications for designers and developers to guide the design of app-based language-learning products for older adults.

Firstly, to ensure suitable, useful, and accessible apps, care should be taken to involve older adults in the development and/or evaluation of new concepts, acknowledging their specific properties (e.g.): (i) heterogeneity, which calls for user-centered and flexible apps that can accommodate a variety of profiles, needs, learning styles and goals, digital literacy, and attitudes towards technology; (ii) specific capabilities or limitations due to age-related changes in cognitive

and physical abilities, which require concrete design-requirements and increased usability. For example, apps may avoid taxing older adults' cognitive resources by providing enough environmental support and an intuitive operating system, or by incorporating or simulating components (e.g., services, functions, apps) already familiar to older adults (e.g., WhatsApp). Increasing usability will also improve app design for all ages; (iii) contrary to the stereotype, retired adults are busy people, and products should aim for simplicity and concision.

Secondly, language-learning products for older adults should be pedagogically-informed, that is, they should integrate principles for effective learning in (older) adulthood to optimize learning outcomes. This requires knowledge transfer from academia to the tech industry to ensure access to research on educational gerontology and SLA.

Finally, apps for older adults should capitalize on technology to improve aspects and cover crucial needs of later life. For example, apps should provide opportunities for enhancing social interaction and connectedness. This requires avoiding overly technocentric concepts. Technology can be a useful resource for improving older adults' language-learning experiences and their social lives but it should not replace face-to-face contact.

Limitations

DT was an effective methodology to develop a user-centered innovation for older adults in a bottom-up fashion. However, there are a few limitations to our study that may affect the generalizability of our findings. First, our research may have been subject to the possible bias in older adults voluntarily taking part in this project. Our participants were urban, highly educated, socially and physically active, and also everyday users of smartphones and other digital devices. They were moreover residing in Germany, a country with developed mobile infrastructure and a high rate of smartphone penetration among older adults (Puebla et al., 2022). In addition, our participants were pre-selected to include older adults interested in L2 learning. Many of them could speak several L2s and a few were currently engaged in language learning, which is not necessarily the norm among older individuals. Hence, our participants' needs and interests, as well as their attitudes towards technology and level of digital literacy may not be representative of the general older population. On the assumption that the average older population holds lower levels of digital literacy, openness towards technology, and interest in L2 learning, we may expect additional usability problems and/or conceptual issues that we could not detect in our study due to our sample's relatively advanced

technological profile and genuine interest for languages. Second, the prototype was tested with only 10 older adults; thus, the user feedback and evaluation results cannot be generalized to all potential target users. Although the prototype was positively received among our participants, at this stage it is difficult to predict to what extent older adults would adopt and use the fully developed app in a real-life scenario. Finally, our participants were highly motivated to help in scientific research, and most had regularly taken part in previous studies at our lab. For this reason, we cannot discard the possibility that they performed 'impression management' during the evaluation sessions, thus giving overly positive feedback during the tests (Franz & Neves, 2019). The app requires therefore further evaluation with a larger and more diverse sample of older adults to better tailor the product for a wider spectrum of target users.

CONCLUSIONS

As the global population ages, there is a pressing need to develop tailored strategies and products that promote a healthy, active, and independent aging to protect older adults from physical and mental conditions, help them preserve an adequate level of social support, and ultimately improve their quality of life and well-being. The multiple benefits of learning a language in older adulthood, coupled with the potential of digital technology to enhance social participation and interaction in later life, calls for increased efforts to involve older adults in the design and development of innovations for language learning. User involvement can provide us with valuable insights into design opportunities for more effective, useful, and better-tailored apps for older users.

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Ethical standards

The present research was approved by the Ethics Committee of the University of Potsdam (application 44/2017). Col-

The innovation presented in the current article integrates crucial elements for effective language learning in (older) adulthood while addressing older adults' specific requirements. Our app takes advantage of smartphones' mobility, connectivity, and advanced communication features to encourage a socio-constructivist approach to learning. At the same time, interaction with technology can be kept to a minimum and digital materials can be combined with face-to-face activities. As a highly flexible, social, and less techno-centered product than current language-learning apps, *Sprachen-Tanz* may be a promising alternative to promote language learning among older adults. The principles and features of the app presented above can serve as a model in the design of new language-learning products for older adults.

Developing suitable apps for older language learners poses specific challenges to ensure universally accessible and useful products that meet a wide range of abilities, requirements, and learning goals. It also requires an interdisciplinary approach that captures the multiple dimensions of language learning, aging, and technology adoption. We believe that efforts in this direction will pay off, as inclusive design and appropriate app-based language-learning concepts will not only positively influence older adults' perceptions and attitudes towards technology and increase their chances to learn a language in the digital era, but will also improve the apps' flexibility, learnability, and accessibility, improving, in turn, the language-learning experiences of all segments of society. We hope that the insights presented in the current article contribute to a deeper understanding of the characteristics of older language learners and to a more effective design of apps that address their needs, aspirations, and capabilities.

lected data were anonymised and processed exclusively within the project. Written informed consent was obtained from all older adults who participated in this study.

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