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REVIEW

The Attributes and Characteristics of Leisure Activity Engagement that Foster Cognition in Aging: A Scoping Review

Karen Carnicello Wenzel[1] · Marieke Van Puymbroeck[2] · Ryan Gagnon[3] · Stephen Lewis[3] · Francis McGuire[3] · Julie Vidotto[4]

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Abstract
The association between leisure activities and cognition in aging is well supported, suggesting that intellectual, physical, and social leisure engagement protects against cognitive decline. However, less is known about the attributes and characteristics of leisure activity engagement that foster neurological protection. The purpose of this study was to review the current evidence related to the salient features of leisure activity engagement that foster cognition in aging. Using scoping review procedures, nine databases were searched. Sixty-five articles, published between 2000 and 2021 met study criteria, providing empirical information about the ways in which attributes and characteristics of leisure engagement have shown an association with cognition in aging. The purpose of a scoping review is to systematically map the literature on a topic, identifying key concepts, theories, sources of evidence, and gaps in the research. This review identified and explored the attributes of leisure engagement which were frequency, intensity, duration, and variety. Characteristics of leisure engagement identified include novelty, active/productive engagement, enjoyment, meaning, and self-direction. Literature supports, to varying degrees, the association between leisure attributes and characteristics and cognition in aging. This information may provide more meaningful direction for intervention than recommendations for engagement in specific activities or activity domains. Results suggest that it is the way leisure is experienced, i.e., the attributes and characteristics of leisure engagement, and not any specific leisure activity or category of activities that may determine the protection provided against cognitive decline in aging. This can be used to guide future research, provide beneficial recommendations to older adults, and in the design of efficacious interventions to prevent cognitive decline in aging.

Keywords Leisure engagement · Leisure attributes · Cognition · Aging · Cognitive reserve

Introduction

In an increasingly aging world, there is an associated prevalence of chronic disease, disability, and cognitive decline (United Nations UN DESA, 2020). A large amount of research has focused on cognitive decline in the aging population, which is a leading cause of disability, institutionalization, and mortality (Alzheimer's Association, 2020). Researchers predict a two- to three-fold increase in the global prevalence of cognitive decline by 2050 (Alzheimer's Association, 2020), causing unprecedented strain on families, healthcare systems, and society (Christie et al., 2017). Preservation of cognition is of critical importance, and as such, has been deemed a public health priority (D. Sherzai & Sherzai, 2019). Accordingly, extensive research has been directed toward efforts to preserve or enhance cognition in aging (Park et al., 2007). Brookmeyer (2007) noted that even delaying the onset of dementia by 12 months would reduce nine million cases of dementia, resulting in a savings of 10 billion dollars over 10 years. Modifiable risk factors may account for up to 40%–50% of worldwide dementias (Livingston et al., 2020; Pettigrew & Soldan, 2019; Valenzuela et al., 2007), and include lifestyle factors

✉ Karen Carnicello Wenzel
karenwenzel@msn.com

1 Department of Parks, Recreation, and Tourism Management, Clemson University, Littleton, CO, USA

2 The Graduate School, Department of Parks, Recreation, and Tourism Management, Clemson University, Clemson, SC, USA

3 Department of Parks, Recreation, and Tourism Management, Clemson University, Clemson, SC, USA

4 Osher Lifelong Learning Institute, Clemson University, Clemson, SC, USA

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(e.g., physical inactivity, tobacco use, unhealthy diets) and effective management of medical conditions (e.g., diabetes, hypertension, obesity, depression). Additional potentially modifiable risk factors include social isolation and cognitive inactivity (World Health Organization, 2021).

Leisure Activities as Protection Against Cognitive Decline in Aging

For many years, researchers have hypothesized that engagement in mental, physical, and social leisure activities fosters protection against cognitive decline in aging populations. These leisure activity categories have been studied both in combination (Karp et al., 2006; Pettigrew et al., 2019; Phillips, 2017; Ruthirakuhan et al., 2012; Song et al., 2021), and in separate classes of cognitive leisure activities (Doi et al., 2017; Ferreira et al., 2015; Qiu et al., 2019; Saczynski et al., 2008; Stern & Munn, 2010; Tesky et al., 2010; Yates et al., 2016), physical leisure activities (Ku et al., 2012; Cohen et al., 2017; Fernandez-Matarrubia et al., 2021; Ogino et al., 2019; Zotcheva et al., 2018) and social leisure activities (Bourassa et al., 2017; Evans et al., 2019; Haslam et al., 2014; Ihle et al., 2021; James et al., 2011).

The association between leisure activities and cognition in aging is well supported, but less clear is what salient features of leisure engagement are neuroprotective. Leisure activities are not inherently efficacious, just by their fundamental nature, notably because they are not ubiquitously experienced (e.g., a book club might be intellectually challenging and engaging for one individual, and social for another). It has been suggested that studying one activity or activity domain does not yield useful information (Bielak & Gow, 2023). Rather, selected attributes or characteristics of leisure engagement may be more important than the specificity of an activity or activity domains. This represents a paradigm shift from provision of a specific leisure activity to providing a certain kind of leisure experience. The characteristics of leisure engagement may be more relevant to advancing knowledge of the activity and cognition association (Bielak, 2017). Research that conceptualizes leisure activities in terms of a combination of their meaning or purpose, in addition to the cognitive, physical, or social demands of an activity, has been recommended as a means of better identifying salubrious factors among elderly (Adams et al., 2011; Maselko et al., 2014).

While general or specific leisure activities have been found to be beneficial for cognitive performance in aging, it is likely that most leisure activities are beneficial (Wang et al., 2013; Yang et al., 2022). There has not been as much research on the potential importance of attributes of engagement, such as the frequency, intensity, duration, and variety. The most commonly used metric in leisure and cognition in aging research has been a self-reported frequency of engagement in a predetermined list of leisure activities (Fallahpour et al., 2015). However, frequency of engagement in leisure activities provides a limited perspective on the leisure engagement experience, and might not effectively capture the cognitively beneficial aspects (Bielak, 2017; Bielak et al., 2019; Fallahpour et al., 2015). Research exploring attributes and characteristics of leisure engagement that may contribute to cognition in aging is less common. Understanding the link between activity engagement and cognition in aging may require different approaches in how leisure activity engagement is conceptualized and measured (Bielak, 2010, 2017; Carlson, 2011; Eakman et al., 2010; Jackson et al., 2020). Examining the attributes and characteristics of leisure activity engagement may provide a more nuanced understanding of the ways leisure engagement enhances cognition in aging. Attributes of leisure engagement (e.g., frequency, intensity, duration, variety) are easier to measure as they are more objective and quantifiable and are amenable to measurement from an external definitional vantage point. Characteristics of leisure engagement (e.g., novelty, intensity, active engagement, complexity, enjoyment, and meaning) are more subjective in nature and qualitative. Characteristics of leisure reflect an intrinsic experience and amenable to measurement from an internal vantage point, and draw from research in the leisure sciences on beneficial aspects of engagement (Iwasaka et al., 2018). The overall intent of this scoping review is to identify and map the available literature on attributes and characteristics of leisure activity engagement that may enhance cognitive function in aging and reduce the risk of cognitive decline, MCI, and dementia.

Method

The present study is a scoping review, guided by the Preferred Reporting Items for Systematic Reviews and Meta Analysis Scoping Review (PRISMA ScR) structure. The purpose of this scoping review is to identify the current state of science identifying attributes and characteristics of leisure activity engagement that foster cognition in aging.

Study Design

Scoping reviews use a framework of steps to develop a comprehensive overview of the evidence supporting a specific question (Peters et al., 2021). The goal is to rapidly map key concepts of a research area (Peters et al., 2021; Tricco et al. 2018), reviewing the current literature to systematically identifying key concepts, theories, sources of evidence, and gaps in the research (Munn et al., 2018). The steps are specified in the PRISMA-ScR checklist and are summarized: (1) identify the question or objectives; (2) identify related studies; (3) select studies based on the inclusion criteria; (4) create evidence charts; and (5) collect, summarize, and report the results (Arksey & O'Malley, 2005). The research questions addressed by this scoping review are the following: 1) What are the attributes and characteristics of leisure activity engagement that foster cognition in aging? 2) What is the evidence supporting benefit? 3) Are there recommended dosages? 4) In what ways does the leisure engagement attribute or characteristic impact cognition in aging?

Identifying and Selecting Related Studies

Nine databases were searched including Academic Search Complete, CINAHL, ERIC, Medline, PsycArticles, APA PsycInfo, Psychological and Behavioral Sciences Collection (searched concurrently in EBSCO), PubMed, and Web of Science. A professional librarian assisted with identifying the search terms, which were (((leisure OR recreation OR intellectual OR social OR cognitive OR physical OR lifestyle) AND (activit*)) OR leisure OR recreation)) AND (lifestyle AND (modification or change or intervention or choice)) AND (older adults or elderly or geriatric or geriatrics or aging or senior or seniors or older people or aged 65 or 65+) AND (cogni* OR dementia OR Alzheimer's).

Additional sources were identified through review of references of articles included in the study, and by ongoing notification of pertinent research via Google Scholar, Mendeley, PubMed, and Web of Science using the search words, leisure, aging, and cognition. Articles generated through these means were uploaded into Mendeley for management and analysis.

Inclusion Criteria

Articles published on human subjects between January 1, 2000, through September, 2021, were included in database search. Additional inclusion criteria required that articles were 1) empirical, 2) peer reviewed, 3) written in English, 4) focused on older adults (65 and older), 5) independent variable focused on leisure or activities that could be considered to be leisure activities (i.e., intellectual activities, social activities), and 6) cognitive ability as the primary outcome (all levels of cognitive decline, ranging from mild cognitive impairment (MCI) to Alzheimer's disease (AD), and enhanced cognition). The exclusion criteria were articles that were 1) duplicate, 2) animal studies, 3) focused on non-leisure lifestyle or interventions (i.e., nutrition, sleep), and/or 4) focused on specific health conditions in aging (i.e., diabetes, stroke, Parkinson's disease).

Identified studies ($N=6920$) were first assessed for duplicate records. After removing duplicates ($n=772$), 6148 articles were screened for inclusion by title and abstract review. Based on inclusion/exclusion criteria, an additional 2822 articles were excluded. After exhausting all available options, 11 articles were not retrievable. The resulting 3326 articles were retrieved and fully reviewed for eligibility. An additional 3380 articles were excluded after full review, resulting in the final selection of articles included in this scoping review. These articles were reviewed further, and separate evidence tables were created to guide analysis and synthesis of the data was conducted by identifying main concepts, theories, sources, and knowledge gaps. The search process and results are summarized in the PRISMA-SCr diagram (see Fig. 1). The literature search resulted in the eventual selection of 65 articles meeting eligibility criteria, providing a rich body of knowledge on the attributes and characteristics of leisure activities that foster cognition in aging.

All the steps in the screening, selection, and review process were completed by two reviewers, one a Ph.D. and the other a Ph.D. candidate with expertise in recreational therapy and leisure sciences. Data were managed using Mendeley and extracted and put into evidence tables. Evidence was rated using the following schema:

- Level I: Systematic reviews, meta-analysis, randomized controlled trials;
- Level II: Two groups, nonrandomized studies (i.e., cohort studies, case control);
- Levell III: One group, nonrandomized (i.e., pretest and posttest);
- Level IV: Descriptive studies that included analysis of outcomes (i.e., single-subject design, case series);
- Level V: Case reports and expert opinions that included narrative literature review and consensus statements (Schneider et al., 2019).

Evidence tables mapping the article characteristics, as well as summarizing the research on the attributes and characteristics of leisure engagement, were created. A summary of the findings related to each engagement attribute and characteristic, as well as discussion of the significance and application of the information follows.

Results

Summary of Article Characteristics

A total of 65 articles were selected, based on eligibility criteria, and categorized into four attributes (i.e., frequency, intensity, duration, variety) and five characteristics (i.e., novelty, productivity, enjoyment, meaning, and self-direction). Ten of the research studies were included in more than one attribute or characteristic category (Bielak et al., 2019; Carlson et al., 2015; Carlson et al., 2008; Jackson et al., 2020;

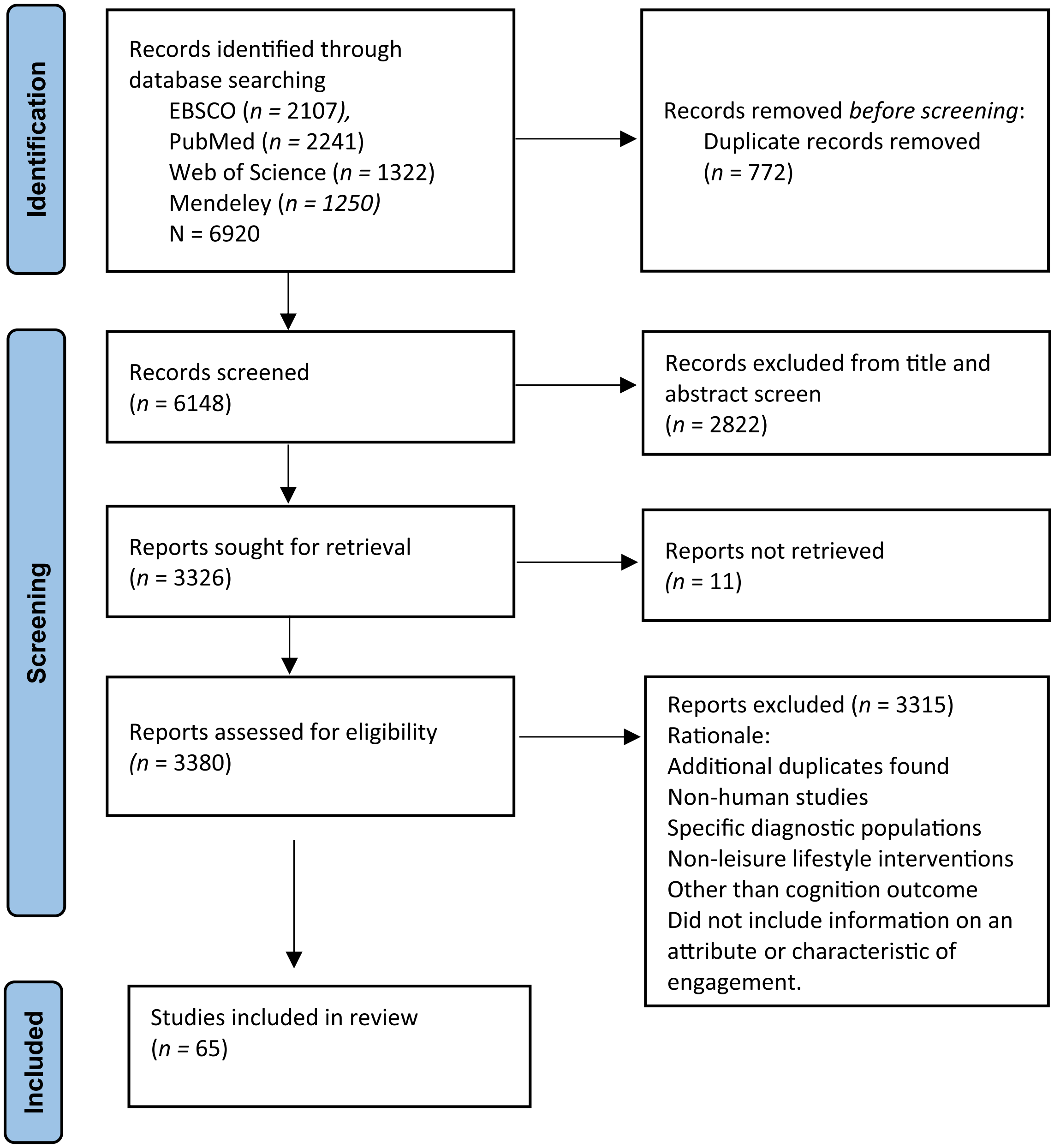

Fig. 1 PRISMA scoping review diagram. *Note:* Tricco et al. (2018). PRISMA extension for scoping reviews (PRISMA-ScR): Checklist and Explanation. *Annals of Internal Medicine 169*(7): 467–473

Krell-Roesch et al., 2019a, 2019b; Lee et al., 2020; Park et al., 2014; Regier et al., 2022; Urban-Wojcik et al., 2022; Wilson, 2011).

The evidence levels of the articles per the schema referenced included all levels of research.

- Level I: Three systematic reviews and 11 randomized controlled trials (RCT);
- Level II: 29 longitudinal cohort studies and three case control;
- Level III: 16 cross-sectional studies;
- Level IV: Descriptive studies that included analysis of outcomes (i.e., single subject design, case series): there were none;
- Level V: Three narrative literature reviews.

Research included in this review was predominantly conducted in the USA ($n = 39$) but demonstrated global diversity with representation from 13 countries (Australia, China, England, France, Iceland, Japan, Sri Lanka, Sweden, Switzerland, USA, and a three nation European study). Forty-two of the studies utilized data and subjects from 37 different longitudinal population-based studies. Additional evidence is summarized in Table 1, which is an alphabetized listing of the evidence, engagement attribute or characteristic, study design, longitudinal cohort (if applicable), cognitive outcome measured, country, and level of evidence. More specific information about the study design, subjects, instruments used, and detailed outcomes are included in Table 2 and 3 which chart the evidence for attributes and characteristics, respectively. These tables present information in the following order: authors, years of publication, study design, participants, interventions, measures, and results. Narrative descriptions of the evidence for each attribute and characteristic are provided below.

Attributes and Characteristics of Leisure Activity Engagement

While various leisure activity domains and specific leisure activities have demonstrated a beneficial effect on cognition in aging, not as much is known about the potential importance of the attributes and characteristics of leisure activity engagement. This review delineates between attributes that are more concrete in nature, more readily quantified, and amenable to measurement from an external vantage point, and characteristics which are abstract concepts, measured from an internal vantage point and are subjectively determined. The attributes of leisure activities are somewhat analogous to dosing in the prescription of medications: specifying the medication class, strength, frequency, and duration. Research identifying the attributes of leisure activities that impact cognition in aging, similarly, focus on the general class of activity (physical, cognitive, or social) and the dosage that is most efficacious in fostering cognition in aging (frequency, intensity, duration, and variety). Characteristics of leisure include novelty, active engagement, complexity, enjoyment, meaning, and self-direction. These characteristics have previously been identified as salubrious in leisure science research.

Attributes of Leisure Activity Engagement

Attributes of leisure activity engagement can be quantified in terms of amount or dose. As in a medication prescription, the medication class is specified, which is analogous to the leisure activity classes of intellectual, physical, and social engagement. Dosage in terms of frequency, intensity, duration, and variety can also be measured and recommended, although it has been noted that incommensurate metrics have been used when reporting on leisure activity engagement dosage (Fallahpour et al., 2015). While these "dosages" have predominantly been self-reported metrics, they can be considered more objective in nature and amenable to quantification.

Frequency of Engagement The most common method for assessing leisure activity engagement has been via a self-report questionnaire, in which individuals report their typical frequency of engagement in a list of specific activities (Bielak, 2019; Fallahpour et al., 2015). This basically refers to the number of times within a specified time period that an individual engaged in a leisure activity. Twenty articles are included that report on the association of frequency of leisure activity engagement and cognition in aging (see Table 2). Fifteen of the articles, or 75%, were longitudinal studies, with follow-up ranging from 1 to 15 years. Three studies were cross-sectional, and two studies were systematic reviews. The number of subjects ranged from 206 to 8966, and in all the research studies, subjects were community-dwelling older adults, dementia free at baseline.

All the research articles in the frequency attribute of this review used a self-report questionnaire, although four studies collected self-reported data via an interview. The number of leisure activities on the questionnaires ranged from 5 to 57 items. One interview gave subjects the opportunity to provide open-ended responses (Wang et al., 2002a, 2002b). All participants in these studies reported on frequency of engagement as recorded in daily, weekly monthly, or yearly terms, and sometimes converted into an overall "high," "moderate," or "low" levels, or into units of measure of activity days per week (Verghese et al., 2003, 2006). All of the studies included a cognitive battery or testing, but in addition two used MRI (Moored et al., 2021; Saczynski et al., 2008), and one used post-mortem autopsy (Wilson et al., 2021).

All but two of the articles reported a significant positive association between frequency of participation and cognition in aging (Eriksson Sörman et al., 2014; Weaver & Jaeggi, 2021). Two of the studies found that frequency and variety were similar constructs (Bielak et al., 2019; Moored et al., 2021). Seven of the studies found that the association varied by the class of activity (i.e., cognitive activities but not social or physical) (Bielak et al., 2019; Eriksson Sörman et al., 2014; Krell-Roesch et al., 2019a, 2019b; Moored et al., 2021; Verghese et al., 2003, 2006; Wang et al., 2002a, 2002b), and three identified variation by frequency of participation in specific leisure activities (Fu et al., 2018; Krell-Roesch et al., 2019a, 2019b; Moored et al., 2021).

The cognitive outcomes measured included reduced risk of cognitive decline or impairment (Hall et al., 2009; Wilson et al., 2010; Zhu et al., 2017), of MCI (Krell-Roesch et al., 2019a, 2019b; J. Verghese et al., 2006), of dementia (Akbaraly et al., 2009; Eriksson Sörman et al., 2014; Moored et al., 2021; Paillard-Borg et al., 2012; Verghese et al., 2003; Wang et al., 2002a, 2002b), and of AD (Akbaraly et al., 2009; Wilson et al., 2002). Risk reduction for cognitive decline ranged from 40 (Akbaraly et al., 2009) to 80% (Krell-Roesch et al., 2019a, 2019b). One systematic

Table 1 Summary of article characteristics

Reference	Engagement attribute or characteristic	Study design	Longitudinal cohort	Cognitive outcome measured	Country	Level of evidence
Akbaraly et al. (2009)	Frequency	Longitudinal cohort	Three-City Longitudinal cohort	Incident dementia and Alzheimer's disease (AD)	France	II
*Bielak et al. (2019)	Frequency and variety	Cross-sectional		Cognitive function	USA	III
Boyke et al. (2008)	Novelty	RCT		Gray matter volume	USA	II
Bugos et al. (2007)	Novelty	RCT		Cognitive function	USA	I
*Carlson et al. (2008)	Complexity and meaningful	RCT	Baltimore Experience Corps	Cognitive function	USA	I
Carlson et al. (2012)	Variety	Longitudinal cohort	Women's Health & Aging Study II	Incident cognitive impairment	USA	II
*Carlson et al. (2015)	Complexity and meaningful	RCT	Baltimore Experience Corps	Cortical & Hippocampal Volume	USA	I
Chan et al. (2016)	Novelty	RCT		Cognitive function	USA	I
Crowe et al. (2003)	Variety	Case control	Swedish Twin Registry/OCTO Twin Study	Incident AD	Sweden	II
Da Ronch et al. (2015)	Productive	Cross-sectional		Cognitive function	3 European	III
Dannhauser et al. (2014)	Complex	RCT		Cognitive function	England	I
Eriksson Sörman et al. (2014)	Frequency	Longitudinal cohort	Betula	Dementia	Sweden	II
Fallahpour et al. (2015)	Frequency	Systematic review		Cognitive decline		I
Fancourt & Steptoe (2019)	Productive	Longitudinal cohort	English Longitudinal Study of Aging	Cognitive function	England	II
Flatt & Hughes (2013)	Enjoyable	Review		Cognitive function		V
Friedland et al. (2001)	Variety	Case control	AD Case–Control Study at Case Western Reserve University	Incident AD	USA	II
Fritsch et al. (2005)	Novelty	Cross-sectional	AD Case–Control Study at Case Western Reserve University	Cognitive function	USA	III
Fu et al. (2018)	Frequency	Cross-sectional	China Health and Retirement Longitudinal Study	Cognitive function	China	III
Gardner et al. (2020)	Enjoyable	Cross-sectional		Cognitive function	USA	III
Hall et al. (2009)	Frequency	Longitudinal cohort	Bronx Aging Study	Memory decline	USA	II
Hughes et al., (2018a, 2018b)	Duration	Longitudinal cohort	Monongahela-Youghiougheny Healthy Aging Team Study	Incident MCI	USA	II
Ihle et al. (2018)	Duration	Longitudinal cohort	Vivre-Leben-Vivere Study	Cognitive function	Switzerland	II
Ihle et al. (2019)	Novelty	Longitudinal cohort	Vivre-Leben-Vivere Study	Cognitive function	Switzerland	II
Iizuka et al. (2021)	Variety	Cross-sectional	Neuron to Environmental Impact across Generations	Hippocampal and gray matter volume	Japan	III
Infurna & Gerstorf (2013)	Self-directed	Longitudinal cohort	Nationwide Health and Retirement Study	Memory decline	USA	II
*Jackson et al. (2020)	Variety and novelty	Cross-sectional		Cognitive function	USA	III
Karp et al. (2006)	Variety	Longitudinal cohort	Kungsholmen Project	Cognitive function	Sweden	II

Table 1 (continued)

Reference	Engagement attribute or characteristic	Study design	Longitudinal cohort	Cognitive outcome measured	Country	Level of evidence
*Krell-Roesch et al., (2019a, 2019b)	Frequency and variety	Longitudinal cohort	Mayo Clinic Study of Aging Olmstead County	Incident MCI	USA	II
*Küster et al. (2016)	Enjoyable and self-directed	RCT		Global cognition	Germany	I
Leanos et al. (2020)	Novelty	RCT		Cognitive function	USA	I
*Lee et al. (2020)	Duration and variety	Longitudinal cohort	National Study of Daily Experiences (Midlife in the US Survey)	Cognitive function	USA	II
Lindstrom et al. (2005)	Productive	Case control		Incident AD	USA	
Maselko et al. (2014)	Meaningful	Cross-sectional	Sri Lanka Healthy Minds Study	Cognitive function	Sri Lanka	III
McDonough et al. (2015)	Productive	RCT		Increased brain modulation	USA	I
McPhee et al. (2019)	Duration	Systematic Review		White matter		I
Moored et al. (2021)	Frequency	Longitudinal cohort	Gingko Evaluation of Memory Study	Dementia	USA	II
Niti et al. (2008)	Productive	Longitudinal cohort	Singapore Longitudinal Aging Studies	Incident cognitive decline	Singapore	II
Paillard-Borg et al. (2012)	Frequency	Longitudinal cohort	Kungsholmen Project	Dementia	Sweden	II
Parisi et al. (2012)	Variety	Cross-sectional	Experience Corps	Cognitive function	USA	III
Park & Bischof (2013)	Enjoyable	Review		Cognitive function		V
*Park et al. (2014)	Duration, novelty and productive	RCT		Enhanced episodic memory	USA	I
Payne et al. (2011)	Enjoyable	Cross-sectional		Cognitive function	USA	III
Proulx et al. (2018)	Productive	Longitudinal cohort	Health and Retirement Survey	Cognitive function	USA	II
*Regier et al. (2022)	Enjoyable and meaningful	Cross-sectional	National Health and Aging Trends Study	Improved memory function	USA	III
Sachdev et al. (2013)	Novelty	Longitudinal cohort	Sydney Memory and Aging Study	Cognitive function, Reversion of MCI	Australia	II
Saczynski et al. (2008)	Frequency	Cross-sectional	Age Gene/Environment Susceptibility—Reykjavik Study	White matter lesions	Iceland	III
Scarmeas et al. (2001)	Variety	Longitudinal cohort	Health Care Financing Administration Data List	Dementia	USA	II
Schooler & Mulatu (2001)	Complexity	Longitudinal cohort	Kohn & Schooler Study	Cognitive function	USA	II
Soubelet & Salthouse (2010)	Complexity	Cross-sectional		Cognitive function	USA	III
Stine-Morrow et al. (2008)	Complexity	RCT		Cognitive function	USA	I
*Urban-Wojcik et al. (2022)	Variety and Novelty	Cross-sectional	Midlife in the US Survey	Hippocampal volume	USA	III
Valenzuela & Sachdev (2006)	Frequency	Systematic Review		Incident dementia		I
Valenzuela et al. (2008)	Complexity	Longitudinal cohort		Hippocampal volume	Australia	II
Verghese et al. (2003)	Frequency	Longitudinal cohort	Bronx Aging Study	Dementia	USA	II
Verghese et al. (2006)	Frequency	Longitudinal cohort	Bronx Aging Study	Dementia	USA	II

Table 1 (continued)

Reference	Engagement attribute or characteristic	Study design	Longitudinal cohort	Cognitive outcome measured	Country	Level of evidence
Wang et al., (2002a, 2002b)	Frequency	Longitudinal cohort	Kungsholmen Project	Dementia	Sweden	II
Wang et al. (2013)	Variety	Longitudinal cohort	Four County Shichuan and Shandong Provinces	Cognitive function	China	II
Weaver & Jaeggi (2021)	Frequency	Cross-sectional		Cognitive function	USA	III
Weuve et al. (2004)	Duration	Longitudinal cohort	Nurse's Health Study	Cognitive function & cognitive decline	USA	II
Wilson et al. (2002)	Frequency	Longitudinal cohort	Catholic Nuns and Priests	Incident AD	USA	II
Wilson et al. (2010)	Frequency	Longitudinal cohort	Chicago Health and Aging Project	Cognitive decline, MCI, AD	USA	II
*Wilson (2011)	Complex and enjoyable	Review		Cognitive function	USA	V
Wilson et al. (2021)	Frequency	Longitudinal cohort	Memory and Aging Project	Cognitive decline	USA	II
Wingo et al. (2020)	Meaningful	Cross-sectional	Emory Healthy Aging Study	Cognitive decline	USA	III
Zhu et al. (2017)	Frequency	Longitudinal cohort	Chinese Longitudinal Healthy Longevity Survey	Cognitive impairment	China	II

*References are found in more than one attribute or characteristic

review summarized that leisure activities provided a protective effect of approximately 40–50% (Valenzuela & Sachdev, 2006). Four of the studies reported on cognitive function as the outcome, noting improvement in composite scores of memory, speed of processing, and executive function (Bielak et al., 2019; Fu et al., 2018; Ihle et al., 2019; Saczynski et al., 2008), while one of the studies found no significant improvement in global cognitive performance (Weaver & Jaeggi, 2021). One of the two studies that used MRI imaging to measure neurological changes resulting from more frequent participation concluded leisure activity participation reduced the effect of white matter lesion pathology on cognitive performance (Saczynski et al., 2008). Frequency of engagement in leisure activities has often been associated with enhanced cognition in aging, but not in all of the studies cited in this review (Eriksson Sörman et al., 2014; Weaver & Jaeggi, 2021), and some studies only found correlation with certain domains of leisure activities (Eriksson Sörman et al., 2014; Fu et al., 2018; Krell-Roesch et al., 2019a, 2019b; Moored et al., 2021).

Intensity of Engagement Intensity when applied to leisure activity engagement can reflect differing constructs. Using the analogy of medication dosage, the intensity would refer to the strength of the pharmacologic agent. Intensity has frequently been studied in relation to physical leisure activities referencing the physical demands of the activity and measured in terms of metabolic equivalents which quantify the energy demand of any given activity. However, for the purposes of this review, intensity will refer to the cognitive demands or complexity of the leisure activity**.** Leisure activities exercising multiple facets of cognition can be considered more complex or intense. There are nine studies included in this review that report on activity complexity in relation to cognition in aging (see Table 2). Two of the studies were longitudinal cohort studies, with follow-up ranging from 3 to 20 years (Schooler & Mulatu, 2001; Valenzuela et al., 2008) and one was cross-sectional in design (Soubelet & Salthouse, 2010). Four of the studies were randomized controlled studies (Carlson et al., 2008, 2015; Dannhauser et al., 2014; Stine-Morrow et al., 2008), and two of the articles were reviews (Wilson, 2011), one of which was a systematic review (Valenzuela & Sachdev, 2006). The number of subjects in the studies ranged from 37 to 2257, although the largest study also incorporated younger adults (Soubelet & Salthouse, 2010).

Complexity has been quantified in varying ways. Some studies have asked subjects to provide ratings of the cognitive demands for participation in a predetermined list of leisure activities (Soubelet & Salthouse, 2010). One study measured self-reported engagement in complex leisure activities during three different stages of life (Valenzuela et al., 2008). Three studies employed a complex multimodal intervention requiring participants to make lifestyle changes

Table 2 Attributes of leisure engagement

Attribute and reference	Study design	Pop description	Activity measure	Cognitive outcome	Summary/outcomes
Frequency of engagement					
Akbaraly et al. (2009)	Longitudinal cohort, 4 years	$N=5{,}698$, >65, dementia free, community dwelling	Self-reported frequency of daily (7) and monthly (9) activities- and scores assigned for activity participation	Cognitive battery, neurological exam	Persons engaging in stimulating activities at least twice a week had a 50% reduced risk of developing dementia over the 4-year follow-up, and 40% reduced risk of AD as compared to persons engaged in such activities less than once per week. Stimulating leisure activities were found to be significantly associated with a reduced risk of dementia ($n=161$, HR = 0.49, 95% confidence interval [CI]: 0.31; 0.79) and Alzheimer's disease ($n=105$, HR = 0.39, 95% CI: 0.21; 0.71) over the 4-year follow-up 1) independently of other proxies of CR, 2) after adjusting for vascular risk factors, depressive symptoms, and physical functioning, and 3) independently of other leisure activities
Bielak et al. (2019)	Cross-sectional	$N=199$, mean age 70.36, community dwelling	Victoria Longitudinal Cohort Study Activity Lifestyle Questionnaire (57 items)	Cognitive battery	Frequency indices had stronger associations with cognition for both 2-year and daily activity estimates. However, frequency and variety had similar associations with cognition
Eriksson Sörman et al. (2014)	Longitudinal cohort, 15 years	$N=1475$, ≥ 65, dementia free at baseline	Leisure Activity Questionnaire—frequency of participation leisure-time activities (16)	Cognitive battery, neurological exam	Higher levels of total activity and social activity, but not mental activity was associated with decreased risk of dementia. This association was only significant in the first time period, 1–5 years after baseline. The results from this study provide little support for the hypothesis that frequent engagement in leisure activities among elderly serve to protect against dementia diseases across a longer time frame
Fallahpour et al. (2015)	Systematic review	$N=52$ articles			Findings support growing consensus that participation in leisure activities might significantly contribute to prevention of dementia, but also identifies major limitations to progress
Fu et al. (2018)	Cross-sectional	$N=8966$, mean age 68.1, community dwelling	China Health and Retirement Longitudinal Study Questionnaire, frequency of (5) activities in past month	Cognitive battery, Telephone Interview of Cognitive Status	Higher frequency of participation in certain social activities had a positive association with cognitive function
Hall et al. (2009)	Longitudinal cohort, 12–18 months	$N=109$, mean age 79.5, dementia free, community dwelling	Frequency of participation in (6) leisure activities	Cognitive battery, neurology exam	Each additional self-reported day of cognitive activity at baseline delayed the onset of accelerated memory decline by 0.18 years. Higher baseline levels of cognitive activity were associated with more rapid memory decline after onset of dementia

Table 2 (continued)

Attribute and reference	Study design	Pop description	Activity measure	Cognitive outcome	Summary/outcomes
Ihle et al. (2019)	Longitudinal cohort 6 years	$N = 897$, mean age 74.33	Leisure activity engagement in 18 activities	Cognitive battery (Trail Making Tests parts A and B)	A higher frequency of leisure activities in wave 1 significantly predicted a smaller subsequent increase in Trail Making Tests completion time from wave 1 to wave 2 (i.e., a smaller decline in executive functioning, $\beta = -0.13$, $p = 0.004$)
Krell-Roesch et al., 2019a, 2019b)	Longitudinal cohort, 5 years	$N = 2000$, ≥ 70 years, dementia free at baseline	Frequency of participation (5) leisure activities	Cognitive battery, neurology exam	Risk of incident MCI was significantly reduced for participants who engaged in social activities (hazard ratio [95% confidence interval] 0.80 [0.64–0.99]) and playing games (0.80 [0.66–0.98]) in both late life and midlife combined. Using a computer was associated with a decreased risk regardless of timing. Craft activities were associated with a reduced risk of incident MCI only when carried out in late life but not midlife (0.58 [0.34–0.97]). Furthermore, engaging in a higher number of activities in late life was associated with a significantly reduced risk of incident MCI (any 2 activities: 0.72 [0.53–0.99], any 3: 0.55 [0.40–0.77], any 4: 0.44 [0.30–0.65], all 5: 0.57 [0.34–0.96])
Moored et al. (2021)	Longitudinal cohort, 8 years	$N = 3069$, mean age 78.5, dementia free at baseline	Lifestyle Activity Questionnaire—baseline participation in (26) activities over past year	Cognitive battery, neurological exam, MRI	Each additional activity reported was associated with 8.4% reduced hazard of dementia. Each additional day of average intellectual activity reported in the past month was associated with 6.6% reduced hazard of dementia. Higher frequency of intellectual activities was associated with reduced dementia risk for those without MCI (HR: 0.946 [0.91, 0.98]), but not those with MCI (HR: 0.976 [0.93, 1.02]). Frequency of physical and social activities was not associated with dementia risk
Paillard-Borg et al. (2012)	Longitudinal cohort, 9 years	$N = 1375$, mean age 81.2, dementia free at baseline, community dwelling	Interview—responses grouped into (29) main types of activities	Cognitive battery, neurological exam	Age at onset of dementia was significantly older in persons who had higher levels of participation in mental, physical, or social activity (β: 0.18, 0.29, and 0.23, respectively, $p < 0.001$ for all the activities). There were 17 months difference in mean age at dementia onset between the inactive group and the most active group. An active lifestyle postpones dementia onset by more than one year in very old adults
Saczynski et al. (2008)	Cross-sectional	$N = 1787$, 66–92, mean ages 74.5–77.3	Frequency of participation in (10) leisure activities during past 12 months	Cognitive battery, MRI	High leisure activity was associated with higher performance in memory, speed of processing, and executive function. High white matter lesion (WML) load was associated with significantly lower performance in speed of processing (SP). The effect of WMLs on SP performance was modified by high leisure activity

Table 2 (continued)

Attribute and reference	Study design	Pop description	Activity measure	Cognitive outcome	Summary/outcomes
Valenzuela & Sachdev (2006)	Systematic review	$N=6$			Higher brain reserve was associated with a lowered risk for incident dementia (summary odds ratio, 0.54; 95% confidence interval, 0.49–0.59). This effect was found over a median of 7.1 years follow-up and resulted from integrating data across more than 29,000 individuals. Increased complex mental activity in late life was associated with lower dementia rates independent of other predictors; a dose–response relationship was also evident between extent of complex mental activities in late life and dementia risk
Verghese et al. (2003)	Longitudinal cohort, 5.1 years	$N=469, \geq 75$, dementia free at baseline,	Interview—frequency of participation in (6) cognitive and (11) physical leisure activities. Units of measure were activity-days per week	Cognitive battery	A one-point increment in the cognitive-activity score was significantly associated with a reduced risk of dementia (hazard ratio, 0.93 [95% confidence interval, 0.90 to 0.97]), but a one-point increment in the physical-activity score was not (hazard ratio, 1.00). Increased participation in cognitive activities at baseline was associated with reduced rates of decline in memory
Verghese et al. (2006)	Longitudinal cohort 5.6 years	$N=437, >75$, community dwelling, dementia, and MCI free at baseline	Interview frequency of participation in (6) cognitive and (10) physical leisure activities. units of measure	Cognitive battery	A one-point increase on the cognitive (hazard ratio (HR) 0.95, 95% CI 0.91–0.99), but not Physical Activities Scale (HR 0.97, 95% CI 0.93–1.01) was associated with lower risk of amnestic MCI. Subjects with cognitive-activity scores in the highest (HR 0.46, 95% CI 0.24–0.91) and middle thirds (HR 0.52, 95% CI 0.29–0.96) had a lower risk of amnestic MCI compared to subjects in the lowest third. Cognitive activity participation is associated with lower risk of developing amnestic MCI, even after excluding individuals at early stages of dementia
Wang et al., (2002a, 2002b)	Longitudinal cohort, 6.4 years	$N=1375, >75$, dementia free, community dwelling	Interview re: frequency of activity and organization participation	Cognitive battery, neurological exam	Frequent (daily-weekly) engagement in mental, social, or productive activities was inversely related to dementia incidence. Adjusted relative risks for mental, social, and productive activities were 0.54 (95% confidence interval (CI): 0.34, 0.87), 0.58 (95% CI: 0.37, 0.91), and 0.58 (95% CI: 0.38, 0.91), respectively. Results suggest that stimulating activity, either mentally or socially oriented, may protect against dementia, indicating that both social interaction and intellectual stimulation may be relevant to preserving mental functioning in the elderly

Table 2 (continued)

Attribute and reference	Study design	Pop description	Activity measure	Cognitive outcome	Summary/outcomes
Weaver & Jaeggi (2021)	Cross-sectional	$N=206$, mean age 72.9, dementia free	Community Healthy Activities Model Program for Seniors Physical Activity Questionnaire for Older Adults (41) items	Cognitive battery	Activities were grouped into composite categories (cognitive, social, and physical). None of the activity categories or breadth/frequency of activity engagement were predictive of global cognitive performance
Wilson et al. (2002)	Longitudinal cohort, mean follow-up 4.5 years	$N=835, \geq 65$, AD free at baseline	Interview re: time spent in 7 common activities	Cognitive battery	Relative risk (RR) of developing AD decreased by 33% for each 1-point increase in the composite measure of cognitive activity. Activity frequency at the 10th percentile the RR of disease was reduced by 28% in a person whose cognitive activity frequency was at the 50th percentile and by 47% in a person whose activity frequency was at the 90th percentile
Wilson et al. (2010)	Longitudinal cohort, 5.6 years and 5.7 years thereafter	$N=1, 157, >65$, dementia free at baseline	Frequency of participation in 7 cognitive activities	Cognitive battery	Annual rate of global cognitive decline in persons without cognitive impairment was reduced by 52% (estimate $=0.029$, SE $=0.010$, $p=0.003$) for each additional point on the cognitive activity scale. In the mild cognitive impairment group, cognitive decline rate was unrelated to cognitive activity (estimate $=0.019$, SE $=0.018$, $p=0.300$). In AD, the mean rate of decline per year increased by 42% (estimate $=0.075$, SE $=0.021$, $p=0.001$) for each point on the cognitive activity scale. Mentally stimulating activity in old age appears to compress the cognitive morbidity associated with AD by slowing cognitive decline before dementia onset and hastening it thereafter
Wilson et al. (2021)	Longitudinal cohort, 6.8 years	$N=457$, diagnosed with AD 88.6	37-item activity questionnaire	Cognitive battery annually, neurological exam, neuropathology exam	Low cognitive activity (10th percentile) was associated with a mean onset age of 88.6 years compared to mean onset age of 93.6 associated with high cognitive activity (90th percentile). Cognitive activity was unrelated to postmortem markers of AD and other dementias. Cognitively active lifestyle in old age may delay onset of dementia by as much as 5 years
Zhu et al. (2017)	Longitudinal cohort, 5 years	$N=6586$, mean age 79.5	Frequency of participation in (9) leisure activities	Cognitive battery, MMSE	A high level of participation in all types of leisure activities was associated with a 41% decrease in the risk of cognitive impairment
Intensity of engagement (Complexity)					
Carlson et al. (2008)	RCT	$N=128$ ($N=70$ intervention and $N=58$ control), mean age 70.1	Baltimore Experience Corps®	Cognitive battery	Intervention group showed improvements in executive function and memory relative to matched controls ($p<0.10$), and those with impaired function at baselines showed greatest improvement, between 44 and 51% in executive function and memory at follow up compared to declines among impaired controls ($p<0.05$)

Table 2 (continued)

Attribute and reference	Study design	Pop description	Activity measure	Cognitive outcome	Summary/outcomes
Carlson et al. (2015)	RCT	$N=111$ ($N=58$ intervention and $N=53$ control), mean age	Baltimore Experience Corps®	MRI	Men in the control arm exhibited age-related declines over two years, men in the Experience Corps arm showed a 0.7–1.6% increase in brain volumes (cortical and hippocampal). Women also exhibited modest intervention-specific gains of 0.3–0.54% by the second year of exposure that contrasted with declines of about 1% among women in the control group
Dannhauser et al. (2014)	RCT	$N=63$, mean age 73.9 MCI diagnosis	12-week activity intervention using 3 activities; physical activity, group cognitive activity, individual cognitive activity	Cognitive battery	Significant treatment effects ($p<0.05$) were evident on improved working memory (5.3/6.3 items)
Schooler & Mulatu (2001)	Longitudinal cohort, 20 years	$N=315$ men, 320 women, mean age 64.5	Frequency of engagement in complex leisure activities	Cognitive battery	The present findings indicate that even in old age carrying out substantially complex leisure activities builds the capacity to deal with intellectual challenges such complex environments provide
Soubelet & Salthouse (2010)	Cross-sectional	$N=2,257$, age 18–97, mean age 50.3	Activity inventory with 22 activities, self-ratings of duration and intensity of engagement (cognitive demand)	Cognitive battery	Activity engagement is important but can differ with respect to the return per unit of time spent in the activity rather than in the amount of time devoted to the activity. Recommend obtaining a measure of "cognitive yield" for given amount of activity time
Stine-Morrow et al. (2008)	RCT	$N=181$, (87 experimental and 63 control), mean age 73	Senior Odyssey of the Mind	Cognitive battery	Relative to controls, experimental participants showed positive change in a composite measure of fluid ability from pretest to posttest
Valenzuela & Sachdev (2006)	Meta-analysis	$N=22$ articles			Increased complex mental activity in late life was associated with lower dementia rates independent of other predictors. A dose–response relationship was evidence between mental activities in late life and dementia risk. All studies focusing on mentally stimulating activities ($N=6$) found a significant protective effect, both before (combined OR 0.50, 95% CI 0.42–0.61, – <0.001) and after controlling for relevant covariates
Valenzuela et al. (2008)	Longitudinal cohort, 3 years	$N=37$, mean age 70.3	Lifetime of Experiences Questionnaire—the LEQ measure complex mental activity levels in 3 stages of life	MRI at year three	High levels of complex mental activity across the lifespan were correlated with a reduced rate of hippocampal atrophy. Results suggest that neuroprotection in medial temporal lobe may be one mechanism underlying the link between mental activity and lower rates of dementia observed in population-based studies

Table 2 (continued)

Attribute and reference	Study design	Pop description	Activity measure	Cognitive outcome	Summary/outcomes
Wilson (2011)	Review				Mentally stimulating and growth-oriented lifestyle is an important part of maintaining cognitive health in old age. Current research suggests that the activities should be complex and challenging, and because they need to be sustained over a period of time, these endeavors should be engaging and enjoyable
Duration of engagement					
Hughes et al., (2018a, 2018b)	Longitudinal cohort, average 9.12 years	$N=867$, 65+	Florida Cognitive Activities Scale	Cognitive battery	Maintaining engagement in cognitive activities may be protective against progression to MCI, alternatively, declining engagement may be a marker for impending cognitive impairment
Ihle et al. (2018)	Longitudinal cohort, 6 years	$N=897$, mean age 74.33	Leisure activities via an interview, current and those at age 45	Cognitive battery	Finding confirms the conceptual view that cognitive stimulation throughout the life course may be associated with cognitive reserve, and cognitive functioning in older age
Kramer & Willis (2002)	Review				Training and exercise benefits are realized only after extensive practice with specific training strategies. Well learned skills can be maintained at a relatively high level of proficiency
Lee et al. (2020)	Longitudinal cohort, 10 years	$N=732$, mean age 56, but data stratified for older adults, mean age 68	National Study of Daily Experiences	Cognitive battery, Telephone Interview of Cognitive Status	Enhanced cognitive performance in those who sustained high levels of activity participation over a 10-year period
McPhee et al. (2019)	Systematic review	$N=7$ articles		MRI—white matter microstructure	Persistent cognitive activity could preserve white matter microstructure in older adults, and this benefit could be seen as a form of brain maintenance, reducing age-associated cognitive decline
Park et al. (2014)	RCT	$N=221$, mean age 72	Quilting, photography, or combination, and control groups—average of 17.2 h/week, for 14 weeks	Cognitive battery	Sustained engagement in cognitively demanding, novel activities enhance memory function in older adulthood, but, somewhat surprisingly, study found limited cognitive benefits of sustained engagement in social activities
Valenzuela et al. (2008)	Longitudinal cohort, 3 years	$N=37$, mean age at baseline 70.9	Lifetime of Experiences Questionnaire	MRI	High level of complex mental activity across the lifespan was correlated with a reduced rate of hippocampal atrophy. This finding could not be explained by general differences in intracranial volume, larger hippocampi at baseline, presence of hypertensive disease, gender, or low mood
Weuve et al. (2004)	Longitudinal cohort, 2 years	$N=18{,}766$ women, 70–81	Avg. time/week in the past year leisure time physical activities	Cognitive battery	Higher levels of long-term regular leisure time physical activity were strongly associated with higher levels of cognitive function and less cognitive decline

Table 2 (continued)

Attribute and reference	Study design	Pop description	Activity measure	Cognitive outcome	Summary/outcomes
James et al. (2013)	Longitudinal cohort, mean 5.8 years	$N=294$, mean age at death 89.3	Frequency of participation in 37 leisure activities (7 late life and 30 early-life activities)	Cognitive battery and postmortem neuropathology exam measuring gross and microscopic infarction, Lewy bodies, amyloid burden, and tangle density	More frequent late-life cognitive activity and early-life cognitive activity were each associated with slower cognitive decline. The 2 measures together accounted for 14% of the residual variability in cognitive decline not related to neuropathologic burden. The early-life–activity association was attributable to cognitive activity in childhood and middle age but not young adulthood. More frequent cognitive activity across the life span has an association with slower late-life cognitive decline that is independent of common neuropathologic conditions, consistent with the cognitive reserve hypothesis
Variety of engagement					
Bielak et al. (2019)	Cross-sectional	$N=199$, mean age 70.36, community dwelling	Victoria Longitudinal cohort Study—Activity Lifestyle Questionnaire (57 leisure activities), Activity Characteristics Questionnaire (activity log)	Cognitive battery	Frequency and variety of engagement have similar associations with cognition, and the most active individuals also have the most diverse engagement. Therefore, a variety index may be sufficient when collecting activity data
Carlson et al. (2012)	Longitudinal cohort, 9.5 years	$N=379$ Women, mean age 74 at baseline, community dwelling	Lifestyle Activities Questionnaire	Cognitive battery	Immediate and delayed verbal recall, psychomotor speed, and executive function were each measured at baseline and at five successive exams, spanning a 9.5-year interval. Greater variety of participation in activities, regardless of cognitive challenge, was associated with an 8 to 11% reduction in the risk of impairment in verbal memory and global cognitive outcomes
Crowe et al. (2003)	Case control, longitudinal, 30 years	$N=107$ same sex twins ($N=214$) Discordant pairs	Frequency of participation in 11 leisure activities	Cognitive battery, neurological exam	Participation in greater overall number of activities represented a significant protective factor ($p<0.05$) for all dementias combined as well as for AD alone. All dementias (OR .63; 95% CI 0.39–1.0), AD (OR .54; 95% CI 0.29–1.0)
Friedland et al. (2001)	Case control	$N=193$ probable AD $N=358$, mean age 72.5. Healthy control group $N=358$, mean age 71.3	26 nonoccupational activities	Cognitive battery, MRI	The odds ratio for AD in those performing less than the mean value of activities was 3.85 (95% confidence interval: 2.65–5.58, $P<0.001$). Diversity of activities and intensity of intellectual activities were reduced in patients with AD as compared with the control group

Table 2 (continued)

Attribute and reference	Study design	Pop description	Activity measure	Cognitive outcome	Summary/outcomes
Iizuka et al. (2021)	Cross-sectional	$N=482$, mean age 73.2, community dwelling	20 leisure activities, classified into 10 categories	MRI	Hippocampal and gray matter volumes were significantly greater in participants with ≥ 3 types of leisure activities than no activity counterparts. Hippocampal volume was significantly greater among those who engaged in one type of LA than among those who engaged in no such activity. Those who engaged in ≥ 3 types of LAs had approximately 3.0% greater total hippocampal volume (217 mm3/7213 mm3) and approximately 1.3% greater total gray matter volume (7954 mm3/569,911 mm3) than their no-activity counterparts. This indicates that there is a difference in the brain volume equivalent to 3–4 years of atrophy in those who engage in ≥ 3 types of LAs than those who engage in no such activity
Jackson et al. (2020)	Cross-sectional	$N=476$, mean age 72.5, community dwelling, no dementia	Activity Questionnaire	Cognitive battery	Associations with activity diversity were similar across facets of openness, ranging from $r=0.18$ for the competence facet, to $r=0.23$ for the intellect, ingenuity, and quickness facets, and $r=0.21$ for creativity. Activity diversity explained significant variance in the relationship between openness and cognitive ability. This relationship differed as a function of education level, such that participating in a more diverse array of activities was most beneficial for those with less formal education. Overall, these findings suggest that participating in a diverse array of behaviors may partially be responsible for the association between openness and fluid cognitive ability in older adulthood
Karp et al. (2006)	Longitudinal cohort, 3 years	$N=732$, > 75, with no dementia at first wave follow up	Regular leisure activities and frequency—grouped into 29 leisure activities, by personal interview	Cognitive battery, neurological exam	Incident dementia cases $N=123$. A broad spectrum of activities containing more than one activity component seems to be more beneficial than to be engaged in only one type of activity. RRs of dementia associated with participation in 1–2 activities, and participation in 3–7 activities, versus no participation were 0.77 (95% CI: 0.51–1.15) and 0.56 (95% CI: 0.31–0.99), respectively. The most beneficial effect was present for subjects with high scores 2 or all 3 of the activity components (mental, physical, and social) (RR of dementia = 0.53; 95% CI: 0.36–0.78)

Table 2 (continued)

Attribute and reference	Study design	Pop description	Activity measure	Cognitive outcome	Summary/outcomes
Krell-Roesch et al., (2019a, 2019b)	Longitudinal cohort, median 5 years	$N=2000$, ≥ 70, community dwelling, no dementia	5 leisure activities	Cognitive battery, neurological exam	Incident development of MCI $N=532$. Engaging in a higher number of activities in late life was associated with a significantly reduced risk of incident MCI (any 2 activities: 0.72 [0.53–0.99], any 3: 0.55 [0.40–0.77], any 4: 0.44 [0.30–0.65], all 5: 0.57 [0.34–0.96]
Lee et al. (2020)	Longitudinal cohort, 10 years	$N=732$, mean age 56, but data stratified for older adults, mean age 68	National Study of Daily Experiences	Cognitive battery, Telephone Interview of Cognitive Status	Cognitive functioning, executive functioning, and episodic memory were better in older adults who had maintained higher activity diversity, or increased activity diversity over ten years. Activity diversity was associated with higher cognitive functioning. The association between activity diversity and overall cognitive function ($B=0.70$, $SE=0.30$, $p<0.05$). For executive function ($B=0.59$, $SE=0.29$, $p<0.05$), and episodic memory was not significant in the full model ($B=0.21$, $SE=0.33$, $p>0.10$). Increases in activity diversity during past 10 years ($B=0.69$, SE $=0.32$, $p<0.05$)
Parisi et al. (2012)	Cross-sectional	$N=675$, mean age 67, community dwelling, dementia free, socio-demographically at-risk	Lifestyle Activities Questionnaire (self-reported frequency of participation in a wide range of activities during past year)	Cognitive battery	Greater participation in a variety of activities also completed more years of education, was in better physical health, and exhibited fewer depressive symptoms ($p<0.01$). Greater total participation was related to measures of processing speed and memory, which may reflect more cognitively complex processes
Scarmeas et al. (2001)	Longitudinal cohort, 2.9–7 years	$N=1772$, >65, dementia free at baseline	Participation in 13 leisure activities via an interview	Cognitive battery	Incident dementia $N=207$. A protective effect for incident dementia was seen for each additional point, implying a cumulative effect for the number of activities adopted. The risk of dementia was decreased in subjects with high leisure activities (RR, 0.62; 95% CI 0.46 to 0.83). Individuals with high number of leisure activities had 38% less risk of developing dementia
Wang et al. (2013)	Longitudinal cohort, mean 2.4 years	$N=1463$, >65	Leisure Activities Assessment (cognitive, physical and social)	Cognitive battery	Those who engaged in any one of the activities maintained their cognition, and those who engaged in two or three activities improved their cognition. Different types of activities seem to benefit different cognitive domains

Table 3 Characteristics of leisure engagement

Attribute and reference	Study design	Pop description	Activity measure	Cognitive outcome	Summary/outcomes
Novel engagement					
Boyke et al. (2008)	RCT	$N=69$, mean age 60, dementia free community dwelling	Juggling	MRI	Training group demonstrated a significant increase in gray matter in the hippocampus and the nucleus accumbens ($p<0.001$), this was exclusive to the training group
Bugos et al. (2007)	RCT	$N=31$, mean age 69.6. Experimental group $N=16$, control group $N=15$, community dwelling, dementia free	Individualized piano instruction with 3 h of practice/week	Cognitive battery	The experimental group significantly improved performance on the Trail Making Test and Digit Symbol measures as compared to healthy controls. Interestingly, the experimental group does not maintain performance gains when practice is discontinued
Chan et al. (2016)	RCT	$N=54$, mean age 74.4, 1 experimental, 2 control groups, community dwelling, dementia free	iPad training for 15 h/week/3 months or social group or placebo group	Cognitive battery	iPad training improved cognition relative to engaging in social or nonchallenging activities. significant effect for processing speed ($F(2,50)=4.34$, $p=0.018$) and episodic memory ($F(2,50)=6.279$, $p=0.004$), but not for mental control or visuospatial processing ($F<1.7$, $p=\text{ns}$)
Fritsch et al. (2005)	Case control	$N=264$ with AD, $N=364$ control group A, $N=181$ control group B	Life History Questionnaire (16 leisure activities engaged in between 20 and 60)	1-way between subjects' analyses of variance, calculating odds of AD as a function of participation in activities	Greater participation in novelty-seeking activities was associated with reduced odds of AD (OR, 0.248; 97.5% CI, 0.139–0.443). Greater participation in activities involving exchange of ideas was also associated with a reduced odds of AD (OR, 0.695; 97.5% CI, 0.467–1.034). Participation in social activities did not increase or decrease the odds of being in the AD group (OR, 1.057; 97.5% CI, 0.636–1.756)
Leanos et al. (2020)	Two sequential RCT's	$N=42$, mean age 69.44, study one; 6 interventions, 9 control. Study two; 27 intervention community dwelling, dementia free	15-week intervention (simultaneously learning Spanish, painting and use of tech devices)	Cognitive battery	The difference in cognitive scores (composite score for working memory and cognitive control) between the intervention and control groups became significant at post-test ($t=2.36$, $p=0.03$, effect size$=0.66$). From pre-test to post-test, the intervention group increased more than one standard deviation in the cognitive scores on average ($M=0.55$, SD$=0.44$, range 0.31 to 0.93). Learning multiple skills simultaneously increased cognitive abilities in older adults by midpoint of the intervention, to levels similar to performance in a separate sample of middle-aged adults, 30 years younger
Park et al. (2014)	RCT	$N=221$, mean age 71.67, community dwelling, dementia free	Quilting, photography, or combination, and control groups, 15 h/week for 3 months	Cognitive battery	Engagement in cognitively demanding, novel activities enhance memory function in older adulthood. Episodic memory improved more than other cognitive abilities

Table 3 (continued)

Attribute and reference	Study design	Pop description	Activity measure	Cognitive outcome	Summary/outcomes
Sachdev et al. (2013)	Longitudinal cohort	$N=233$, mean age, 28.61, diagnosed with MCI at baseline	Leisure activity engagement, intellectual, physical and social—NEO 5 Personality Inventory	Cognitive battery, MRI	There were 66 reverters to normal cognition and 157 non-reverters. Reversion from MCI to normal cognitive functioning was more likely for participants with higher complex mental activity ($p=0.003$) and greater openness to experience ($p=0.041$). Reverters had greater white matter volumes and a trend toward greater gray matter volumes, notably the hippocampus and amygdala of the left hemisphere
Productive engagement					
Da Ronch et al. (2015)	Cross-sectional	$N=1383$, age 65–84, community dwelling, dementia free	Physical Activity Questionnaire, TV watching questionnaire	Cognitive battery	Statistically significant inverse correlation between Mini-Mental State Examination scores and TV viewing time ($p<0.001$)
Fancourt & Steptoe (2019)	Longitudinal cohort 6 years	$N=3662$, mean age 67.1, dementia free at baseline	Television viewing	Cognitive battery	Television viewing for more than 3.5 h per day is associated with a dose–response decline in verbal memory over the following 6 years, but not semantic fluency
Lindstrom et al. (2005)	Case control	Older adults with AD; $N=135$ cases (median 1922). Controls; $N=331$ (median 1924), dementia free	Leisure activities ($n=26$) Life History Questionnaire, Leisure activities ($n=26$), daily activity hours, daily % intensity (surrogates reported for individuals with AD)	Diagnosis of AD	Each additional daily hour of middle-adulthood television viewing the associated risk of AD development increased 1.3 times. Participation in intellectually stimulating activities and social activities reduced the associated risk of developing AD. Subjects in the present analysis reported viewing an average 1.3 h of television per day among controls and 1.7 h of television per day among cases
McDonough et al. (2015)	Preselect subgroup of RCT, pre-post testing of fMRI, but randomized intervention	$N=39$, mean age ranged from 66 to 70.22 community dwelling, no dementia	Participation in productive and receptive interventions—14 weeks	fMRI one year after intervention (pre-posttest), and weekly record of participation in 70 activities	The high-challenge group (productive), but not the low-challenge group (receptive), showed increased modulation of brain activity in medial, frontal, lateral, temporal, and parietal cortex. Older adults who engage in a mentally challenging activity show increased modulation of brain activity, restoring a more youth-like state, with more efficient use of neural resources. Researchers are cautiously optimistic that age-related cognitive decline can be slowed or even partially restored if individuals are exposed to sustained, mentally challenging experiences

Table 3 (continued)

Attribute and reference	Study design	Pop description	Activity measure	Cognitive outcome	Summary/outcomes
Niti et al. (2008)	Longitudinal prospective cohort, mean 1.5 years follow up	$N = 1635$, mean age 66, community dwelling	Frequency of participation in leisure activities $N = 16$ (physical, social, and productive)	Cognitive battery (Mini Mental Status Exam MMSE)	Cognitive decline was observed in 30% of the respondents. Controlling for age, gender, education and other risk factors, odds ratios (ORs) were significantly reduced (40%) in those with medium (OR: 0.60, 95% CI: 0.45–0.79) and high activity levels (OR: 0.62, 95% CI: 0.46–0.84). A stronger association was shown for productive activity (OR = 0.36), than for physical (OR = 0.78) and social activities (OR = 0.85)
Park et al. (2014)	RCT	$N = 259$, mean age 71.67, community dwelling, no dementia	Six study conditions—14 weeks in duration. Three productive (quilting, digital photography, or both) and three receptive (social club, placebo, or no intervention)	Cognitive battery	Productive leisure engagement caused a significant increase in episodic memory compared with receptive engagement. Improvements were also shown in visuospatial processing and processing speed. Somewhat surprisingly, the researchers found limited cognitive benefits of sustained engagement in social activities
Stine-Morrow et al. (2008)	RCT	$N = 87$ intervention, 63 control, mean age 72.5, retirement community dwelling	Senior Odyssey of the Mind team-based competition	Cognitive battery	Experimental participants showed positive change in composite measure of fluid ability from pretest to posttest. Experimental group showed differential positive change relative to the control group reliable for speed, $t(146) = 1.81$, $p = 0.036$, inductive reasoning, $t(146) = 1.83$, $p = 0.034$, and divergent thinking, $t(147) = 1.88$, $p = 0.031$, but not for working memory, $t(146) = 1.01$, $p = 0.136$, or visual–spatial processing, $t(144) = 0.60$, $p = 0.275$. Overall composite of these variables, which might be taken as a measure of fluid ability, showed differential positive change among those who participated in the cognitive intervention, $t(149) = 3.11$, $p = 0.001$ (one-tailed)
Enjoyable engagement					
Flatt & Hughes (2013)	Review				Little is known about enjoyment in later life and if it is important for cognitive health. A deeper understanding of the mechanisms by which enjoyment in later life may affect cognitive health could help to inform future clinical and public health interventions
Gardner et al. (2020)	cross-sectional	$N = 58$, mean age 72.9, community dwelling	California Older Persons Pleasant Events Scale, Geriatric Depression Scale	Cognitive battery	Perceived pleasantness/enjoyment predicted higher scores on attention, processing speed, and language. Perceived enjoyment of some activities is related to cognition in later life. Important to formally assess enjoyment

Table 3 (continued)

Attribute and reference	Study design	Pop description	Activity measure	Cognitive outcome	Summary/outcomes
Küster et al. (2016)	RCT	$N = 54$, subjective memory complaints, mean age 71.4	Two training groups (physical and cognitive) and matched wait-list control. Lifestyle was self-report of leisure activities prior to study using the Community Healthy Activities Model Program for Seniors Physical Activity Questionnaire for Older Adults ($N = 40$ physical, social and cognitive activities within the previous 4 weeks)	Cognitive battery	Neither training intervention improved global cognition in comparison to control group. However, self-reported lifestyle was positively associated with benefits in global cognition ($p < 0.001$) and memory ($p < 0.001$). Active leisure lifestyle had stronger association with cognitive change over time in dementia risk group than short-term specific training interventions. Enjoyment and intrinsic motivation were hypothesized to be factors crucial for designing interventions, which are more efficient than currently available training intervention
Park & Bischof (2013)	Review				An important aspect not considered sufficiently is how enjoyable activities are. Engagement in pleasurably challenging leisure activities that activate core cognitive processes such as working memory, episodic memory, and reasoning may prove more effective than computer-based training techniques due to sustained engagement
Payne et al. (2011)	Cross-sectional	$N = 197$, mean age 72.1, community dwelling	Activity Flow State Scale	Cognitive battery	More cognitively demanding activities elicited higher levels of flow for those with higher fluid ability. Flow as an exceptionally pleasurable state should be considered in understanding cognitive optimization in older adults

Table 3 (continued)

Attribute and reference	Study design	Pop description	Activity measure	Cognitive outcome	Summary/outcomes
Regier et al. (2022)	Case control	$N = 1397$ living with dementia and $N = 4719$ cognitively healthy, mean age 77.7	Identification of favorite activity (then categorized into; self-care, productive, shopping, household, care of others, socializing, nonactive leisure, active leisure, religious/organizational, and other/misc	Cognitive battery	Most frequently endorsed favorite activity for persons living with dementia was nonactive leisure (44.5%), followed by active leisure (30.1%). For cognitively healthy individuals (CHP), most frequently endorsed favorite activity was active leisure (43.1% followed by nonactive leisure (30.8%). For CHP engagement in favorite activity was associated with greater functional independence, decreased depression and anxiety, and better performance on memory measures
Wilson (2011)	Review				Mentally stimulating and growth-oriented lifestyle is an important part of maintaining cognitive health in old age. Current research suggests that the activities should be complex and challenging, and because they need to be sustained over a period of time, these endeavors should be engaging and enjoyable
Meaningful engagement					
Carlson et al. (2008)	RCT	$N = 149$ (70 experimental, and 58 control), mean age 70.1. community dwelling, 28% with possible cognitive impairment	Baltimore Experience Corps volunteering	Cognitive battery	Intervention group showed improvements in executive function (EF) and memory relative to matched controls ($p < 0.10$). Those with impaired baseline EF showed greatest improvements, between 44 and 51% in EF and memory at follow up compared to declines among impaired EF controls ($p < 0.05$)
Carlson et al. (2015)	RCT	$N = 111$ (58 intervention, 53 control) mean age 67.2	Baltimore Experience Corps volunteering	MRI at 12- and 24-month follow-up, memory measure	Men in the control arm exhibited age-related declines over two years, men in the Experience Corps arm showed a 0.7–1.6% increase in brain volumes. Women also exhibited modest intervention-specific gains of 0.3–0.54% by the second year of exposure that contrasted with declines of about 1% among women in the control group. Purposeful activity embedded within a social health promotion program halted and, in men, reversed declines in brain volume in regions vulnerable to dementia

Table 3 (continued)

Attribute and reference	Study design	Pop description	Activity measure	Cognitive outcome	Summary/outcomes
Maselko et al. (2014)	Cross-sectional	$N=252$, mean age 71.8, 71% were considered cognitively impaired	Leisure activities ($N=17$, generative, social or solitary)	Cognitive battery (Montreal Cognitive Assessment MoCA), and Informant Questionnaire on Cognitive Decline in the Elderly (IQCODE)	Frequent engagement in generative leisure activities was associated with higher levels of cognitive function. More frequent engagement in generative leisure activities was associated with higher levels of cognitive function, independent of the impact of other social and solitary leisure activities. In a fully adjusted model combining all three leisure activities, generative activities independently predicted cognitive function as measured with the MoCA ($\beta=0.47$ (0.11 to 0.83) and the IQCODE ($\beta=-0.81$ (−1.54 to −0.09)
Proulx et al. (2018)	Longitudinal cohort,	$N=11{,}100$, mean age 66, community dwelling	Formal volunteering	Cognitive battery	Formal volunteering was associated with higher levels of cognitive functioning over time, especially with working memory and processing more so than recall/memory. The positive association was stronger for women and for those with below average levels of education
Regier et al. (2022)	Case control	$N=1397$ living with dementia and $N=4719$ cognitively healthy	Identification of favorite activity (then categorized into; self-care, productive, shopping, household, care of others, socializing, nonactive leisure, active leisure, religious/organizational, and other/misc	Cognitive battery	Results suggest that engagement in valued activities considered personally meaningful may have significant and distinct benefits for persons with and without dementia. For cognitively healthy, engagement was associated with improved memory function
Wingo et al. (2020)	Cross-sectional	$N=5441$, mean age 63	Frequency of physical activities, hobbies, and enrichment activities. Purpose in Life (PIL) (adapted from Ryff and Keyes Psychological Well-being Scale) 10 items	Perceived cognitive decline (Cognitive Function Instrument)	Greater purpose in life (PiL) was associated with less cognitive decline after adjusting for relevant factors. Further, PiL is a robust predictor of cognitive decline when considered simultaneously with known protective (education, exercise, enrichment activities)

Table 3 (continued)

Attribute and reference	Study design	Pop description	Activity measure	Cognitive outcome	Summary/outcomes
Self-directed engagement					
Infurna & Gerstorf (2013)	Longitudinal cohort, 4 years	$N = 4177$, mean age, 67	Level of change in physical activity; vigorous, moderate, and mild sports/activities and perceived control—10 items	Cognitive battery—episodic memory	Perceiving more control over one's life predicted less memory decline, an effect similar in midlife and old age
Küster et al. (2016)	RCT	$N = 54$, subjective memory complaints, mean age 71.4	Two training groups (physical and cognitive) and matched wait-list control. Self-report of leisure activities prior to study using the Community Healthy Activities Model Program for Seniors Physical Activity Questionnaire for Older Adults ($N = 40$ physical, social, and cognitive activities within the previous 4 weeks)	Cognitive battery	Training interventions did not improve global cognition in comparison to the control group, who participated in self-reported, self-chosen activities in the past 4 weeks. Participation was associated with global cognition ($p < 0.001$) and memory ($p < 0.001$). Enjoyment and intrinsic motivation were hypothesized to be factors crucial for designing interventions

in a variety of ways (e.g., higher demands for self-direction, social activities focused on intellectual goals, routine engagement in brainteasers, novel activity choice, and public recognition for success), such that the goal was not to isolate just one primary mechanism (Carlson et al., 2008, 2015; Dannhauser et al., 2014; Stine-Morrow et al., 2008). By placing older adults in a complex environment, cognitive challenge was created through diverse stimulation and the number of decisions required.

Cognitive changes were measured using cognitive testing for five the studies; three of which were interventions (Carlson et al., 2008; Dannhauser et al., 2014; Stine-Morrow et al., 2008), and two were based on self-reported engagement in complex leisure activities (Schooler & Mulatu, 2001; Soubelet & Salthouse, 2010). Two of the studies conducted MRIs and reported on structural changes in brain associated with complex leisure engagement (Carlson et al., 2015; Valenzuela et al., 2008), reporting on changes in brain volume (cortical and hippocampal).

The results were all significant for complex or intense leisure engagement and benefit to cognition in aging. Intervention groups demonstrated improved executive function and memory relative to control (Carlson et al., 2008), improved working memory (Dannhauser et al., 2014), and fluid cognition (Stine-Morrow et al., 2008). MRI studies showed an increase in brain volume in contrast to decreases in control group (Carlson et al., 2015) and reduced rate of hippocampal atrophy (Valenzuela et al., 2008). There is strong agreement in the literature that complex or intense leisure engagement fosters cognition in aging.

Sustained Engagement—Duration Sustained engagement can be defined as continuous or long-term engagement in a leisure activity. The time period studied has ranged from a 14-week intervention to lifetime engagement in leisure activities. Nine articles provide support for the association between cognition in aging and continued or sustained engagement in leisure activities (see Table 2). A majority of the studies ($N=6$ or 67%) were longitudinal cohort studies, with follow-up ranging from 2 to 10 years (Hughes et al., 2018a, 2018b; Ihle et al., 2018; Lee et al., 2020; Valenzuela et al., 2008; Weuve et al., 2004; James et al., 2013). One study was a randomized controlled trial, evaluating cognitive changes following an intervention of 14 weeks (Park et al., 2014). Two studies were reviews, one was a systematic review (Kramer & Willis, 2002; McPhee et al., 2019). The number of subjects in the studies ranged from 37 to 18,766.

Leisure activity engagement was measured in divergent ways: self-reported via standardized instruments; the Florida Cognitive Activities Scale (Hughes et al., 2018a, 2018b), and the National Study of Daily Experiences (Soomi et al., 2020), the Lifetime of Experiences Questionnaire (Valenzuela & Sachdev, 2007), as well as by estimating frequency of participation in leisure and physical activities (Ihle et al., 2018; Weuve et al., 2004; James et al., 2013).

Six of the studies used cognitive batteries to measure outcomes (Hughes et al., 2018a, 2018b; Ihle et al., 2018; Lee et al., 2020; Park et al., 2014; Weuve et al., 2004; James et al., 2013). One study used MRI to measure hippocampal atrophy (Valenzuela et al., 2008) and the systematic review focused on studies using neuroimaging to measure structural brain changes (McPhee et al., 2019). One study used postmortem neuropathology measures to measure common neuropathologic conditions (James et al., 2013). All of the studies concluded that sustained participation in leisure activities had a positive impact on cognition in aging, although one found that sustained engagement in social activities had limited cognitive benefits (Park et al., 2014).

Outcomes included protection from progression to MCI (Hughes et al., 2018a, 2018b), enhanced memory function (Park et al., 2014), enhanced cognitive performance (Ihle et al., 2018; Lee et al., 2020; Weuve et al., 2004), slower late-life cognitive decline (Weuve et al., 2004; James et al., 2013), and enhanced cognitive reserve (Ihle et al., 2018; Valenzuela et al., 2008). Neuroimaging studies found reduced hippocampal atrophy (Valenzuela et al., 2008) and preserved white matter microstructure (McPhee et al., 2019). Postmortem neuropathology findings reported that more frequent activity across the life span was associated with a slower rate of late-life cognitive decline. This was independent of some of the more common neuropathologic conditions including gross and microscopic infarction, Lewy bodies, amyloid burden, and tangle density (James et al., 2013). All the studies concluded that sustained participation in leisure activities had a positive impact on cognition in aging.

Variety of Engagement Variety or diversity of leisure engagement can be defined as the breadth of leisure activity repertoire or the number of different activities or types of activities in which an individual engages. Twelve studies report on diversity of activity engagement and cognition in aging (see Table 2). Six studies used a longitudinal cohort (Carlson et al., 2012; Karp et al., 2006; Krell-Roesch et al., 2019a, 2019b; Lee et al., 2020; Scarmeas et al., 2001; Wang et al., 2013), with follow-up periods ranging from 2.4 to 10 years. Five studies employed cross-sectional design (Bielak et al., 2019; D. Chan et al., 2018; Iizuka et al., 2021; Jackson et al., 2020; Parisi et al., 2012). Two studies employed case control design, one matching individuals with probable AD with a healthy control group (Friedland et al., 2001) and the other matching discordant twins, in which one had AD and the other did not (Crowe et al., 2003). The number of subjects in these studies ranged from 193 to 1772.

Leisure activity participation was measured in divergent ways, but two studies used the Lifestyle Activities

Questionnaire (Carlson et al., 2012; Parisi et al., 2012), one used the Lifetime of Experiences Questionnaire (Chan et al., 2018), and one used the Activity Lifestyle Questionnaire from the Victoria Longitudinal Cohort Study (Bielak et al., 2019). Bielak et al. (2019) used two different activity measures, one that focused on activity characteristics in addition to a standardized instrument measuring frequency of participation. The remaining studies used predetermined lists of leisure activities, ranging in number from five activities (Krell-Roesch et al., 2019a, 2019b) to 29 activities (Karp et al., 2006).

All the studies but one used a cognitive battery to measure cognitive outcomes (see Table 2). One study used neuroimaging (MRI) (Iizuka et al., 2021), and one study used both cognitive battery and MRI (Friedland et al., 2001). The outcomes reported included decreased risk of MCI (Krell-Roesch et al., 2019a, 2019b) and decreased incidence of cognitive impairment and dementia (Carlson et al., 2012; Karp et al., 2006; Scarmeas et al., 2001). Karp et al. (2006) reported a reduced risk of dementia (RR, 0.53; 95% CI: CI 0.36–0.78) for individuals with high scores in two or three leisure activity categories (mental, physical, and social). Carlson et al. (2012) found an association between participation in a greater variety of activities and a decreased risk of cognitive impairment, independent of the cognitive demand of the activity. Additionally, this study found that variety predicted decreased risk of cognitive impairment more than frequency of engagement.

All the articles found that the number of activities endorsed was associated with positive cognitive outcomes, either in measure of cognitive function or by reducing the risk of cognitive decline. Six of the studies found an association between higher levels of cognitive function and leisure activity variety (Bielak et al., 2019; Carlson et al., 2012; Jackson et al., 2020; Lee et al., 2020; Parisi et al., 2012; Wang et al., 2013). Wang et al. (2013) found that individuals engaging in two or three leisure activities improved their cognition. The one exception found benefit, but it was strongly associated with frequency of participation (Bielak et al., 2019) concluding that it did not matter how activity participation was defined, as high engagers in leisure activities were superior on both metrics. The article using neuroimaging as part of the cognitive outcome measure reported that greater variety in leisure activity engagement was associated with significantly larger hippocampal and gray matter volumes (Iizuka et al., 2021). Variety of participation in cognitively complex activity, regardless of frequency, has been found to be positively correlated to enhanced cognition in aging (Carlson et al., 2012; Karp et al., 2006; Lee et al., 2020).

Characteristics of Leisure Activity Engagement

As a subjective phenomenon, characteristics of leisure engagement can be described as the "… mental experience [of an individual] while engaged in leisure activities and the satisfaction or meanings derived from these involvements" (Mannell & Kleiber, 1997, p. 55). Researchers have noted that these more subjectively experienced aspects of leisure engagement might more effectively identify pertinent qualities of leisure activities that foster cognitive reserve and neuroplasticity (Bielak, 2010, 2017, 2019; Fallahpour et al., 2015). There are examples in the literature related to leisure, aging, and cognition of studies examining subjective qualities or characteristics of older adults' leisure experiences. This type of examination explores how each individual uniquely experiences a leisure activity, and if the differences impact cognition in aging and includes such characteristics as novelty, active engagement, enjoyment, meaning, and self-direction.

Novelty of Engagement Novelty refers to engagement in a leisure activity that is new for the individual, requiring new learning. Seven articles are included that report on engagement in novel leisure activities and cognition in aging (see Table 3). Five of the studies are randomized controlled studies, which introduced novel leisure activities to older adults: juggling (Boyke et al., 2008), iPad instruction (M. Y. Chan et al., 2016), piano instruction (Bugos et al., 2007), quilting, and digital photography (Park et al., 2014) and Spanish language, painting and use of a technology device (Leanos et al., 2020) and evaluated cognitive impact. Two of the studies presented two or more novel activities simultaneously (Leanos et al., 2020; Park et al., 2014). One study was a case control design (Fritsch et al., 2005) and one a longitudinal cohort study which also measured the psychological construct of novelty seeking or openness to experience (Sachdev et al., 2013). The number of subjects in the studies ranged from 31 in the piano instruction study (Bugos et al., 2007) to 809 in the case control study (Fritsch et al., 2005). The subjects included dementia-free, community-dwelling older adults (Boyke et al., 2008; Bugos et al., 2007; M. Y. Chan et al., 2016; Leanos et al., 2020), older adults with MCI at baseline (Sachdev et al., 2013), and older adults with AD (Fritsch et al., 2005).

Five of the seven studies evaluated the impact of engagement in a novel leisure activity on cognition, while one study focused on novel activities engaged in between ages 20 and 60 and AD diagnosis (Fritsch et al., 2005), and another, the impact of novelty on reversion from MCI to normal cognitive function (Sachdev et al., 2013). Two of the studies also included MRI, evaluating the impact of novelty on brain structure (Boyke et al., 2008; Sachdev et al., 2013).

All the studies cited benefit from engagement in novel leisure activity. The five intervention studies reported significant improvement in a variety of cognitive scores, with one study (Leanos et al., 2020) noting that the improvements led to similar cognitive performance of a sample of middle-aged adults, who were 30 years younger than the study population. The MRI studies revealed that engagement in novel (and complex) leisure activities resulted in greater white and gray matter volume, notably impacting the hippocampus and nucleus accumbens (Boyke et al., 2008; Sachdev et al., 2013). One study reported that higher levels of participation in novelty-seeking activities were associated with reducing the odds of AD (OR, 0.248; 97.5% CI, 0.139–0.443) (Fritsch et al., 2005). Older adults with MCI who engaged in higher complexity mental activity and who were more open to novel experience were also more likely to revert from MCI to normal cognition ($p = 0.003$ and $p = 0.041$, respectively) (Sachdev et al., 2013). Engagement in novel activities has been reported as beneficial to cognition in aging in all the studies included in this review.

Productive vs. Receptive Engagement Productive engagement refers to cognitively challenging activities requiring sustained activation of working memory, long-term memory, and other executive processes (Park et al., 2014, p. 104). Alternatively, receptive engagement refers to activities that rely on passive observation, use of existing knowledge, and familiar activities (Park et al., 2007). Seven articles are included in this section reporting on productive and/or receptive engagement in leisure activities (see Table 3). Four articles focus on productive engagement (McDonough et al., 2015; Niti et al., 2008; Park et al., 2014; Stine-Morrow et al., 2008), one of which uses a subset of subjects from another study, but reports on different outcomes (McDonough et al., 2015; Park et al., 2014, respectively). Three of the studies address the impact of receptive engagement on cognition in aging, specifically the impact of television viewing (Da Ronch et al., 2015; Fancourt & Steptoe, 2019; Lindstrom et al., 2005). These studies employed a variety of design; three studies reported on a RCT (McDonough et al., 2015; Park et al., 2014; Stine-Morrow et al., 2008), two used longitudinal design (Fancourt & Steptoe, 2019; Niti et al., 2008), one used cross-sectional design (Da Ronch et al., 2015), and one used case control design (Lindstrom et al., 2005). The number of subjects ranged from 39 to 3662. In all the studies but one, the subjects were community-dwelling older adults with no dementia. The case–control study evaluated older adults with AD to a matched control, who were community dwelling, with no dementia (Lindstrom et al., 2005).

Two of the RCT studies reported in this review created six different study conditions, which were 14-week activity interventions. Three of the interventions were productive, learning a new activity skill (quilting, digital photography, or both), and three were receptive (social club, placebo, or no-treatment) (McDonough et al., 2015; Park et al. 2014). One RCT involved participation in Senior Odyssey of Mind, a team-based competition involving creative problem solving (Stine-Morrow et al., 2008). Three of the studies used measures of frequency of engagement in leisure activities, two of which were standardized instruments (International Physical Activity Questionnaire, Life History Questionnaire) and one which ask about participation in 16 leisure activities (Da Ronch et al., 2015; Lindstrom et al., 2005; Niti et al., 2008, respectively). Two of the studies specifically collected data on TV viewing frequency (Da Ronch et al., 2015; Fancourt & Steptoe, 2019). Five of the studies used a cognitive battery to assess outcomes, and one used functional MRI (fMRI) (McDonough et al., 2015).

Productive leisure engagement was shown to foster episodic memory (Park et al. 2014), reduce the risk of cognitive decline (OR = 0.36) (Niti et al., 2008), improve fluid cognitive ability (Stine-Morrow et al., 2008), and increase modulation of brain activity in the medial, frontal, lateral, temporal, and the parietal cortex of the brain (McDonough et al., 2015). Conversely, receptive leisure engagement as measured by TV viewing resulted in a significant decline in MMSE scores (Da Ronch et al., 2015), a decline in verbal memory (Fancourt & Steptoe, 2019), and a 1.3 times increased risk of incident AD for each additional daily hour of middle-adulthood television viewing (Lindstrom et al., 2005). All the articles in this section of the review support the hypothesis that productive leisure activities support cognitive function in aging and reduce the risk of cognitive decline.

Enjoyable Engagement Enjoyable or pleasurable activities are those which foster positive stimulation of the senses and evoke positive emotions. It has been noted that enjoyment has received very little attention in the literature with regard to cognitive health (Flatt & Hughes, 2013; Park & Bischof, 2013). Six articles are included reporting on cognitive benefits associated with pleasurable engagement (see Table 3). Three of these studies are reviews (Flatt & Hughes, 2013; Park & Bischof, 2013; Wilson, 2011), two studies are cross-sectional (Gardner et al., 2020; Payne et al., 2011) and one is a RCT (Küster et al, 2016). The number of subjects in the research articles ranges from 54 to 197. Two of the studies included subjects who were community dwelling, with no dementia (Gardner et al., 2020; Payne et al., 2011), and one studied subjects with subject memory complaints (Küster et al., 2016).

The instruments used to measure enjoyable engagement were standardized measures of pleasant events (California Older Persons Pleasant Events Scale) and a measure of an engagement state referred to as "flow" (Activity Flow State Scale) (Gardner et al., 2020; Payne et al., 2011, respectively). The RCT also incorporated a measure of leisure activity engagement prior to the intervention using the Community Healthy Activities Model Program for Seniors Physical Activity Questionnaire for Older Adults, which measured participation in 40 different physical, social, and cognitive leisure activities (Küster et al., 2016). The cognitive outcomes were measured using a cognitive battery.

Results from the current studies suggested that older adults who experienced more pleasure in certain activities also had higher performance on some tasks of attention (Gardner et al., 2020). Additionally, engagement in one's preferred leisure activity was associated with higher levels of functional independence, a decrease in depression and anxiety, and better performance on tests of memory (Regier et al., 2022). Of interest was the finding from the RCT that the training interventions did not impact global cognition, but the self-reported, naturally occurring lifestyle activities were positively associated with improvements in both global cognition and memory. The engagement attribute of enjoyment has limited evidence, but strong theoretical and hypothetical credibility.

Meaningful Engagement Meaningful activities are those from which an individual derives meaning and which fulfill a purpose for the individual. A related construct, purpose in life, refers to a tendency to derive meaning from life experiences and possess a sense of direction and purpose (Wingo et al., 2020, p. 311). This activity attribute emphasizes the underlying meaning and purpose of the activity versus the specific characteristics of the activity itself (e.g., physical vs. social) (Maselko et al., 2014). Another term used reflecting this attribute is generative leisure activities, which are defined as activities motivated by a concern for others and the need to contribute something to the next generation (Maselko et al., 2014, p. 1707). There are six articles associating meaningful or generative activities to cognition in aging (see Table 3). Two of the studies were cross-sectional (Maselko et al., 2014; Wingo et al., 2020), two were RCTs of the same intervention, but using different subjects and measures (Carlson et al., 2008, 2015), one was longitudinal (Proulx et al., 2018), and one was a case control design (Regier et al., 2022). The number of subjects ranged from 111 to 11,100. All the studies addressing meaningful engagement and purpose in life were part of large aging-related studies. Two of the studies were part of the Baltimore Experience Corps (Carlson et al., 2008, 2015), and the remaining were part of the Sri Lanka Healthy Minds Study (Maselko et al., 2014), the National Health and Aging Trends Study (Regier et al., 2022), the Health and Retirement Survey (Proulx et al., 2018), and the Emory Healthy Aging Study (Wingo et al., 2020). The subjects were predominantly community dwelling with only one study having an eligibility requirement of healthy cognition at enrollment, and this was only in reference to the control subjects ($N=4719$) who were matched with 1397 individuals living with dementia (Regier et al., 2022). One of the Baltimore Experience Corps studies noted that 28% of the subjects had possible cognitive impairment at enrollment (Carlson et al., 2008).

Three of the studies measured leisure activity engagement, one using a 17 activities checklist (Maselko et al., 2014), one by identification of a favorite leisure activity (Regier et al., 2022), and one by self-report of exercise frequency, hobbies, walking frequency, and engagement in enrichment activity (Wingo et al., 2020). The longitudinal study compared individuals who volunteered to those who did not (Proulx et al., 2018). The two RCTs were interventions based on engagement in the Baltimore Experience Corps, which is civic-engagement activity characterized by high-intensity and intergenerational interactions in which older adults mentored and tutored elementary school-aged children (Carlson et al., 2008, 2015). The measures used to determine cognitive outcome included cognitive batteries (Carlson et al., 2008; Maselko et al., 2014; Proulx et al., 2018; Regier et al., 2022), perceived cognitive decline (Wingo et al., 2020), and brain volume changes as measured by MRI (Carlson et al., 2015).

Community-dwelling older adults who reported more frequent exercise, physical leisure activities, walking frequency, and higher number of enrichment activities also reported having higher purpose in life and were found to report a slower rate of cognitive decline (Wingo et al., 2020). Older adults reporting frequent engagement in generative or personally meaningful leisure activities were found to have higher levels of cognitive function (Maselko et al., 2014), 2014) and improved memory function (Regier et al., 2022). Volunteering was positively associated with cognitive function which increased over time (Proulx et al., 2018). Those participating in the Baltimore Experience Corps showed improvements in executive function and memory relative to matched controls, and those who had cognitive impairment at baseline showed the greatest improvements; 44% in executive function and 51% in memory compared to controls (Carlson et al., 2008). In the second study reporting outcomes of engagement in the Baltimore Experience Corps, males in the control group demonstrated age-related declines in brain volume, while the experimental group demonstrated a 0.7–1.6% increase in brain volumes (Carlson et al., 2015). All the articles included in this review on meaningful or generative leisure engagement found a positive association with cognitive function in aging.

Self-Directed Engagement By definition, a leisure activity implies something done by choice (Adams et al., 2011). Self-direction can be defined as leisure engagement by choice and intrinsically directed. Research on perceived control of leisure engagement in aging and the impact this has on cognition is limited, and this section reviews two articles (see Table 3).

One study was longitudinal in design, using a cohort of 4177 from the Nationwide Health and Retirement Study (Infurna & Gerstorf, 2013), and the other was a RCT of 54 older adults with subjective memory complaints (Küster et al., 2016). The longitudinal study measured engagement in differing levels of physical activities (mild, moderate, and vigorous) and measured perceived control using a 10-item instrument. The RCT provided two training groups and a control group. All the subjects completed a self-report of leisure activities prior to the interventions using a standardized instrument with 40 activities categorized as physical, social, and cognitive (Küster et al., 2016). Both studies used a cognitive battery to measure cognitive function as the dependent variable. Perceived control mediated level of change in engagement in activities as well as predicted less memory decline (Infurna & Gerstorf, 2013). The RCT intervention groups did not demonstrate improved global cognition as compared to the control group, who continued to participate in self-chosen activities. The control group did improve, and an association with global cognition and memory was found. Intrinsic motivation was hypothesized as a crucial factor in the design of future interventions.

Discussion

While there is a substantive body of research associating leisure activities and protected cognitive function, it still is not clear if specific types of activities contribute to the prevention or delay of cognitive decline associated with increasing age (Maselko et al., 2014). Bielak & Gow (2023) propose that studying one activity or activity domain is not fruitful, as all activity is likely relevant. A noted gap in the literature has been identification of the attributes and characteristics of the leisure experience that foster cognition in aging. Participating in a leisure activity is not a ubiquitous experience and attributing cognitive preservation to a specific activity or type of activity is simplistic. Categorizing leisure activities based on a combination of their purpose or meaning as well as their cognitive, physical, and social demands will more effectively guide future research and advise informed recommendations and efficacious intervention. The attributes and characteristics of the engagement may provide more meaningful direction for intervention than recommendations to engage in specific activities or activity domains.

Engagement in leisure activity has been shown to enhance cognition in aging, and frequency as measured by time spent participating in leisure activities has been the most commonly used metric to measure engagement (Fallahpour et al., 2015). Frequency of participation may not be an effective metric in predicting cognitive benefit. This is supported by the mixed findings of the studies reporting on frequency of engagement in this review. Frequent engagement in an activity has been proposed to strengthen neural connections and has been hypothesized as the mechanism of action enhancing cognition in aging (Phillips, 2017). However, quantity of engagement is likely mediated by the quality of the engagement. Participation in passive or cognitively unchallenging activity is less likely to strengthen neural connections. This has been supported by research demonstrating that extensive time spent viewing television is associated with poorer cognitive function in aging (Da Ronch et al., 2015; Fancourt & Steptoe, 2019). Research on complexity of engagement suggests that quality of engagement modulates the benefit of frequency of engagement. It has been proposed high-intensity cognitive activity provides greater cognitive benefit than low cognitive intensity activity (e.g., Hultsch et al., 1999; Schooler & Mulatu, 2001; Wilson, 2011). Leisure activities can differ with respect to the return per unit of time spent in the activity, as suggested by a recommendation to measure the "cognitive yield" for a given amount of activity time (Soubelet & Salthouse, 2010). Frequency of engagement in leisure activity has been proposed to strengthen neural connections, resulting in resiliency in the face of cognitive decline (Phillips, 2017).

Intensity of leisure engagement when considered an attribute of leisure engagement was defined as the intensity of the cognitive demand implicit in an activity. The articles reviewed addressed studied leisure activities that had higher level cognitive demands or complexity. Leisure activities exercising multiple facets of cognition can be considered more complex or intense. One of the reasons proposed for substantive leisure activity complexity playing a viable role in broadly enhancing cognition is that an investment in complex leisure "…requires one to be ever nimble in tackling problems with whatever one has in one's repertoire, inevitably requiring the exercise of multiple abilities in different combinations and in different contexts" (Stine-Morrow et al., 2008, p. 778). It has been hypothesized that the cognitive complexity afforded by a cognitively and/or socially intense lifestyles can foster dendritic branching and synaptic connections, alleviate amyloid burden in the brain, and improve or preserve cognitive function in aging (Fratiglioni et al. 2004). This attribute is also closely related to the subjectively experienced characteristic of leisure addressing the uniquely experienced challenge of an activity.

Maintaining leisure activity engagement for a sustained period of time has also been associated with cognition in aging, with studies examining lifetime engagement in leisure activities, as well as those studying the impact of maintaining participation over prolonged periods of time (Hughes et al., 2018a, 2018b; Ihle et al., 2018; McPhee et al., 2019). There is an expansive literature on lifetime leisure activity engagement as one of the proxies for cognitive reserve in aging (cf., Dekhtyar & Wang, 2017; León-Estrada et al., 2017; Opdebeeck et al., 2015; Valenzuela & Sachdev, 2007). This literature strongly supports the hypothesis that dementia risk is a life-course process and that the differences found among individuals in their ability to withstand age-related cognitive decline and brain changes ultimately depend on their life-time accrual of cognitive reserve (Dekhtyar et al., 2015). However, research also suggests that individuals who have predominantly been "cognitively sedentary" for most of their lives can benefit from increasing their leisure activity engagement in late life (Casaletto et al., 2020; Hui-Xin Wang et al., 2002a, 2002b; Leung et al., 2010). Two studies of the same cohort found that even after adjusting for activity earlier in life, higher levels of late-life activity were strongly associated with lower AD incidence (Wilson, 2011; Wilson et al., 2007).

There is also a strong argument for the relationship of activity variety, both in terms of different activity variety as well as specific activity domain variety (e.g., intellectual, physical, and social) (e.g., Carlson et al., 2012; Iizuka et al., 2021). Participation in a variety of activities appears to influence cognition independently from frequency of participation (Friedland et al., 2001; Parisi et al., 2015). Determining what constitutes leisure engagement requires further exploration. Activities are time restricted and more frequent participation in one leisure activity has the impact of necessarily limiting the amount of time that can be devoted to other activities. For example, one individual may read every day, and another may read and play chess on alternate weekdays. The former individual would achieve a higher overall activity frequency score, but the latter individual could receive equal or potentially greater cognitive benefits resulting from exposure to a more enriched or complex environment. An analogy used in the literature is to that of "cross training" in the exercise literature. If an individual exercises multiple muscle groups (e.g., alternates between running, weight training, and biking) rather than isolating one group of muscles by running every day, they would derive greater physiological benefit. It has similarly been hypothesized that participation in a variety of leisure activities may exercise numerous abilities and the associated neurobiological pathways. This can include the organizational skills required to manage a schedule and shift between different activities (Wang et al., 2013).

Participating in a variety of activities requires people to adjust to differing situations and to engage in more diverse behaviors (Yates et al., 2016). Different activities require differing levels of engagement in the various domains. Individuals whose activity repertoires showed higher numbers of activities involving two or more domains (i.e., mental, social, physical) demonstrated higher levels of dementia risk reduction than those who participated in activities involving lower levels of social, mental, and physical engagement. Researchers concluded that greater diversity of stimulation across activity domains may positively impact cognitive ability (Karp et al., 2006). Lifestyles characterized by a diverse range of activities are more likely to require the individual to experience a wider range of behaviors, and this has an impact on cognition (Jackson et al., 2020).

Research has reported that older adults are typically less interested in exploring new leisure pursuits, tending to prefer familiar activities (Nimrod & Janke, 2020). However, Nimrod (2008) also reported that older adults who added brand-new leisure activities after retirement reported higher life satisfaction. The studies cited in this review found an association between novel leisure activity engagement and cognition in aging. Similarly it has been noted that studying the characteristic activity, such as novelty, may be more relevant than studying a specific activity or domain (Bielak, 2010). The hippocampus, the subcortical brain structure which impacts learning, memory, spatial navigation, and other aspects of cognitive functioning, is hypothesized to change in structure as a result of exposure to and engagement with novel experiences and environments (Urban-Wojcik et al., 2022). Application of these findings supports the development of interventions to help older adults engage in novel leisure activities. Acquiring a novel skill requires engagement of a new set of neural pathways, which must then be further developed to provide the structure for task performance in early skill-acquisition stages (Park & Reuter-Lorenz, 2009). It has been hypothesized that engagement in novel activities offers cognitive protection because the active processing of novelty requires increased neural activation leading to enhanced cognitive reserve (Park et al., 2014).

Active or productive engagement has been referred to as activities that are cognitively challenging and require sustained activation of working memory, long-term memory, and other executive processes (Park et al., 2014). It has been hypothesized that the cognitive complexity afforded by a cognitively and/or socially engaged lifestyles can foster dendritic branching and synaptic connections, alleviate amyloid burden in the brain, and improve or preserve cognitive function in aging (Fratiglioni et al. 2004). Neuroimaging studies reported increased modulation of brain activity in multiple areas of the brain resulting from participation in productive activities (McDonough). This has been contrasted with receptive or passive engagement, as exemplified by television viewing, which been associated with decreased cognition and increased risk of incident AD (Da Ronch et al., 2015; Fancourt & Steptoe, 2019; Lindstrom et al., 2005). An additional hypothesis regarding the link of television viewing with negative cognitive outcomes is that it could be displacing other cognitively beneficial activities (Fancourt & Steptoe, 2019).

Current research suggests that leisure activities should not only be complex and challenging but they should also be sustained over a period of time. This is more likely to happen if the endeavors are engaging and enjoyable (Wilson, 2011). Enjoyable activities are hypothesized to foster higher engagement and intrinsic motivation (Küster et al., 2016). Enjoyment and intrinsic motivation were hypothesized to be the crucial factors, and notably those that may be lacking in currently available training interventions (Küster et al., 2016). Enjoyable activities foster cognitive attendance and motivation, thereby fostering sustained engagement, but are also hypothesized to lead to improved cognitive flexibility, broadened scope of attention, and thought-action repertoires, as well as enhancement of other cognitive functions (Gardner et al., 2020; Garland et al., 2010).

Leisure activities with higher potential to be personally meaningful, such as volunteering, have been shown to foster cognition in aging (Maselko et al., 2014). Engaging with one's purpose in life requires higher-order cognition, with the evidence pointing toward an association between cognitive functions such as memory and executive function (McKnight & Kashdan, 2009). Another proposed explanation for the beneficial effects of meaningful or generative leisure activities is that they typically keep older adults civically and socially engaged. Further research is needed to determine whether the desire to be generative and to make a valued contribution serve merely as motivation for engagement, or whether it actually represents an independent attribute contributing to cognitive reserve (Fried et al., 2004). There is a rich literature supporting the association between purpose in life, as measured psychometric measures, and cognitive function in aging (e.g., Boyle et al., 2010, 2012; Kim et al., 2019; Lewis et al., 2017). An alternative observation was that personally meaningful and productive engagement could also be thought of as attentional engagement, or an implicit or explicit choice to put forth effort, and this might be an essential determinant of cognitive change in aging (Stine-Morrow et al., 2008).

Self-directed engagement was the final engagement characteristic included in this review. There was limited amount of research using freely chosen and self-directed leisure activities as an independent variable and enhanced cognition as the outcome. In spite of this, perceived control and self-direction in aging more generally have been studied extensively and repeatedly associated with slower rates of decline in cognitive abilities, including memory, processing speed, and executive functioning among older adults (Agrigoroaei & Lachman, 2011; Bielak et al., 2007; Windsor & Anstey, 2008). Perhaps of more significance is that definitions of leisure include the constructs self-direction, choice, and intrinsic motivation (Walker et al., 2019). Leisure science research has widely reported on choice, self-directed, or intrinsically motivated leisure as being associated with numerous benefits for older adults (Fancourt et al., 2021; Walker et al., 2019). The limited research in this engagement characteristic represents a gap in leisure and aging research that merits further exploration.

Limitations of the research include recognition of the existing challenges in studying leisure activities, cognition, and aging. The extensive amount of existing research made the screening, selection, and review process challenging. Articles that may have added to the review may have inadvertently been omitted. Because the methodology employed was a scoping review, the research included represents differing methodology with varying degrees of inference possible. Many of the studies were correlational, and as such cannot infer causality. However, the correlational studies support many of the intervention studies and provide useful surrounding data. The intent of a scoping review is to identify the depth and breadth of existing research in a specific subject area, and to suggest opportunities for further exploration. A long-standing challenge in aging and cognition research is that of directionality, essentially addressing whether activity participation impacts cognition, or if cognition impacts activity participation. Both directions of association continue to be supported in the extant research (Bielak & Gow, 2023). Thus, it is important to note that bidirectionality should be considered when identifying attributes and characteristics of leisure engagement that foster cognition in aging. Additionally, this review focused on leisure engagement in older adulthood. This is not intended to minimize the significance of a lifespan approach to studying leisure engagement and cognition, which is well documented in the literature.

Conclusion

The attributes of leisure engagement associated with cognition in aging include frequency of engagement, intensity, variety of activities, and duration of time spent in activities. Better conceptualization and measurement of frequency, intensity, duration, and variety of leisure activity associated with late-life cognitive benefit are needed. Additional research on the characteristics of leisure engagement associated with cognition in aging includeing novelty, active engagement, enjoyment, meaning, and self-direction could also further knowledge and practice. This information would provide more effective strategies for both older adults and healthcare providers to enhance cognition in aging, moving from prescriptive, or specific activity interventions to a more personalized and self-directed approach. The value of such an approach can be epitomized by the limited evidence-based strategies currently recommending older adults complete daily crossword puzzles to enhance and maintain cognitive function. Current research suggests that targeting an individual activity, such as crossword puzzles, does not result in durable cognitive benefits, nor does it generalize to a broader range of cognitive abilities or to independent function (National Academies of Sciences, 2017). Additionally, the evidence seems to support the cognitive benefits of novel, complex, and challenging leisure activities, in contrast to the diversional and passive entertainment activities frequently programmed for older adults in congregate living settings. The commercial successes of cognitive training interventions and brain training games have also been found to have limited cognitive benefit. While prescribed training interventions may demonstrate short-term benefit, this differs from the cumulative stimulation attained when an individual has sustained engagement in personally meaningful leisure activities. A more nuanced understanding of the salient attributes and characteristics of leisure engagement that potentially foster cognition in aging will provide more efficacious guidelines. This knowledge also offers an optimistic perspective of aging, suggesting accessible strategies that provide older adults with some control in promoting cognitive health in aging.

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Declarations

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