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ORIGINAL RESEARCH

Designing web search UI for the elderly community: a systematic literature review

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Abstract
Now-a-days the number of older people or senior citizens are rapidly increasing across the world and their need for the internet is also increasing mostly for information searching to make them up to date with the current trends and news. Therefore, they need a search user interface that is to be elderly-friendly so as to communicate with the computing system and to attain better results for their search task. The user interface is the only way of communication between the users and the computing systems. Currently, available user interfaces focus only on youngsters' needs and their recommendations to attract them, but the need for seniors is neglected, because of which the elders could not handle these complicated user interfaces for their search task and attain their target information. Thus, this topic is in trend today by the researchers to build a new type of user interface that can cope up with the elderly needs and to improve their daily life. Even though there exists a considerable growth in this research area, there are no attempts made to analyze the existing studies systematically and utilize those ideas mentioned by various other researchers. Thus, in this systematic literature review, the existing methods of search user interfaces and the elderly user behaviors are well analyzed and then certain recommendations are proposed which are useful for future researches in this field. The objective of this systematic literature review (SLR) is to collect and analyze the facts that are proposed in existing research articles and existing designs of web search user interface that are related to the challenges, impact and limitations that elderly people are experiencing while doing a web search in their daily activities so as to gather information online. This SLR is organized by gathering all the existing survey papers and research papers that have been published over a specific period of time. These papers are systematically reviewed by some pre-defined reviewing strategy thereby making a conclusion regarding the design of user interface for the elderly community. A total of 30 studies are selected as primary subject for the literature survey regarding web search user interface for the elderly. From these selected studies, the data needed for the research are extracted using an approach of systematic mapping and are synthesized to acquire knowledge related to the current research topic. These studies are analyzed and synthesized in such a way that the knowledgeis used for answering the research questions formulated during the survey. The information regarding the user interface for interaction, the assistance provided to elderly by the existing user interfaces, the impact created by those UI's on the elderly community and the research gaps and limitations that occur in existing researches and systems while communicating with the computing systems through a user interface for their daily internet search activities are extracted and some recommendations are proposed for future researchers. There are some more research gaps identified in the current state-of-the-art since most of the researches don't focus on the aging of the elderly and their consequences while interacting with the computing system through a user interface. Thus, this research can help in finding a better understanding of elders and the difficulties faced by them while searching through the internet so as to develop a positive impact for the researchers to create an elderly-friendly user interface for web search activities.

Keywords Systematic literature review (SLR) · Web search user interface · Elderly community · Older adult community · User friendly interface · Web search · Supporting elements · Search engine · Performance

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1 Introduction

The number of elderly people is growing rapidly and the aging population is wide spread all over the world even in developed countries. The people around the age of 60–75 are the young older, the ones who arebetween the age of 75–85 are the old-older and the ones who are above the age of 85 are very old. The persons who are at an age group of over 60 years are primarily focused on this research. Since they are at the starting stage of getting old and are most vulnerable to loneliness and cognitive disability. Cognitive disability includes degrading memory power, confusions, impaired judgements and difficulties in learning new things mostly because of age factor and medications, makes its challenging for them to usesearch engines like Google, Yahoo, Bing, etc. The older people make themselves up to date with society by surfing through the internet. Usually, the search task is started by generating a search query based on the topics related to the task. After generating it, this search query is used to search through the internet. If the user gets the expected outcome, then this process is ended. Otherwise, by reformulating the search query, the desired result can be acquired. This process can be easily done by younger people when compared to the older people due to the fact of their cognitive disability and less exposure to computing knowledge. These difficulties experienced by the older people are taken into consideration and to overcome this, a new design for the user interface which is more user-friendly to the elderly community is proposed by systematically analyzing the existing research papers or studies related to elderly user behavior and web search user interface and by recommending a better design and providing additional knowledge for future researchers who will do research in this field.

For this, a set of studies are identified from online databases and other sources in the duration of 2005–2019 years. These studies are then screened for removing the duplicates and to meet to inclusion/exclusion criteria. And at last, a set of 30 studies are selected as primary studies for further research progress. Then these papers undergo a quality assessment and based on the scores, the quality standards are assigned for the studies. After these filtration processes, all the important data required for the research process are extracted and synthesized from these studies. The literature review is done in such a way that the findings from these papers are used to answer the research questions formulated during the research progress.

2 Search methodology

As stated above, this literature review is about the evaluation and designing of a user interface that is elderly-friendly. The proposed user interface design should be in such a way that anyone who is old or anyone with a disability could access all the elements and contents of the web. This can be achieved by performing a literature survey by identifying all the available research papers within a specific duration. By analyzing the research methodologies followed in each paper and the evaluation criteria followed by the researchers, thereby answering the research question that are used during the survey. By this literature survey, the research gaps and limitations of the existing methodologies are identified so that to make recommendations for future researches. In this method of literature survey, the guidelines proposed by Kitchenham and Charters (2007) are used for undertaking the Systematic Literature Review in this paper, which includes three phases to complete this systematic literature survey, which are Planning, then Organizing and finally documenting. These phases have their own subdivisions which are given as follows: (1) research questions, (2) data/information sources, (3) criteria for inclusion/exclusion of selected papers, (4) study of quality assessment, (5) systematic review strategy, (6) extraction of data and synthesis. The following sections describe these phases of reviewing methodology.

2.1 Research questions (RQ)

The aim of the systematic literature review is to identify and understand the methodologies, evaluation criteria, other fact and proofs presented in the identified research papers or studies. This knowledge is used to compare the efficiency, feasibility and performance of existing user interfaces and its usability for the elderly's by answering some research questions that are formulated during the survey related to web search user interface for the elderly community. So, in this SLR, 4 research questions (4 RQs) are formulated which are given as follows: These questions are to be clearly answered in order to complete the SLR successfully.

RQ-1 Are there any designed web search UI for the elderly community?
RQ-2 To what extent the existing web search UI provide the appropriate assistance to the elderly?
RQ-3 Improvements needed in existing web search UI to have a significant impact on the elderly's daily internet search activities?
RQ-4 What are the limitations and gaps within current review studies and their effect on the elderly's daily internet search activities?

2.2 Data/information sources

The most appropriate and generally used terminologies in this systematic literature review are elderly, elder people, older people, older adults, aged and senior, then web search, user interface and web search user interface.

OR operator is used to comparing the above given key terms to search for related contents.

1. elderly OR elder people OR older people OR older adults OR aged OR senior
2. web search OR user interface OR web search user interface

AND operator is used to concatenating the above given key terms to form a new search string.

(elderly OR elder people OR older people OR older adults OR aged OR senior) AND (web search OR user interface OR web search user interface).

Eventhough these search strings support in finding the most appropriate research papers, it has a negative aspect also. That is it check against the title of the article. Thus, there is a need for some other criteria to identify and finalize the articles for further review purposes. The first one is, the papers should be acquired from some electronic libraries. The libraries used here to identify the research papers in this SLR is given as follows.

- Springer
- First Monday
- Elsevier
- Sagepub
- ACM
- Wiley
- Research Gate
- IEEE Explore
- J Med

Another criterion was added that paper should focus on web search user interface and aging or elders. The papers which have focused on persons' disabilities were excluded. At the last stage, we had finalized the research studied based on the completeness of the research and their analysis in user interface designing.

2.3 Criteria for inclusion/exclusion

The major reason for applying inclusion criteria and exclusion criteria is to make sure that the studies selected for this literature review are related to a user interface for elderly web search and are beneficial in developing a new user interface for elderly or to enhance the existing user interface and make it elderly friendly or adaptable for them and also it should meet the requirements to achieve the objective of this literature survey. For that, some of the inclusion and exclusion criteria are derived and are shown in Table 1 with the criteria used in this review process. The total number of records identified for the research purpose is 340 which are found through online database search and additional 15 records are found through various other sources. These records are screened to remove duplicates and 44 records were excluded from this review post scrutiny. After removing the duplicate records, there exist 311 records. These 311 records undergo further screening by applying the title and/or abstract exclusion criteria and 275 records were excluded from the review process. Finally, only 30 research papers were selected as primary studies for this systematic review process.

The inclusion criteria applied to this research is given as follows:

- Sample of target members who are above 60 years of age
- Records only after publishing
- Records related to a user interface for web search
- All records published during the year 2005–2019
- Records from electronic libraries

The exclusion criteria applied to this research is given as follows:

- All records not written in English
- Thesis and dissertations
- Records with no full text
- Records published other than the duration2005-2019

2.4 Study of quality assessment

The quality assessment study is a primary step that helps a researcher to identify whether the selected paper is related

Table 1 Records for inclusion and exclusion criteria

Criteria	Inclusion	Exclusion
Availability	Full text	No full text
Language	English	Other than English
Timeline	From 2005 to 2019	Gray paper and papers not in the range of 2005 and 2019
Research questions	Papers that can answer at least any one of the research questions	Duplicate papers and incomplete papers

to the specific topic at which the current literature survey is done and also whether those papers are useful in the way to develop a new user interface or to enhance the already existing user interface which can be elderly friendly. For this purpose, here formulated 5 quality assessment (QA) questions and reviewed them in detail and gives related scores based on the analysis.

QA1 Is the proposed topic related to web search user interface?
QA2 Does this research help in finding a new user interface for a web search for the elderly community?Does this research help in finding a new user interface for a web search for the elderly community?
QA3 Does the research help to improve the user interface fora web search for the elderly community?
QA4 Whether the proposed topic is described adequately?
QA5 Whether the proposed topic is user-friendly for Elderly People?

The above given five quality assessment questions help in the way of reviewing the selected studies based on its usage for this research. The purpose of doing the quality assessment is to improve the ability of the researchers to understand the specificity and usability of the findings for this research. Nidhra et al. (2013) proposed high-level quality criteria by providing specified scores to the findings. According to Nidhra et al. (2013), three types of ratings are provided for quality assessment which includes "high", "low" and "medium" qualities. These quality ratings are given by answering the quality assessment questions and based on the overall scores for quality, corresponding ratings are provided. From this outcome, the ratings are split-up into three categories. A quality score of '2' is provided for the studies that completely fulfils the quality standard. A quality score of '1' is provided for the studies that partially fulfils the quality standard. If the quality standard is not yet fulfilled, then the score provided is '0'. Thus for five quality assessment questions, a total of '10' score, which is the highest possible score is given for each finding (i.e., $5 \times 2 = 10$). If the selected finding does not meet the quality standard, then a total of '0' score is given to it, which is the lowest possible score (i.e., $5 \times 0 = 0$). In this SLR, the findings that secure a score of '7' or greater than '7' are considered as a high-quality finding. The findings that secure a score of '6' is meant to be a medium-level quality finding and the findings with the score of '5' or less than '5' are considered to be a low-quality finding. By considering the quality assessment scores, a total of 0 studies do not fulfil the quality standard criteria and those findings are finally excluded from this review. The scores provided for each of the selected studiesare tabulated in Appendix-B.

2.5 Systematic review process

Figure 1 describes the stages involved in the current literature review process. The first stage is the identification of records related to current research. So, in this SLR, the papers related to web search user interface for the elderly are selected. These records are searched from electronic libraries and the records that don't meet the inclusion criteria are excluded in the process. The keywords used for searching the records related to the current research are as follows: elderly, elder people, older people, older adults, aged and senior, then web search, user interface and web search user interface.These keywords are used in the way by comparing and concatenating specific key terms like (*elderly OR elder people OR older people OR older adults OR aged OR senior*) *AND* (*web search OR user interface OR web search user interface*) to generate a new search string which is useful for searching the findings related to this study. After searching the online libraries and some other data source like Springer, Elsevier, ACM, Wiley, Research Gate, IEEE Explore etc., the results are about 340 studies are identified from online databases and 15 studies are identified from other sources. In this case, no studies are excluded. Then in the second stage, the screening process goes on and as a result,44 studies are excluded for duplication and a set of 275 studies are excluded from the findings due to title/abstract or other exclusion criteria and only 36 papers exist after screening. Finally, in the third stage, 06 studies are excluded since it does not have a full-text content. Thus, a total of 30 studies are selected from the findings for further data synthesis and review purposes. These details are shown in Table 2.

2.6 Extraction of data

An important step involved in the study selection process of SLR is data extraction. The process of data extraction is the first step of synthesizing and extracting the results from the selected studies and to answer the relevant research questions. In this process, the required knowledge from the 30 selected papers is extracted which is most important for the review process. The extracted results include the author names, and the publication year, the data provider details, the title of the study, the region where that paper originated, and also extracted major data such as, type of web search user interfaces used in the research, context of that papers, the topic to which it belongs to, the method of gathering research data and evaluation criteria, whether users are involved in the study or not and if yes, then the number of users or samples included in the study and their demographic details and what type of paper it is. It is clearly tabulated in Appendix-A.

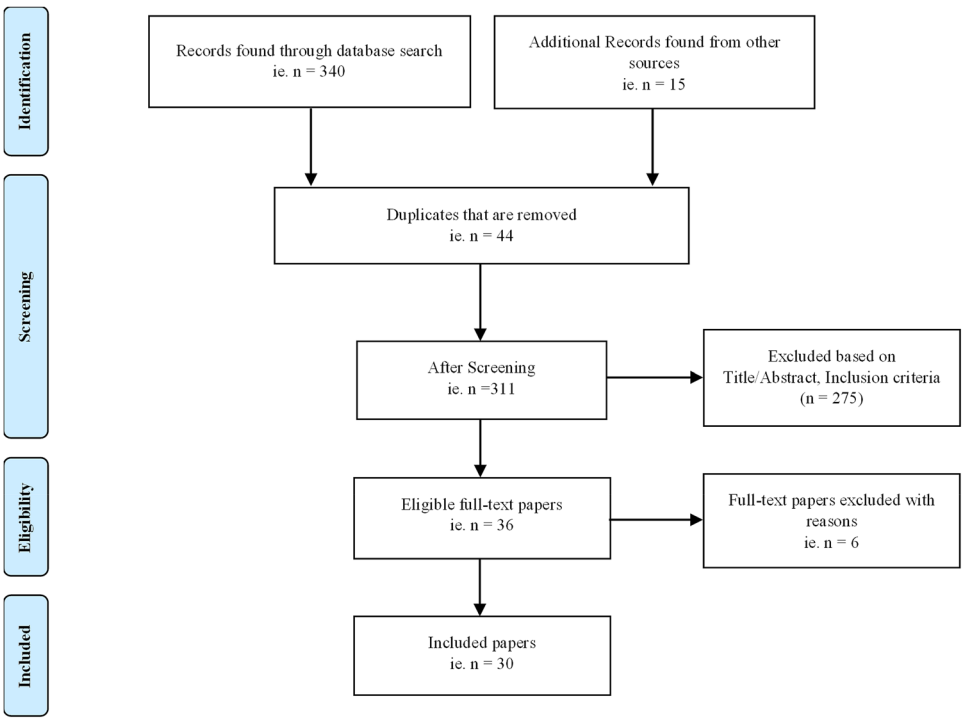

Fig. 1 Study selection process results

Table 2 Records for systematic review process

Phases	Included	Excluded
Identification	Database search = 340 Other sources = 15	None excluded
Screening	311	275
Eligibility	36	06
Included	30	None excluded

2.7 Publication sources and types of papers

After the inclusion and exclusion criteria, the papers that don't meet the requirements are rejected and finally, only 30 papers are selected for primary research purposes. Out of these 30 papers, 11 papers are research articles, 10 papers are from journal articles, 5 papers are from conference proceedings, and 4 papers are from CHI proceedings. These papers are collected from various data sources online. It is represented in graphical format in Fig. 2. The various online databases used for searching the research papers used for this literature survey is given as follows: (1) Springer, (2) First Monday, (3) Elsevier, (4) Sagepub, (5) ACM, (6) Wiley, (7) Research Gate, (8) IEEE Explore, (9) J Med.

2.8 Publications over a period of time

This section shows the number of papers published during the selected period of time (ie., 2005–2019) graphically in

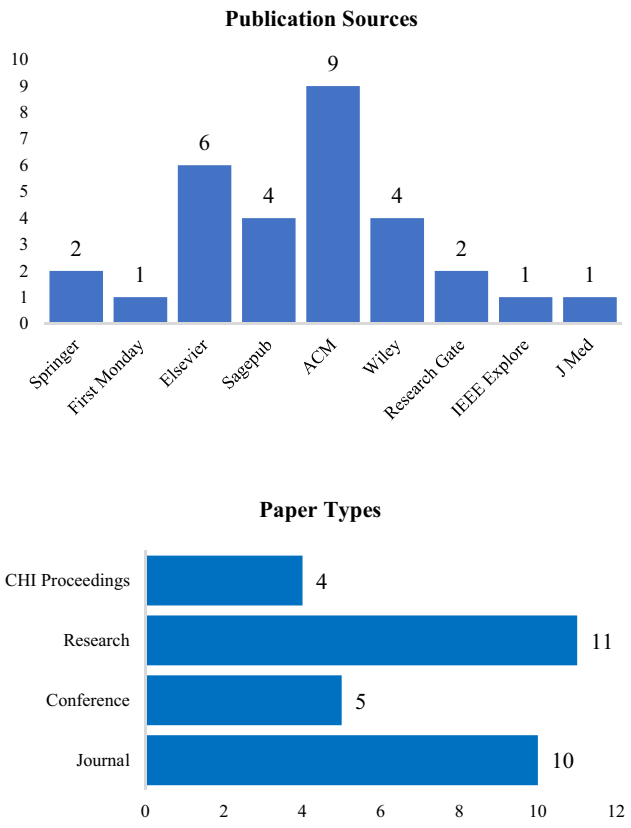

Fig. 2 Distribution of publications through sources and types

Fig. 3. Out of 30 selected studies, more studies published in the area of web search user interfaces are in 2017 and fewer number of studies are published in the same area is from 2006 to 2010 and no such studies were published in the year 2012 and 2018.

2.9 Publication regions

The papers selected from the online database and other sources are about 340. But finally, only 30 papers are screened and selected for this systematic literature review purpose. These 30 papers are from various regions which are classified as follows: Out of 30 studies, the region with leading percent of studies is from Europe which is about 44%. The next maximum papers are from the USA region which is about 23%. The regions with minimum papers published are from Spain, China and Cyprus regions which are about 3%. The regions of Illinois, Canada and Germany have a distribution of about 7% of the studies. This can be graphically viewed in Fig. 4.

2.10 Research methods

In this SLR, 2 methods of research are used. They are Quantitative methods and Qualitative methods. The one with both the methods of research is called mixed method. These methods are used to analyze the knowledge from the 30 selected papers that are related to web search user interface for the elderly community. Figure 5 shows the division of selected studies under these methodologies. From this figure, it can be clearly seen that, out of 30 selected studies, 60% of studies are under the quantitative method, 23% studies are under the qualitative method and 17% studies are under mixed methods, which means the combination of both quantitative and qualitative methodologies is 83%. The 30 papers are categorized into three kinds based on their topics. They are Tools, User Behavior and Platform. The papers under the tools category are related to any new prototype or design developed or proposed. The papers under the user behavior category are related to the behavior of users while they are involved in the research, which in other words mean how

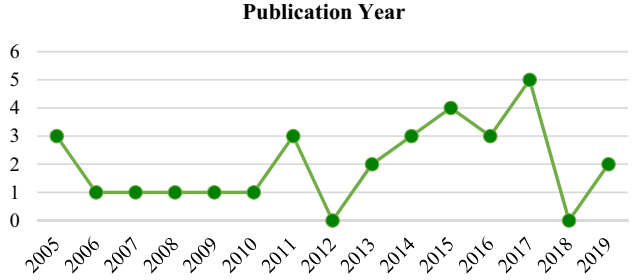

Fig. 3 Publicationyear (2005–2019)

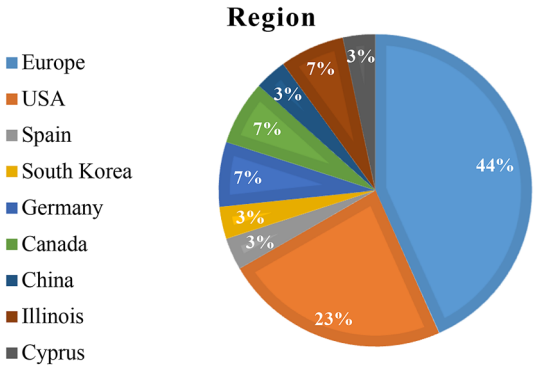

Fig. 4 Region of classification for selected papers

the user reacts to the usage of the presented research and the papers under the category, platform or related to the overall topic regarding the research, ie., elderly-friendly web-search user interface.

2.11 Sample size and demographics

To get a clear picture of how the elderly behavior varied from younger ones, the understanding of the samples used in each selected research papers are studied. Totally there are 30 papers selected and from that only one paper doesn't use any samples for their research. All other papers used an adequate sample needed for their research purpose.

The demographic details of those samples are collected for future references by some researchers. By making them work on the interfaces by giving some specified search tasks and then comparing the performances of elders and youngers, the variation of usability of the user interface is analyzed. Figure 6 shows the total number of both elder and younger samples used in each selected study (Fig. 7).

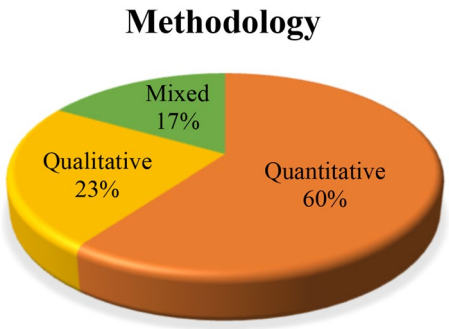

Fig. 5 Classification of papers through research methodology

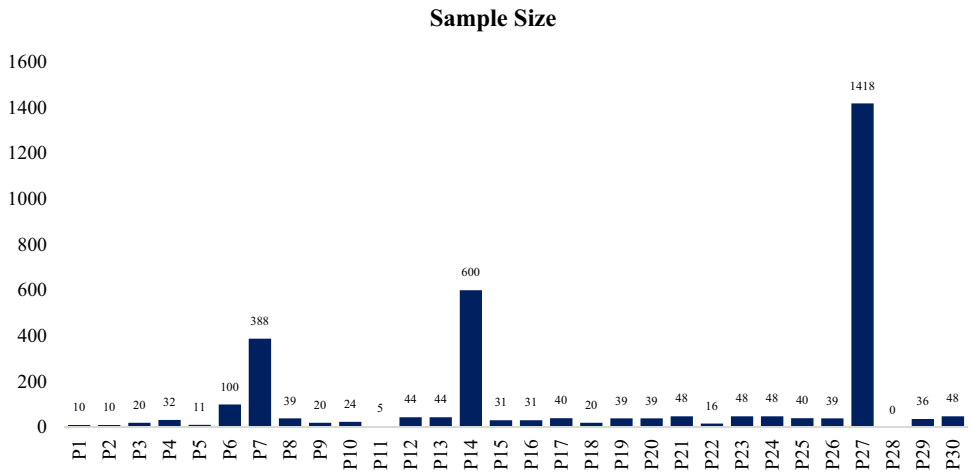

Fig. 6 Sample size and demographic details

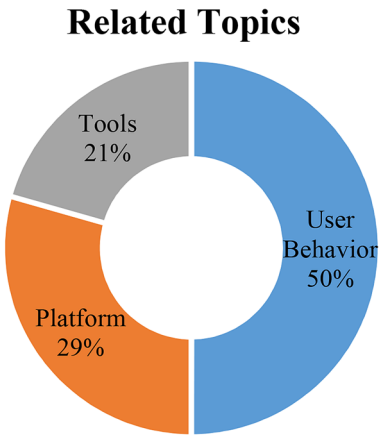

Fig. 7 Classification of papers through their related topics

2.12 Research question results

This section describes the summary of the selected studies based on the research questions formulated. By answering the formulated questions, a clear description of the findings is provided from this review.

2.12.1 Are there any designed web search UI available for the elderly community? (RQ-1)

Yes, many web search user interfaces are available for the elderly community, one of them is developed by Aula (2005) named Etsin, which is specially designed for older adults. In Etsin interface, the upper part contains a logo for Etsin, a text box to search for queries and also contains two buttons for clearing and submitting the queries. Below the buttons, a bar is available which consists of the number of hits that arereturned while searching. In the right, there is a drop-down that shows the URL of the acquired results in a simplified form. In Google, the URLs are only shown. But in Etsin, those URLs are shown in a list format that has the title and summary of that page which was given by Google. These tiles are linked to the results page and the text is underlined and the font color is blue which in default represents a link. After visiting the links, the title color turns into purple, so as to identify whether the page is visited or not in the future. For summarizing the visited pages and making them easier to read, Aula (2005) proposed the list type of view with a bullet. This list is enhanced further by using a relevant applicant item near it, since Etsin can easily recognize the Word, PowerPoint, Excel and pdf files and provides the corresponding icon beside it.Another standalone application was developed by Stronge et al. (2006) using Java. This prototype has an interface as in email clients and windows explorer. The left side of this window has a collection of all available links related to the search query whereas the right side of the window shows the contents inside the links which has been selected from the collection. This design is a familiar one and is very easy toadopt and understand by all. Both the left and right panel are tightly coupled so as to get the result immediately once the link is clicked. The keywords related to the search query are highlighted in pale yellow color to show the connection between the search keywords and the results obtained from it. If there is nothing selected from the category list, then no result is displayed and the result page is empty. But it won't be like that, since the built-in category "All results" is available. Thus if no specific category is selected, then all the results retrieved from the query are viewed, 150 results are default at first. In this case, the order of the results is determined by the search engine and it will not be in sequential order. It will be ordered by the rank given by the search engine. The top of the user interface has a text box to enter the search query and a 'Cancel' and 'Search' buttons to control the action of the search engine. The bottom of the window is a status bar that gives the information related to the number of documents found and the online/offline status of the system.

Dickinson et al. (2007) also proposed a Proof of Concept (P-of-C) system which fulfill the W3C standards and is easy to access for older adults. This system is developed in such a way that it must be visually accessible. It uses sans-serif font with a minimum of 14 pt. and the targets area minimum of 28 pt. with high contrast between background and foreground. These colors are referred by commercial designers and are evaluated by the research teams and older people for clarity and preferences. This layout has an off-white background for reducing glare and a high contrast text over a pale background which is easy for reading. There hasn't been distinguishing different colors like blue, purple and green fonts, since ageing makes their retina insufficient to variate those colors. There is also an option to change the color of the foreground and background and to vary the text size according to their preferences. A page-specific help is given throughout the system, since the elders without any background knowledge and lagging in language view the websites as an alien. So this help content can make them grow their knowledge and remove the dependencies in learning and make them familiar with new concepts. However, each page in this system is restricted to their function, this support is practically possible.A taxonomy (hierarchy) based approach was proposed by Pak and Price (2008) and Kaki and Aula (2005) which makes the users search for an item based on categories. At first, one should search for the most common terminology related to their search query, then to find out the relevant top-level category for that term and subsequently move into the exact category within which the required keyword is available so as to select the exact webpage they needed. In the tag-based system, the exact keywords related to the search query is a must. So the user should have a clear understanding in synonyms. Chung et al. (2011) from his findings said that the zoomable user interface is much useful for older adults. But the difference in the usability of ZUI is vast. The younger adults used the zooming and panning function than the elder adults and achieved the target with better accuracy and in high speed. Time is the major difference than the performance between younger and older adults. Older adults take more time than younger ones. This time difference is due to the insufficient usability of panning function by the older adults. The older adults used the zooming function to enlarge a specific location and then zoom out to go for the next location while the younger adults haven't zoom out from a page whereas they panned to the next location. This is due to the cognitive disability which occurs due to ageing. Thus a zoomable user interface that uses the Original-center focus method is a difficult tool for elderly people due to the fact the usage of the mouse here is dominating which requires additional knowledge like movement control, spatial cognition and memory. Thus a new zoomable user interface was suggested by Chung et al. (2011) which reduces the demand for cognitive ability. This results from using the proposed ZUI shows that it does not affect the speed of younger users and the speed of older users got increased.

Gossen et al. (2013) suggest that to design a coherent search user interface suitable for both children and adults, the position of various parts of the search user interface must be fixed. So a new elderly search UI is developed by Gossen et al. (2013) which has five groups of elements. (1) help, (2) bookmarks storage, (3) result visualization, (4) keyword search elements (5) navigation menu. This UI is based on Knowledge journey. The search option helps the users to search for an item using keywords and the menu option helps the ones who have problems with generating keywords for search query especially for children. First of all, the needs for children are analyzed and developed the options for browsing menu, graphical separation for search results, coverflow research visualization, etc. The menus used in this Search User Interface (SUI) are Pie-menu and Classic menu. These menus can be hidden from the interface if the user does not need them. Comprehension-based linked model of deliberate search (CoLiDeS) splits the user behavior for navigation into four cognitive processing stages. Webpage parsing into high-level schematic regions, focusing on any one of the parsed regions, elaborating or comprehending the objects of the screen within the region and selecting and evaluating the most suitable screen object in the region (Karanam et al. 2015). This system is based on the information foraging theory connected with Construction-Integration reading Model. The information sent in CoLiDeS is operationalized like the semantic similarity of the user target and the hyperlink. The value of semantic similarity is used to predict the hyperlink that a user is most expected to click. This process goes on repeating for every page until the target page is reached by the user. The CoLiDeS can also find the usability problem by the prediction of unclear hyperlinks (van Oostendorp and Karanam 2016). Another system called Scent-based Navigation and Information Foraging in ACT Architecture (SNIF-ACT) is used to predict the choices for navigation and simulate the user behavior for performing tasks that are unfamiliar to them. Predictions for taking decision for which link is to be clicked or next page or to leave a page is done by measuring information sent. User choices are more sensitive to the location of a hyperlink on the webpage. SNIF-ACT 2.0 presented a new Bayesian Satisficing Model by combining the information sent measure and position of a hyperlink on the webpage number of links clicked, for predicting to click more hyperlink or to click on the best hyperlink (Karanam et al. 2015).

Abegaz et al. (2015) and van Oostendorp and Karanam (2016) proposed that for a prototype of the search engine, four different types of interfaces are developed. Out of these, three uses visual stimuli based on color/shape. These stimuli have three levels viz., low positive, high positive and neutral.

The labels of interfaces are (1) wCloud, (2) sCloud, and (3) wsCloud. Bing is the baseline interface used here. The wCloud interface uses text formatting like text color. Red, blue and black are used to induce the low positive, high positive and neutral mood levels respectively. sCloud interface incorporates the polygons in visual stimuli. The levels of the stimuli are based on the polygons in angular, mixed or round to induce low positive, neutral and high positive mood (Vijayakumar and Arun 2017). The wsCloud interface, combines the color and shape as visual stimuli. To interact with a search engine, a new design for an automatic support tool is proposed by Abegaz et al. (2015) using the behavioral outcome and by analyzing the contents obtained from search query while reformulating. The support tool 1 is used to reduce the efforts for getting the result from a search task from Search Engine Results Pages (SERP). Even though older adults take more time than younger adults in acquiring the results, the accuracy of the search results for older adults is low when compared with younger adults. The semantic relevance is measured between the search results and the search query using Latent Semantic Analysis (LSA). The search results having higher semantic relevance is highlighted in green color arrow. The Support tool 2 focusses on improving the queries. This tool makes sure that the user doesn't get an irrelevant result due to irrelevant search query.

van Oostendorp and Karanam (2016) describes that the search semantic relevance of a search query by younger adults is constant whereas for older adults, it is decreased sue to their reformulation of the search queries. Thus the support tool 2 is proposed to monitor the average semantic measure for the relevance of SERP to reach the goal and gives the user a warning when the sematic relevance falls below the threshold value. Sanchiz et al. (2019) proposed a support tool called IS Support tool, that consists of a module in the screen top to display all the ultimate queries generated by the user. This tool has 2 functions namely the search goal refresh in the working memory and the navigational support. The search goal refresh in the working memory displays the ultimate query generated by the users to make them remember the search goal and to keep them active like an external memory. This refresh function works like a guide with low cost cognitive and to look on the queries to create a new strategy to work on the SERP and webpage contents. It helps the users to extract new relevant information and to integrate it on users' intellectual representation for their search goal. The navigational support function is clickable. If it is clicked, then the user returns to the SERP. It supports to explore the webpage contents so that the older adults are not needed to allocate resources to remember the path of navigation taken by them to return to the SERP.

2.12.2 To what extent the existing web search UI provide the appropriate assistance to the elderly?(RQ-2)

Kaki and Aula (2005) established a new type of user interface for the elderly. Firstly, the user interface based on category is better when compared with the results obtained through conventional UI in speed. The speed is much important in cases such as most of the time, the search results are not the exact one as we searched for at the first time so that the user needed to go for alternate results. Secondly, this UI not only provide the elders with more options, but it provides more relevant options. The results obtained from this UI is more with relevant results. It showed that the relevant results obtained with conventional reference UI are 40% higher than the proposed UI. Thirdly, the users attain the relevant results quickly when compared with the results attained from reference UI. Fourth, the users have a positive attitude towards the categorized UI. A standalone application developed by Stronge et al. (2006) using Java is a familiar one and is very easy to adopt and understand by all. A web search user interface is developed by Aula (2005) named Etsin, which is specially designed for older adults. Etsin can easily recognize the Word, PowerPoint, Excel and PDF files and provides the corresponding icon beside it. Overall, the interface is felt easier and simple for elderly users when compared with Google, even for those who are familiar with Google, in such a way that Etsin only provides useful and much-needed information, whereas Google provides much information that is unnecessary and is not related to the current search query. The colors like black, blue, bold and green used in Google too messy for them.

A training system called proof of concept project is proposed by Dickinson et al. (2007). A secure learning system for search and navigation was designed to make the older adults who are a novice to computers, to learn how to interact with the user interface while searching for an item in the web. This system can give the users a working experience in conventional browsers. Gradually this training system leads to the usage of more functionalities and various contents through the generalized and conventional interface (Dommes et al. 2011). The major factor that is taken into consideration is that the interface should not be either frightening or confusing. The users are first introduced to the homepage of the training interface, where a brief description of the whole system and also the details about where to get help, how to explore more with the interface is provided. The homepage also provides an explanation of whatever buttons used in the interface. This makes the older novices to understand all the elements inside the UI before getting into it.This training system has two levels of the catalog. One is the initial level having fewer contents and the other is the advanced level having additional contents to go deeper. Overall the presentation is simple to look. A taxonomy (hierarchy) based

approach proposed by Pak and Price (2008) makes the users to search for an item based on categories. At first, one should search for the most common terminology related to their search query, then to find out the relevant top-level category for that term and subsequently move into the exact category within which the required keyword is available so as to select the exact webpage they needed. In tag-based system, the exact keywords related to the search query is a must. So the user should have a clear understanding in synonyms. But with the help of many-to-one mapping available between the menu and page, the chances of generating accurate keyword increases comparing with taxonomy-based system. The designers consider the usage characteristics of older and younger users regarding various zooming scales and zoom focus levels to design a reasonable ZUI (Chung et al. 2011). According to the findings by Chung et al. (2011), the timing and performance is more efficient in selective-focus method when compared to the fixed-focus method. The Aiming-point zoom focus method and the Re-center focus method is also a better option for zooming. While using the aiming-point and re-center focus methods, the time consumption is reduced and the number of operations performed by the elderly user increases comparing with the results obtained from original-center focus method. The ZUI with selective-focus method significantly reduces the panning operations.

Gossen et al. (2013) suggested a new design for the user interface with the following elements to provide assistance for the older users and children. In the menu type, the pie menu has all the available categories represented by an icon with a tooltip text for as their description. It can be operated by a simple point and click interaction. The top-level categories are given at first followed by the sub-categories. In the classic menu, all the top level categories are mentioned as a list and it is also operated by a simple point-and click interaction. In this type of menu, all the sub-categories are opened at once, which can't be achieved by using pie-menu. Based on the size and type, the classic menu occupies more space which leads to scrolling. But this problem doesn't happen in pie-menu. The structure of the menu topic is made in such a way that the available categories should meet the children's entertainment and educational needs. Thus the menu categories like the universe, history, geography, sports and hobbies, entertainment, nature and persons are used. Also adult related categories like shopping, travel, cars, lifestyle, etc. are included. The menu structure is adaptable so that the user interested categories can be made available for view. These are the input types contained in this SUI. Moving forward to the output types, the visualization technique is used. The visualization techniques have three different kinds namely, vertical list of surrogates, tiles and coverflow. There are some more visualization techniques that exist like graph visualization. But they are too difficult for children to understand because of their abstract nature. Each visualization technique has its own advantage and disadvantage. The vertical list of surrogate method made available a fast overview of many results at once. The tiles method also shows all the available results at once but it presents a lot of results in a single page comparing with the list. The older of categories are not much clear in a list. Usually, a user performs little jumps in a list having more contents compared to tiles. So the rank of such results is presented in the proposed user interface. The best choice for children proposed by Gossen et al. (2013) is the Coverflow method. This method provides an attractive animation while searching for a result. The central element is obviously separated from the rest of the elements so that the user concentrates on a single item at a time, resulting in little cognitive load. Children got vexed while finding a lot of results for one search query. So the number of results per page is limited and is fixed to avoid scrolling, 3 results in list and 4 results in tiles. The coverflow method is adaptable for the number of results from 3 to 9. The results obtained from a list or tile can be separated in 3 ways to avoid confusion in visualizing it. They are separation bylines, separation by boxes and no separation. The space between the separation is also adaptable. The surrogate structure consists of result tile and text summary. The text is aligned to the left. The results are ordered by their rank. There is also a picture to represent the result. This UI also uses a thumbnail for the website. The picture size is also adaptable. An additional feature like keyword and URL highlighting is also given. The color of the highlight is also customizable. The results page can be viewed in several ways such as opening a result page in a new tab or in a new window or on the same window. Moreover, the results page can be previewed before opening it. This preview can be turned on/off by the user.

Other general properties such as font size, type of font, avatars, themes and audio support are also considered in this in this proposed UI (Gossen et al. 2013; Abegaz et al. 2015). The font size equal to 14 pt or greater than 14 ptis no suitable for the children. Thus the proposed GUI is customizable for fonts from 10 to 18 pt and uses a type called Sans-serif to increase the readability of text. Also, playful fonts like Arial and Comic Sans MS are visually attractive for children. Additionally, Times New Roman and Impact fonts can also be chosen but it has bad readability of texts. Different fonts can be assigned for various options such as search input, menu, help and surrogate. Themes such as pirate, space, princess and animal themes are implemented here since they are more familiar among children. Themes like pirate and space travel well suits for the search box, since it might give an illusion of experiencing a journey to gather information from a treasure chest or steering or a logbook etc. The themes influence the background image, color scheme and background color of search results, avatar set and the metaphor used for storage. Each theme has its

own set of avatars to be chosen. There is also an option with no themes and avatars in the UI. The audio support is also a highly demanded feature especially for children who takes more time to read. When hovering on an item in a pie menu, a voice description is played. This option is also available to all the elements in UI. The audio support can be switched on or off and can have some voice options like male, female, boy and girl voices. The proposed UI by Gossen et al. (2013) can also work well on touchscreen devices. This is how the user interface affects the search tasks (Kules and Xie 2011).

Abegaz et al. (2015) proposed 2 types of support tools. The support tool 1 is used to reduce the efforts for getting the result from a search task from SERP. Even though older adults take more time than younger adults in acquiring the results, the accuracy of the search results for older adults is low when compared with younger adults. This issue mostly occurs due to the fact that older adults cannot differentiate the non-relevant and relevant results like younger adults. The proposed support tool visually highlights the relevant result for a search query. The main aim of proposing this tool is to support the interaction between the user and the search engine. The semantic relevance is measured between the search results and the search query using LSA. The search results having higher semantic relevance is highlighted in green color arrow. This arrow makes the older users give less effort to find out the relevance and non-relevance in search results so that the accuracy is also increased. If there is no satisfaction in the obtained results, then the user can request the support tool for the next best search result. The support tool 2 focusses on improving the queries. This tool makes sure that the user doesn't get an irrelevant result due to irrelevant search queries. van Oostendorp and Karanam (2016) describe that the search semantic relevance of a search query by younger adults is constant whereas for older adults, it is decreased sue to their reformulation of the search queries. Due to the reformulation of search queries, older adults are getting much distance to the target information that leads to lower accuracy (Chin et al. 2015). Thus the support tool 2 is proposed to monitor the average semantic measure for the relevance of SERP to reach the goal and gives the user a warning when the sematic relevance falls below the threshold value. Thus this tool supports the elder users to be confident while they getting a relevant result and to take any other corrective actions for generating more relevant search queries.

The effect of IS support tool proposed by Sanchiz et al. (2019) is that it is mostly used by older adults than younger adults. As expected, this tool guides the attention of the user towards relevant information for the search goal and it stores all the allocated resources from the earlier stages of an activity to gain more useful information to carefully select a relevant content webpage. This tool helps older adults to refresh the goal of the search in working memory (Abegaz et al. 2015). This IS support tool improved the search strategies of older users by two mechanisms. At first, this tool reduces the parallel processing for older users to do a critical search task, thereby saving the cognitive resources so as to develop a more elegant search strategy. Second, this tool guides older users to pay attention towards more relevant information for their search tasks at a low cognitive cost. The IS support tool helps older adults to efficiently reformulate the search queries. So the older adults are needed to remember and recall the previous search queries used by them and produce a new keyword. The older adults no longer needed to allocate more cognitive resources to refresh the information in their working memory (Sayago and Blat 2009). They can still have enough cognitive resources to reformulate the query more efficiently. This system copes with the lower speed of processing and reduces the difficulty occurred due to time limit and simultaneous mechanisms that weaken the cognitive resources amount in working memory. The support tool not only helps the older users to refresh their earlier search queries but also helps them to elaborate a more coherent mental representation based on the search by extracting a new significant information available in the web and then integrate it on their mental model. So that the older users reformulate the queries for more significant information with added cognitive resources from their working memory (Sayago and Blat 2009). In this way, the proposed IS support tool improves the search strategy of older users and raised more effective decisions.

2.12.3 Improvements needed in existing web search UI to have a significant impact on the elderly's daily internet search activities? (RQ-3)

Aula (2005) explained that security issues cause anxiety to elderly users since they are aware that the internet has many security problems. This makes them unconfident to make a decision (Dickinson et al. 2007). For example, the PDF documents while opening often results in some unwanted alerts like permissions and updates. Even though these alert dialogs are in English, the users cannot understand this, since it is an unexpected dialog or redirecting for opening a PDF file, as they haven't clicked any wrong link which is unavoidable and problematic which causes fear and anxiety in novices. To avoid this situation, a visually clear and different form of highlighting these links is necessary like, "DOC" inside a bracket in Google and Microsoft Word" inside a bracket in orange color in MSN. But this is also not much useful, since novice users are unaware of the technical terms. Usage of dialogs in a user interface is problematic, since it often asks for some information, or gives a warning, or shows if something unexpected has happened. So it is very important that these dialogs are simple to understand what is going to happen next even by novice users. Otherwise, the users

simply close the webpage by clicking on the top-right corner cross button. There are also problems in entering a text or editing it in the query input text box which arises more common among all age groups. It might not be such a serious issue but it is much annoying more than what we think. Most of the users were not well-versed in using the keyboard and also they need to focus more on the keyboard for typing each letter, so that the typing got slowed down. But most of the users don't check whether the cursor is on the text box before typing. They will complete typing the search query but they don't know that nothing is typed there. The arrow of the mouse changes into caret when the cursor is on a text box. The only difference that the cursor is on focus is that it blinks. If the cursor is not blinking, then it is not in focus for typing. But for the older user who hasa visual impairment, cannot differentiate these small differences of the cursor. Making typos are another issue while typing a query in a search box. The typo is also a common problem among all users. But correcting it in an efficient way is difficult for users who cannot point the mouse in the exact location for editing. So that they remove the full typed queries and type a new one. This problem is due to the psychomotor disability and vision impairment arises with aging. This problem can also occur due to less prior experience in handling a pointing device like a mouse. Therefore, the zooming function is a must to avoid such a typo (Chung et al. 2011). But if only the text is zoomed and the size of the text box remains constant, then it is not much efficient. Thus an interface having a customizable text box based on the text size and gaps between each letter is sufficient and is the only solution for users who cannot use a pointing device efficiently.

Using the back button of getting back to the previous results page after viewing the result document is also causes some problems among the older users since they don't have any prior knowledge or experience in differentiating the back button, forward button and home button. The Go button in internet explorer is the same as the forward button. These scenarios cause serious confusion among the users to differentiate the usage of each button. The back button of a browser and a webpage is also sometimes misunderstood by the users and ends in the same page they already exist. Every time a user clicks on the forward or back or home buttons, they needed some help from their moderators to click on it confidently to avoid the confusion of getting into the wrong direction. The users sometimes click more than once in the back button which results in unexpected navigation. To avoid such confusions, the result webpages are to be either opened in a new tab or a new window, so that the users can easily navigate to the results page they needed. It is also much useful if the new window is smaller than the original window so that one can go for the previous window by just clicking on it. Moreover, the pop-up windows are somewhat stressing and confusing the users if it opens automatically without their knowledge. So this method is to be clearly guided before using it and must be customizable for the users (Cioara et al. 2017) to select whether the results page should open in a new tab or in a new window or in the same window where they are searching.

Sometimes the mouse pointer changes into a round cursor when the mouse wheel is clicked. This cursor makes the page scrollable simply by moving the mouse in the correct direction and not by scrolling the mouse wheel. The problem caused by this feature of a mouse is that the scrolling cannot be stopped by stop moving the mouse. To stop this scrolling, one should click on the mouse wheel, but most of the users only shook the mouse with additional force whenever the mouse pointer is not catchable since it can be easily found out when it is moving, which makes the scrolling even more speed are causes confusion that where to end-up. The default function of a mouse wheel is to scroll and not to click. There should not be two functionalities for a single control. Advanced users can customize the functionality of a mouse, but older users and novice users only use the default functionality. If a particular website is not user-friendly in all the ways, then the users go for another alternative webpage even if the former one is much effective, since the users need efficient webpages. Thus Nori et al. (2019) said that age can impact the navigations throughout the browser.

Almost web searchers more often use short queries that include 1 to 3 queries and rarely iterate them. But prior experience affects the query length and the query iteration frequency. Users with prior experience iterate the queries often and use long queries. Most of the elderly users use only 1 and 3 terms. But using queries with 4 or 5 terms are also not uncommon. To formulate more precise queries, it is to be iterated more often. If a successful query is generated at first, then there is no need for modifying or iterating it. Formulating a wrong query leads to getting off-topic results or minimum correct results. The elderly users don't know what is wrong with this and they ask for some hints from the moderators to modify it. The proposed search UI understands the queries by an explanation of natural language regarding the interpretation of the query by the search engine. Google uses AND as their operator in default and returns that "About n pages were found having all the words 'a', 'b' and 'c'". More elaborated queries are also supported, for example, for a query, "'elderly users' search-library', it returns, 'About n pages found having phrase 'elderly users' and the word 'search'. None of the pages has the word 'library'".

Sayago and Blat (2009) explained that while accessing a web page, the visual contents are not likely to be viewed by the aged, since they have a visual disability. So that they

have to go for a reading glass whenever it is needed. Persons with experience in using online websites have their reading glasses near to them but not the unexperienced ones. The unexperienced online users get closer to the system and then try to access the visual contents and then later go for reading glasses. An option of zooming or magnification is not the best solution for visual functionality (Chung et al. 2011). Since while zooming a webpage, all the elements inside the page are enlarged so that either horizontal or vertical zooming is enabled and also the important contexts either go to the next page or exists in previous pages so that scrolling is a must which is a tedious task for aged people. In touch screens, the precision of scrolling is reduced, since two fingers are to be used so that the blurriness between the user and the screen is to be taken into account (van Oostendorp and Karanam 2016). Thus magnifying the elements causes more harm to elderly users than causing them good. So the elders mostly prefer to come closer to the screen or to use reading glass instead of enlarging the webpages and the elements. Sayago and Blat (2009) also said that one word can explain more briefly than an icon. Even though icons are a simple representation of terminology, the unexperienced older users have no idea regarding it. Except for main web icons like E for internet explorer, W for Microsoft word, etc. other icons are not familiar and are difficult to remember them. The older adults pay much attention to words that icons since it is easy to understand and doesn't need additional knowledge and remembrance.

Gossen et al. (2014a, b) said that it is highly believed that older people have many difficulties in using the internet and are much complicated so and hard to learn about internet activities so that they have no benefit from it. But this case is no longer valuable. This is because older people are now more enthusiastic in learning and using the internet. Still some barriers exist due to natural decline in cognitive flexibility, processing speed, the ability for switching to various processes, visuospatial span and attentional control. Due to these disabilities, older users are less efficient and slow while using the internet. They are unaware about the previously clicked links or visited sites and do repeated visit the same pages which consumes more time in completing a search task, taking a long time to click a link, visiting a minimum number of pages, etc. Moreover, crystallized intelligence increases and stable due to ageing. This is about the experience, prior knowledge and vocabulary. Thus it is higher for older than for younger. Now a question arises that whether crystallized intelligence helps the internet users or not. If it helps, then how it is done. Pak and Price (2008) undergone research to identify whether the architecture of a webpage can reduce the performance barriers caused due to ageing. For this Pak and Price (2008) introduces two types of architectures namely, a hierarchical (Chung et al. 2011) and a tag-based architecture. It is found that the older users performed well on tag-based architecture interface since it has a lesser demand for spatial abilities and a greater demand for vocabulary. But a limitation in this research is that the materials used here have no search engine results. By combining some performance measures like accuracy, task completion time and difficulty of tasks, it is found that younger users achieved higher scores than the elder users. But in research on knowledge, experience, cognitive ability, performance, it is found that not only these characteristics are enough to perform better in internet activities, but also complex tasks made both young and older user rely on a combination of knowledge, reasoning abilities, perceptual speed and working memory. Elder people use a top-down strategy (Chung et al. 2011) so that they work well with ill-defined tasks and the younger people use a bottom-up approach, which is suited for well-defined tasks. The materials used here are websites and not interaction with SERPs or search engines and the cognitive models are also not included in this research.

2.12.4 What are the limitations and gaps within current review studies and their effect on the elderly's daily internet search activities? (RQ-4)

A web search user interface called Etsin specially made for elderly people by Aula (2005) has some limitations such as it does not have a cached version of searched results likeGoogle. The cached version in Google highlights the search keywords which is highly useful in longer documents. Etsin also lacks in language selection options so that one who is not well-versed with English would suffer. Even though the Microsoft word icon is more common and easily identifiable by older users, icons like PDF and Microsoft excel are unidentified by them. Kaki and Aula (2005) explained that to get a successive outcome, more number of results should be fetched from the search engine which consumes more time for computation and has a certain price. Even though the Findex computes a lot of results, only 10 of them are displayed at first and the remaining are computed in the background when users evaluate the first fetched results. Thus for Findex, we can get the desired number of results with reduced cost but there is a delay in acquiring it.

Stronge et al. (2006) suggested that implementing system tools in search engines for the sake of elder users to assist their search tasks. The users should be trained and motivated that they can get interesting results while using different strategies for online information search. Pak and Price (2008) concluded that the web search using tag-based system is much efficient than by using hierarchy/taxonomy

based system. This is because, in hierarchical system, one should know the top-level category of a search keyword which can only be possible with users having the high vocabulary, it means by identifying the exact location of the search term. Thus it is not suitable for younger adults and can only suit older adults. But in tag-based system, anyone with a keyword can get their desired result. Sayago and Blat (2009) considers the accessibility barriers that affect the search tasks and enhance the web accessibility for elderly users. The inclusion and independence and also the cognitive load are the key aspects for elders in their everyday interactions with websites. Reducing the cognitive loads, worth the exploration, since it is the major accessibility barrier that includes the understanding of terminologies and remembrance of steps related to the tasks which affect their independency for web search. By finding the way that how the elders and children learned to involve in online activities and to understand the terminologies, designing an elderly-friendly user interface is possible for the designers.

Chung et al. (2011) describe the results related to zooming and panning function in a zoomable user interface (ZUI). The performance and the preference of an elderly user can be affected more by the panning function than the zooming function since the panning function is much complicated. The usage of panning buttons with eight-directions that are grouped together is also available, but Chung et al. (2011) propose a drag and drop function in the information space. The usability of a ZUI can be increased only by considering both the zooming and panning functionalities. Thus a designer should focus on both the understanding of ZUI and how to interact with the ZUI to design an effective and efficient ZUI. From the findings of Chung et al. (2011), the Aiming-point focus and Re-center focus method are the much satisfied methodologies for the elderly users due to the high zoom scale in re-center focus method and the aiming-point focus method regardless of zoom scale. The obtained results from the research show that the user satisfaction rate is evaluated by including the relationship between Z-Scale and Z-Focus. The subjective evaluations include user satisfaction, affection and the preference and practical measures include time and error. Moreover, user satisfaction, affection, and preference are important interests in the development of a product, since it affects the marketing a lot in a positive way.

Gossen et al. (2013) suggested that using management UI elements like components used for bookmarks management or history mechanisms like breadcrumbs, which supports the online users in processing and retaining the information. Most of the researches in the search user interface does not include the UI elements for management. But recently the motivation of using it is increasing in addition to basic properties such as font size and color.

The research by Karanam et al. (2017) has limitations such as regardless of age, factors such as educational experience, past experience in using the internet, crystallized intelligence and fluid ability are not explored. Another one limitation in this study is the usage of assumptions in modeling without making any changes in it, steps including only giving a specific hyperlink and the corresponding SERP is used. Sanchiz et al. (2017) explained that even if the older adults have experience in using the internetthe time is taken by them for the search of a result and the time spent on a particular web page is high. Thus in the future, the research should deepen in this case, that why they are taking this much of time for a search task. Further limitations include, the recruitment of older adults, since older adults of the same age group and with similar internet experience are difficult to find so that the samples used here are less. Thus the comparison of young–old adults and old–old adults is not much efficient. Further research in this field can use eye-tracking technique to extract and analyze the results of the search engine (Abegaz et al. 2015). The limitations also include that the support tool for query reformulation is not much effective, because after reformulating the queries also the results acquired by the older adults are off-topic due to their age-related impairment, even though before entering into a search task, a help topic and query suggestions related to it is displayed at first in the home page.

Sanchiz et al. (2017) done research by making the older users work in Manga which more favor or younger adults. This domain is a good one to study user behavior but it has a serious limitation in it. Manga is a Japanese comic book. So the terms used in Manga have Japanese terminologies that needed additional language support for the users to infer the words. Thus in the future, a more relevant search domain should be employed. The eye-tracking technique is used to study which link is going to be clicked by the younger and older adults and how they reformulate the query. The findings from this research showed that elderly users make use of their prior knowledge to improve the semantic specificity of the generated queries. But if the search query is demand more cognitive ability, then they have difficulty in using their prior knowledge. In this case, they need the help of information support tools to use their prior knowledge and to infer new keywords and evaluating the results obtained from the search engines. The research was done by van Boekel et al. (2017) has no records of how much time a user spends on a web page, their attitudes towards the internet and the supports given by the moderators to them about the new technologies. Since cross-sectional design is used in this

approach, the investigation of causality between included variables was impossible.The works by Sanchiz et al. (2019) uses a smaller number of samples of older adults. The concept of eye-tracking is used in this research which has a limitation that eye-tracking data older adults with lower vision could not be captured well (Abegaz et al. 2015). The usage of support tool also has a disadvantage that the new technologies are difficult to understand by the older users due to their decline in cognitive ability and fluid abilities. There might be in the future, analyzing the impact of a support tool for a long period of time or after the users getting familiar with the tool can give more successful results. Future research on the support tool also analyze how the memory and mental model can impact the search results and enhance the search performance.

3 Discussion and conclusion

As of now while searching for content on an online website, younger users are often more successful than older users due to their prior knowledge in using the web search user interfaces and technologies or due to their intellectual level to quickly learn a new process, etc.This is due to the decrease in cognitive flow, lack of prior experience related to web search user interfaces and technologies, disability in psychomotor functionality, etc. Thus to propose a new recommendation which is more useful for older adults to search through online for information retrieval independently and with less effort, this research is done. In this systematic literature review, a web search user interface for the elderly community is described by studying more research papers found from online database search through related to the keywords web search, user interface and elderly and selected a total of 355 records. After screening these findings, exclusion of papers that don't fulfil the inclusion/exclusion criteria is done. After the complete screening process, a total of 30 papers are selected for further research analysis and synthesis. The papers are searched in online libraries from the duration of 2005–2019. Data extraction is performed on these selected papers and important information from the papers is synthesized. These studies are categorized into three topics namely, tools, user behavior, and platform and follow two methodologies namely, quantitative method and qualitative method and mixed method which combines both quantitative and qualitative methodologies. The samples and demographics used in those papers are also described graphically. The main aim of this systematic literature review is to study the selected papers and then answer the research questions formulated during the research progress. The research questions are related to the existing design of a web search user interface for elderly users, the assistance provided by these interfaces for the elderly, the improvements needed in existing systems to have a significantimpact among the older users, and finally the limitations and research gaps found in the selected papers. The improvements and limitations addressed range from the simply menu versions to complex technical related aspects of the requirement of Cache and language selection etc. Such information and the recommendations provided in this literature survey are used to research in the field of the elderly-friendly user interface for future researchers. This review analyzed all the areas and derived the grey area in this field which can't be identified only by a database search. A limitation of the current literature review is that this research only includes the studies from the duration of 2005 to 2019. If more papers are selected and analyzed, more information can be retrieved.

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Appendix A: Extraction of data and synthesis

The table given below shows the various data extracted from the selected 30 research papers. The extracted data are, the author names, the publication year, the data provider details, the title of the study, the region where that paper originated, and also extracted major data such as, type of web search user interfaces used in the research, context of that papers, the topic to which it belongs to, the method of gathering research data and evaluation criteria, whether users are involved in the study are not and if yes, then the number of users or samples included in the study and their demographic details and what type of paper it is.

ID	References	Data provider	Title	Region	Web search Ui type	Aim	Context	Topic	Method	Data gathered	User involved	Samples and demographics	Paper type
P1	Aula (2005)	Springer	User study on older adults' use of the Web and search engines	Europe	Elderly-friendly search user-interface	To motivate the elders to use computers and to make them use the internet as their source of information retrieval	Human factor	Platform and user behavior	Quantitative	Interview	Yes	10 older adults	Research
P2	Aula (2005)	First monday	Less is more in web search interfaces for older adults	Illinois	Etsin: An Elderly-friendly search user interface developed by comparing Google and Etsin and solved the issues faced by the participants	To evaluate the success of an elderly friendly search UI called Etsin by making some elders work on Google and Etsin browser and by comparing the outcomes	Business	Platform	Qualitative	Observation	Yes	10 older adults	Journal
P3	Kaki and Aula (2005)	Elsevier	Findex: improving search result use through automatic filtering categories	Europe	Text categorization and filtering UI by comparing category design with the de facto standard solution	To develop a UI based on Category and Reference, time taken for completion of the task, results for those tasks, relevance of results and subjective attitude	Business	Tools	Quantitative	Experiment, subjective questions	Yes	20 volunteers 19–57 years	Research
P4	Stronge et al. (2006)	Sagepub	Web-based information search and retrieval: effects of strategy use and age on search success	USA	World Wide Web: America Online and Yahoo	To investigate the factors related to the strategy used to achieve search success and also to understand how age influences the searcher for strategy usage	Human Factor	Platform	Mixed	Behavioral and knowledge engineering	Yes	16 younger and 16 older adults	Research
P5	Dickinson et al. (2007)	ACM	Approaches to web search and navigation for older computer novices	USA	Proof of Concept (P-of-C) web search interface and navigation system	For older adults who see the internet as alien territories	Business	Platform	Quantitative	Training and evaluation tasks (T tests)	Yes	11 older adults	CHI proceedings

ID	References	Data provider	Title	Region	Web search Ui type	Aim	Context	Topic	Method	Data gathered	User involved	Samples and demographics	Paper type
P6	Pak and Price (2008)	Sagepub	Designing an information search interface for younger and older adults	USA	Taxonomy and Tag-based information organization interfaces	To compare the performance of younger and older adults in two information organization interface schemes	Human Factor	Platform	Quantitative	Ability measures	Yes	50 younger and 50 older adults	Conference proceedings
P7	Sayago and Blat (2009)	ACM	About the relevance of accessibility barriers in the everyday interactions of older people with the web	Spain	3 years of ethnographical study based on everyday interactions between older with web	To find the significance of accessibility barriers faced by older people while interacting with the web in their daily activities	Education	Platform and user behavior	Qualitative	Course, Workshops and Public meetings, focus groups, in-depth interviews and semi-structured interviews	Yes	388 older adults	Conference proceedings
P8	Dommes et al. (2011)	Wiley	The role of cognitive flexibility and vocabulary abilities of younger and older users in searching for information on the web	Europe	User behavior through Google	To investigate the cognitive ability and vocabulary variation in age related difference while searching through the web	Education	User behavior	Quantitative	Training and experiment (trail making test, plus-minus test and mill hill)	Yes	19 younger and 20 older adults	Research
P9	Chin and Fu (2010)	ACM	Interactive effects of age and interface differences on search strategies and performance	USA	User Behavior through public medical information websites like WebMD and MedlinePlus.gov	To investigate how interfaces and types of tasks influence the decision making and search strategy	Health care	User behavior	Quantitative	Experiment related to medical decision making	Yes	20 younger adults	CHI proceedings
P10	Chung et al. (2011)	Elsevier	The effects of zoomable user interfaces and user age in searching for a target with a mouse on a two-dimensional information space	South Korea	A Zoomabale UI with 3 zooming focus and two zooming scales	To analyze the effect of zooming in interfaces based on two zooming factors in on two age groups	Business	Tools	Quantitative	Experiment, questionnaire	Yes	24 volunteers	Journal

ID	References	Data provider	Title	Region	Web search Ui type	Aim	Context	Topic	Method	Data gathered	User involved	Samples and demographics	Paper type
P11	Kules and Xie (2011)	Wiley	Older adults searching for health information in MedlinePlus—an exploratory study of faceted online search interfaces	USA	MedlinePlus	To understand how the user interfaces affect user actions and their tactics	Health Care	User Behavior	Mixed	Data Collection, Questionnaire, Intro video regarding tasks, Eye tracking technique	Yes	5 Older Adults	Research
P12	Gossen et al. (2013)	Research Gate	Evolving search user interfaces	Germany	ESUI with coverflow and tiles result visualization	To introduce the concept of an evolving search UI, specifically for children or elders	Education	Platform	Qualitative	Observation, hypothesis (visualization of various UI elements)	Yes	27 children and 17 adults	Research
P13	Gossen et al. (2013)	ACM	Adaptation of a search user interface towards user needs—a prototype study with children & Adults	Canada	User Behavior through the search user interface and adaptable elements	To design an adaptable search user interface, specifically for children or elders	Human factor	User behavior and tools	Qualitative	SUI Adaptation, storing interesting pages and using help option	Yes	27 children and 17 adults	Research
P14	Zhou (2014)	IEEE	investigating information needs of elderly people in Chinese rural community: presenting an information service framework	China	User Behavior through Questionnaire	To take a survey that focuses on the information needs for Chinese rural community	Education	User behavior	Qualitative	Survey, 14 close-ended questions in various topics, thorough examination	Yes	600 respondents	Conference Proceedings
P15	Gossen et al. (2014a, b)	ACM	Usability and perception of young users and adults on targeted web search engines	Germany	User Behavior through Google and Blinde-Kuh.de	To examine the age-related differences in usability and perception of search UI in targeted search engines	Education	User behavior	Mixed	Eye tracking technique, structured pre-interview and demographic data	Yes	14 children and 17 adults	Research

ID	References	Data provider	Title	Region	Web search Ui type	Aim	Context	Topic	Method	Data gathered	User involved	Samples and demographics	Paper type
P16	Gossen et al. (2014a, b)	ACM	A comparative study about children's and adults' perception of targeted web search engines	Canada	User behavior through Google and blinde-kuh. de	To compare the perception and behavior of children and adults while using search interface elements	Education	User behavior	Qualitative	Eye tracking technique, Two-stage experimental design with two factors like web search engine type and search task type	Yes	14 children and 17 adults	CHI proceedings
P17	Chin et al. (2015)	Sagepub	Age differences in information search: an exploration–exploitation trade-off model	Illinois	User Behavior through WWW, Google search engine API	To describe the link between age-related cognitive abilities and search process	Human factor	User behavior	Quantitative	Two tasks to find processing speed and 1 task to find memory capacity	Yes	20 younger and 20 older adults	Conference proceedings
P18	Chevalier et al. (2015)	Elsevier	Strategy and accuracy during information search on the web: effects of age and complexity of the search questions	Europe	User behavior through Google and other websites	To address the age-related differences regarding performance and strategies followed during information searching via the web	Education	User behavior	Quantitative	Search tasks and hypothesis	Yes	10 younger and 10 older adults	Journal
P19	Karanam et al. (2015)	ACM	Modelling and predicting information search behaviour	Cyprus	User behavior through CoLiDeS, SNIF-ACT	To address the cognitive model of search navigation through web and age-related differences in web searching	Business	User behavior and Tools	Quantitative	Demographic questionnaire, domain knowledge test on Manga and health	Yes	19 younger and 20 older adults	Research
P20	Abegaz et al. (2015)	Sagepub	Investigating perceived usability and choice satisfaction of alternative search engine's presentation for older adults	USA	Interfaces labeled as control interface, wCloud, sCloud, wsCloud interfaces	To examine the usage of color, shapes, and other visual stimuli induce the older adults in their search performance	Business	Tools	Quantitative	EyeTribe-eye tracking device	Yes	39 older adults	Conference proceedings
P21	van Oostendorp and Karanam (2016)	ACM	Supporting information search by older adults	Europe	CoLiDeS model, SERPs	To address the limitations faced by older adults in navigation through a search engine and not only by website	Education	Tools	Quantitative	Demographic questionnaire, search tasks	Yes	24 younger and 24 older adults	Research

ID	References	Data provider	Title	Region	Web search Ui type	Aim	Context	Topic	Method	Data gathered	User involved	Samples and demographics	Paper type
P22	Miyake et al. (2016)	Springer	Estimation models of user skills based on web search logs	Europe	Machine learning model to estimate the skill level based on the operation logs in a tablet PC	To build a model based on decision-tree	Education	Platform	Quantitative	Skill evaluation task, web search task	Yes	16 Older adults	Research
P23	Karanam and van Oostendorp (2016)	ACM	Age-related differences in the content of search queries when reformulating	USA	User behavior through Google's search engine	To investigate how reformulation of a search query related to aging and difficulty in search tasks	Education	User behavior	Quantitative	Demographic questionnaire, TMT test, search tasks	Yes	24 younger and 24 older adults	CHI proceedings
P24	Karanam et al. (2017)	Wiley	Cognitive modelling of age-related differences in information search behaviour	Europe	User behavior through CoLiDeS and CoLiDeS+	To evaluate the ability of cognitive models for navigation through the web for aged people	Education	User behavior	Mixed	Demographic questionnaire, search tasks, behavioral experiment	Yes	24 younger and 24 older adults	Journal
P25	Sanchiz et al. (2017)	Elsevier	How do older and young adults start searching for information? Impact of age, domain knowledge and problem complexity on the different steps of information searching	Europe	User behavior throughGoogle Chrome and Google search engine	To address the differences in generating search query and performance of web searching due to aging	Education	User behavior	Mixed	Questionnaire, Search tasks	Yes	20 younger and 20 older adults	Journal
P26	Sanchiz et al. (2017)	Elsevier	Searching for information on the web: Impact of cognitive aging, prior domain knowledge and complexity of the search problems	Europe	Firefox browser and Google search engine	To describe the impact of cognitive ability, domain knowledge and age, in performance, strategy and generating search query while searching through the web	Business	Platform	Quantitative	Task related to knowledge domains like manga and health domain	Yes	19 younger and 20 older adults	Journal

ID	References	Data provider	Title	Region	Web search Ui type	Aim	Context	Topic	Method	Data gathered	User involved	Samples and demographics	Paper type
P27	van Boekel et al. (2017)	J Med	Diversity in older adults' use of the internet: identifying subgroups through latent class analysis	Europe	Browser and Social media	To identify whether diversity or heterogeneity is related to social-related or health-related variables for older adults	Health care	User Behavior	Quantitative	Questionnaire, statistical analysis (ANOVA, Chi-square test)	Yes	1418 older respondents	Journal
P28	Cioara et al. (2017)	Elsevier	Adaptive workspace interface for facilitating the knowledge transfer from retired elders to start-up companies	Europe	Interface collaborative Adaptive workspace	To describe an adaptation and decision-making technique to ratify the automatic generation of the customized workspace of elders based on their impairments and cognitive profile	Business	Platform	Qualitative	Sensors or self-reporting questionnaires	No	–	Journal
P29	Nori et al. (2019)	Wiley	Web searching and navigation: age, intelligence, and familiarity	Europe	User Behavior through Google search engine	To examine the relation between age and navigation throughout the browser by taking into account, the IQ and usage frequency of PC and internet	Education	User behavior	Quantitative	Demographic, computer use questionnaire, MMSE test, Kaufman Brief Intelligence Test, Web search tasks	Yes	18 younger and 18 older adults	Journal
P30	Sanchiz et al. (2019)	Research Gate	User-friendly search interface for older adults: supporting search goal refreshing in working memory to improve information search strategies	Europe	IS Support Tool	To develop a support tool that cope with age related disability while using a search interface for displaying the ultimate query of older users	Business	Tools	Quantitative	Eye-tracking, search tasks, mixed ANOVAs	Yes	30 younger and 18 older adults	Journal

Appendix B. Quality Assessment Scores (QAS).

The quality scores for the questions related to Quality assessment criteria are given as follows:

ID	QAS1	QAS2	QAS3	QAS4	QAS5	Total QAS
P1	1	0	2	1	1	5
P2	2	1	2	2	2	9
P3	2	2	2	2	2	10
P4	2	2	2	2	2	10
P5	2	2	2	1	0	7
P6	2	2	2	2	1	9
P7	2	2	2	1	0	7
P8	2	2	2	2	1	9
P9	1	1	2	2	0	6
P10	2	2	2	2	2	10
P11	2	1	2	2	1	8
P12	2	1	1	1	0	5
P13	2	2	2	1	2	9
P14	2	2	2	2	1	9
P15	2	2	2	2	0	8
P16	2	2	2	2	0	8
P17	1	2	2	1	1	7
P18	2	2	2	2	0	8
P19	1	1	2	1	0	5
P20	1	1	2	1	1	6
P21	1	2	2	1	2	8
P22	1	1	1	1	0	4
P23	1	2	2	2	0	7
P24	1	2	2	2	0	7
P25	1	2	2	1	0	6
P26	1	2	2	1	0	6
P27	1	1	2	1	0	5
P28	2	2	2	2	2	10
P29	1	2	2	1	0	6
P30	2	2	2	2	2	10

The literature papers are classified under the categories tabulated below:

ID	References	Study title	Purpose
1	Aula (2005)	User study on older adults' use of the Web and search engines	Human factor
2	Aula (2005)	Less is more in web search interfaces for older adults	Business
3	Kaki and Aula (2005)	Findex: improving search result use through automatic filtering categories	Business
4	Stronge et al. (2006)	Web-based information search and retrieval: effects of strategy use and age on search success	Human factor
5	Dickinson et al. (2007)	Approaches to web search and navigation for older computer novices	Business
6	Pak and Price (2008)	Designing an information search interface for younger and older adults	Human factor
7	Sayago and Blat (2009)	About the relevance of accessibility barriers in the everyday interactions of older people with the web	Business
8	Dommes et al. (2011)	The role of cognitive flexibility and vocabulary abilities of younger and older users in searching for information on the web	Education
9	Chin and Fu (2010)	Interactive effects of age and interface differences on search strategies and performance	Health care
10	Chung et al. (2011)	The effects of zoomable user interfaces and user age in searching for a target with a mouse on a two-dimensional information space	Business

ID	References	Study title	Purpose
11	Kules and Xie (2011)	Older adults searching for health information in MedlinePlus—an exploratory study of faceted online search interfaces	Health care
12	Gossen et al. (2013)	Evolving search user interfaces	Education
13	Gossen et al. (2013)	Adaptation of a search user interface towards user needs—a prototype study with children and adults	Human factor
14	Zhou (2014)	Investigating information needs of elderly people in Chinese rural community: presenting an information service framework	Education
15	Gossen et al. (2014a, b)	Usability and perception of young users and adults on targeted web search engines	Education
16	Gossen et al. (2014a, b)	A comparative study about children's and adults' perception of targeted web search engines	Education
17	Chin et al. (2015)	Age differences in information search: an exploration–exploitation trade-off model	Human factor
18	Chevalier et al. (2015)	Strategy and accuracy during information search on the web: effects of age and complexity of the search questions	Education
19	Karanam et al. (2015)	Modelling and predicting information search behaviour	Business
20	Abegaz et al. (2015)	Investigating perceived usability and choice satisfaction of alternative search engine's presentation for older adults	Business
21	van Oostendorp and Karanam (2016)	Supporting information search by older adults	Education
22	Miyake et al. (2016)	Estimation models of user skills based on web search logs	Education
23	Karanam and van Oostendorp (2016)	Age-related differences in the content of search queries when reformulating	Education
24	Karanam et al. (2017)	Cognitive modelling of age-related differences in information search behaviour	Education
25	Sanchiz et al. (2017)	How do older and young adults start searching for information? Impact of age, domain knowledge and problem complexity on the different steps of information searching	Education
26	Sanchiz et al. (2017)	Searching for information on the web: impact of cognitive aging, prior domain knowledge and complexity of the search problems	Business

ID	References	Study title	Purpose
27	van Boekel et al. (2017)	Diversity in older adults' use of the internet: identifying subgroups through latent class analysis	Health care
28	Cioara et al. (2017)	Adaptive workspace interface for facilitating the knowledge transfer from retired elders to start-up companies	Business
29	Nori et al. (2019)	Web searching and navigation: age, intelligence, and familiarity	Education
30	Sanchiz. et al. (2019)	User-friendly search interface for older adults: supporting search goal refreshing in working memory to improve information search strategies	Business

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