*This document is the result of an on-going conversation with Gemini … **to be continued!***

Social Isolation on Stress Response and Cognitive Decline

Social interaction is a fundamental human need, deeply ingrained in our biology and essential for overall well-being [1]. The presence of meaningful social connections is a cornerstone of both physical and mental health, contributing to resilience against disease and promoting longevity. However, modern society is witnessing an increasing prevalence of social isolation and loneliness, conditions that pose significant threats to individual and public health [5]. This report aims to provide a comprehensive analysis of the current scientific understanding regarding the impact of social isolation on the human stress response system and the processes underlying cognitive decline. It will explore the various forms of social isolation, the body's physiological and psychological reactions to stress, the intricate relationship between isolation and these stress mechanisms, the effects of isolation on different aspects of cognitive function across the lifespan, the biological pathways mediating these effects, potential protective factors, and the complex role of online social interactions in this context.

Social isolation is not a monolithic entity but rather a spectrum of experiences characterized by varying degrees of social disconnection. At one end lies **objective social isolation**, which refers to a tangible lack of social contact, social networks, or social support [6]. This form of isolation is often quantified by measures such as the frequency of social interactions, the size and density of an individual's social network, and their level of participation in social activities [12]. Objective isolation can arise from a multitude of circumstances, including living alone, experiencing limited mobility due to age or disability, facing geographical distance from family and friends, and encountering barriers such as language differences or lack of transportation [1]. This measurable aspect of social disconnection provides a structural framework for understanding an individual's social environment.

In contrast, **perceived social isolation**, commonly known as loneliness, represents the subjective feeling of being alone, disconnected, or lacking close, meaningful relationships [2]. Loneliness is an internal emotional state reflecting a perceived discrepancy between an individual's desired level of social connection and their actual social experiences [2]. It is crucial to recognize that loneliness is a subjective phenomenon that can occur even in the presence of objective social contact [2]. Individuals surrounded by others, such as at a family gathering or in a crowded workplace, can still experience profound feelings of loneliness if their need for deep,

meaningful connection is not met [7]. Different facets of loneliness have been identified, including emotional loneliness, which refers to the lack of intimate connections, and social loneliness, which pertains to the absence of a broader sense of belonging and shared interests [12]. Some researchers also distinguish between negative loneliness, the unpleasant feeling of insufficient connection, and positive loneliness, a temporary and voluntary state sought for solitude or privacy [13]. Standardized scales, such as the UCLA Loneliness Scale and the Italian Loneliness Scale, are valuable tools for assessing the subjective experience of loneliness [12].

The advent of the internet and online environments has introduced a new dimension to social interaction, offering both opportunities and challenges for social connection [11]. Online platforms can facilitate the maintenance of existing relationships across geographical distances and enable the formation of new connections based on shared interests or circumstances [15]. The concept of **social presence**, the feeling of being present and connected with others in a virtual space, is a key factor influencing the quality of online interactions [16]. However, online socialization can also present barriers to meaningful connection. The absence of nonverbal cues, such as facial expressions and body language, can lead to misunderstandings and a reduced sense of intimacy [11]. Furthermore, relationships formed online can sometimes lack the depth and authenticity of in-person interactions, potentially resulting in superficial connections and persistent feelings of isolation despite a large number of online "friends" [11]. Online communities can be particularly beneficial for individuals who are geographically isolated or who share specific interests or conditions, providing a sense of belonging and support that might be difficult to find offline [15].

When an individual perceives a stressful situation, the body initiates a complex series of physiological and psychological responses designed to cope with the perceived threat. The **sympathetic-adreno-medullary (SAM) axis** is one of the primary systems involved in this stress response [20]. Upon the perception of danger, the sympathetic nervous system is rapidly activated, leading to the release of catecholamines, primarily epinephrine (adrenaline) and norepinephrine (noradrenaline), from the adrenal medulla into the bloodstream [20]. These hormones trigger a cascade of physiological changes, including an increase in heart rate and blood pressure, accelerated respiration, heightened alertness, and the mobilization of energy reserves in the form of glucose and lipids [20]. This immediate and rapid response, often referred to as the "fight-or-flight" response, prepares the body to either confront the perceived threat or escape from it [20].

The **hypothalamic-pituitary-adrenal (HPA) axis** represents another crucial component of the body's stress response system, providing a more sustained and

long-term regulatory mechanism [20]. The process begins in the hypothalamus, which releases corticotropin-releasing hormone (CRH) in response to stress [22]. CRH then stimulates the anterior pituitary gland to secrete adrenocorticotropic hormone (ACTH) into the bloodstream [22]. ACTH travels to the adrenal cortex, prompting it to release glucocorticoid hormones, most notably cortisol, into the circulation [22]. Cortisol, often referred to as the primary stress hormone, plays a vital role in regulating various bodily functions during stress, including increasing glucose levels for energy, modulating the inflammatory response, and influencing immune function [29]. The HPA axis is regulated by a negative feedback loop, where sufficient levels of cortisol inhibit the further release of CRH and ACTH, helping to bring the stress response back to baseline [30]. While acute stress triggers a rapid and adaptive response, prolonged or chronic stress can lead to dysregulation of the HPA axis, resulting in consistently elevated or dysregulated cortisol levels, which can have detrimental effects on various physiological systems over time [20].

Beyond the physiological responses, stress also manifests psychologically, encompassing a range of emotional and cognitive changes [7]. These can include feelings of anxiety, depression, irritability, frustration, and burnout, as well as cognitive impairments such as difficulty concentrating and making decisions [7]. The perception of a threat, whether it is a real danger or a perceived social slight, is a key trigger for these stress responses [20]. The intricate interplay between the physiological and psychological components of the stress response highlights how our mental state can profoundly influence our physical health and vice versa.

Social isolation has been consistently linked to a state of heightened stress reactivity in individuals across the lifespan [5]. The lack of social connection acts as a significant chronic stressor, placing the body in a persistent state of alert. The magnitude of the health risks associated with social isolation is striking, with studies indicating that it can be as detrimental to health as smoking 15 cigarettes a day or having alcohol use disorder, and more harmful than obesity [3]. This underscores the fundamental importance of social connection for maintaining overall well-being.

Loneliness and perceived isolation can lead to a heightened sensitivity to social threats and negative social cues [45]. Individuals experiencing loneliness may become hypervigilant to signs of social rejection, misunderstanding, disrespect, or dismissal, interpreting ambiguous social situations in a more negative light [45]. These negative social interactions, whether occurring in person or online, can trigger the body's stress response, activating the fight-or-flight mechanism and leading to the release of stress hormones [56]. The subjective feeling of being isolated can thus create a negative bias in social perception, making individuals more susceptible to the stress

induced by these interactions [45].

Research has consistently linked social isolation and loneliness to alterations in cortisol levels, a key indicator of HPA axis activity [8]. These alterations can manifest as both increased basal cortisol levels, indicating a chronic state of stress, and a flattening of the normal diurnal cortisol rhythm, which is essential for healthy physiological functioning [71]. These disruptions in cortisol regulation, driven by the stress of social isolation, can have wide-ranging negative consequences for health, affecting immune function, metabolism, cardiovascular health, and cognitive processes [29].

Social isolation and loneliness also appear to influence how the cardiovascular system responds to stress [42]. Studies have shown both blunted and heightened cardiovascular reactivity in lonely individuals, with some research indicating a smaller increase in blood pressure during stressful situations [42], while others report increased heart rate and reduced heart rate variability [51]. These altered cardiovascular responses to stress, potentially reflecting a dysregulation of the autonomic nervous system, can have significant long-term health implications, increasing the risk of hypertension, heart disease, and other cardiovascular problems [25].

Cognitive function, the brain's ability to process information, learn, remember, and reason, is a multifaceted construct. The Diagnostic and Statistical Manual of Mental Disorders (DSM-5) outlines six key domains of cognitive function: complex attention, executive function, learning and memory, language, perceptual-motor control, and social cognition [77]. Each of these domains encompasses a range of specific mental processes essential for navigating daily life [78].

As individuals age, some changes in cognitive abilities are considered a normal part of the aging process [83]. These typical age-related changes often involve a slowing of processing speed, increased difficulty with attention and multitasking, and occasional word-finding difficulties [83]. However, these changes are distinct from pathological cognitive decline, such as mild cognitive impairment (MCI) and dementia, which involve more significant and debilitating declines in cognitive function that interfere with daily activities [83]. Pathological cognitive decline can be caused by a variety of factors, including neurodegenerative diseases like Alzheimer's disease, vascular disease, genetic predispositions, lifestyle choices, and other medical conditions [83]. The rate at which cognitive function declines across the lifespan is influenced by a complex interplay of genetic, lifestyle, medical, educational, and social factors [83].

Social isolation has been shown to have both short-term and long-term effects on

cognitive function. In the short term, social isolation and lack of stimulation can lead to problems with memory, attention span, concentration, processing information, reasoning, and judgment [3]. Some research suggests a short-term reciprocal relationship between loneliness and cognitive performance, where increased loneliness on one day is associated with worsened cognitive function the next, and vice versa [100].

Numerous longitudinal studies and meta-analyses have established a significant association between social isolation and loneliness with an increased risk of long-term cognitive decline, mild cognitive impairment (MCI), and dementia [3]. The risk of developing dementia for socially isolated individuals has been quantified in some studies as being 50% to 60% higher compared to their socially connected counterparts [8]. While both objective social isolation and subjective loneliness are linked to cognitive decline, research suggests they may operate through different pathways [3]. Some studies indicate that loneliness, the subjective feeling of isolation, might have a stronger association with cognitive decline than objective isolation in certain contexts [105]. Specific cognitive domains appear to be particularly vulnerable to the effects of social isolation and loneliness, including memory, executive function, attention, and overall global cognitive function [5]. Some studies have also observed gender differences in the relationship between social isolation and memory decline [92].

Several biological mechanisms are believed to mediate the link between social isolation, chronic stress, and cognitive decline. **Chronic inflammation** has emerged as a key factor in this relationship [3]. Loneliness, in particular, has been associated with higher pro-inflammatory gene expression and increased levels of inflammatory markers in the body [3]. This chronic low-grade inflammation, potentially triggered and sustained by the stress of social isolation, is thought to contribute to neuronal damage and cognitive impairment. Some studies have also indicated potential sex differences in this mediation, with inflammation playing a more significant role in the association between social isolation and cognitive function in older men [111].

Oxidative stress, an imbalance between the production of harmful free radicals and the body's ability to neutralize them with antioxidants, is another biological pathway implicated in the link between social isolation, chronic stress, and cognitive decline [8]. The chronic stress induced by social isolation can exacerbate oxidative stress, leading to damage to neural cells and contributing to cognitive impairment [8]. Animal models have provided evidence linking social isolation stress to increased markers of oxidative stress in the brain [115].

Research has also revealed that social isolation and chronic stress are associated with

structural and functional changes in key brain regions crucial for cognition and stress regulation [46]. These changes include a reduction in hippocampal volume, a brain region vital for memory formation and retrieval, alterations in the prefrontal cortex, which is involved in executive functions, and a decrease in overall gray matter volume [103]. These structural and functional alterations in the brain provide a neurobiological basis for the cognitive deficits observed in socially isolated individuals.

Furthermore, **neuroinflammation**, involving the activation of microglia, the brain's resident immune cells, plays a role in mediating the effects of social isolation and chronic stress on cognitive decline [129]. Chronic stress and social isolation can lead to the overactivation of microglia, resulting in the release of pro-inflammatory cytokines within the brain. This neuroinflammatory response can disrupt normal neuronal function and contribute to the development of cognitive impairment [129].

Fortunately, several factors can buffer the negative effects of social isolation on stress and cognitive decline. **Social support** and a strong sense of connectedness have been consistently shown to mitigate these detrimental impacts [3]. Higher levels of social support are frequently associated with better cognitive functioning and a reduced risk of cognitive decline in older adults [3]. Cultivating and maintaining robust social networks and feeling connected to others can provide emotional and practical resources that help individuals cope with stress and maintain cognitive health.

Engagement in **meaningful activities** and activities that provide **cognitive stimulation** can also play a protective role against the negative consequences of social isolation [101]. Participating in social clubs, volunteering, pursuing hobbies, engaging in lifelong learning, and maintaining an active lifestyle can help preserve cognitive function and reduce feelings of loneliness in isolated individuals [109].

Various **interventions** have been developed and tested to reduce loneliness and improve social connections, with the aim of promoting cognitive health and overall well-being [138]. These include psychological therapies such as cognitive behavioral therapy (CBT) and mindfulness-based interventions, technology-based programs utilizing videoconferencing and telephone support lines, community-based social activities and exercise programs, and peer support groups [138]. The effectiveness of these interventions often depends on tailoring them to the specific needs and preferences of the individuals experiencing isolation [138].

Online social interactions present a complex picture for individuals experiencing social isolation, offering both potential benefits and drawbacks. For those with limited

opportunities for in-person contact due to geographical barriers, physical limitations, or other circumstances, online platforms can be invaluable for maintaining existing social connections with family and friends and even building new relationships [15]. Online communities formed around shared interests or experiences can provide a sense of belonging and support that might otherwise be lacking [19]. Furthermore, participation in online social activities has been linked to cognitive benefits, potentially stimulating various cognitive processes [141].

However, excessive or unhealthy engagement with online social media can also have negative consequences, potentially increasing stress, anxiety, depression, loneliness, and fostering social comparison and fear of missing out (FOMO) [1]. The lack of nonverbal cues in online communication can hinder deep and meaningful interactions, potentially leading to superficial relationships that do not fully address the need for genuine connection [11]. For individuals already experiencing social isolation, relying solely on online interactions might not fully compensate for the lack of in-person social engagement and could even exacerbate feelings of loneliness and isolation [1].

Participation in **open-source development** offers a unique form of online social interaction. It can foster a sense of community and collaboration among individuals contributing to shared projects [10]. However, this type of participation can also be associated with potential stressors, such as high workload expectations, managing feedback from a diverse community (including negative or demanding feedback), dealing with complex technical challenges, and the risk of burnout due to the often voluntary and demanding nature of the work [164]. On the other hand, contributing to open-source projects can also provide cognitive stimulation, opportunities for skill development, and a sense of accomplishment [155].

In conclusion, the evidence overwhelmingly indicates that social isolation, in both its objective and perceived forms, has a significant and detrimental impact on both the stress response system and cognitive function. Social isolation acts as a chronic stressor, leading to heightened stress reactivity, alterations in cortisol regulation, and changes in cardiovascular responses to stress. These physiological changes, coupled with the psychological distress of loneliness, contribute to an increased risk of accelerated cognitive decline, mild cognitive impairment, and dementia. Biological mechanisms such as chronic inflammation, oxidative stress, structural and functional changes in key brain regions, and neuroinflammation appear to mediate these negative effects. While online social interactions offer potential benefits for connecting isolated individuals, they also carry risks of increased stress and may not fully replace the need for meaningful in-person relationships. Protective factors such as strong social support, engagement in meaningful activities, and targeted

interventions aimed at reducing loneliness and improving social connections are crucial for mitigating the negative consequences of social isolation on both mental and cognitive health. Future research should focus on further elucidating the complex causal pathways involved, exploring the nuances of different types of social interaction, and developing effective and accessible interventions to address this growing public health challenge.

Table 1: Definitions of Social Isolation and Loneliness

Source	Social Isolation	Loneliness
NCBI Bookshelf [10]	A state in which the individual lacks a sense of belonging socially, lacks engagement with others, has a minimal number of social contacts, and they are deficient in fulfilling and quality relationships.	A discrepancy between a person's desired and actual social relationships.
CDC [6]	Not having relationships, contact with, or support from others.	The feeling of being alone, disconnected, or not close to others.
AMA [11]	A lack of engagement with others, having very few social contacts or people you would call, text or visit, not having a fulfilling quality relationship.	The subjective sensation of recognizing that there's a disconnect between your social connectiveness and what you really need.
NHS - Centre for Reviews and Dissemination [12]	The lack of social contact or support.	The feeling of being alone or isolated.
Gardiner et al[12].	The objective absence or paucity of_contacts and interactions between a person and a social network.	A subjective feeling state of being alone, separated or apart from others, and has been conceptualized as an imbalance between desired social contacts and actual social contacts.

Poscia et al[12].	An objective lack of meaningful and sustained communication.	The way people perceive and experience the lack of interaction.
Shvedko et al[12].	A state in which the individual lacks a sense of belonging socially, lacks engagement with others, has a minimal number of social contacts, and they are deficient in fulfilling and quality relationships.	A discrepancy between a person's desired and actual social relationships.
AIFS [13]	An objective, measurable lack of contact with social connections, usually when a person experiences a low number of social interactions.	A person's subjective feeling about, or perception of, the quality of their social connections. Usually, a negative feeling of being unsatisfied with their social relationships and connections.
Royal Society Publishing [2]	Deficits in social relationships.	Perceived social isolation, colloquially known as loneliness, is a useful construct to examine the importance of social relationships for health and fitness. Represents a mismatch between an individual's social needs and the provisions the social environment offers or is perceived to offer.
Wikipedia [14]	A state of complete or near-complete lack of contact between an individual and society.	Reflects temporary and involuntary lack of contact with other humans in the world.

Table 2: Key Physiological Changes in Stress Response

System/Axis	Hormone/Neurotransmitter	Primary Effects

Sympathetic-Adreno-Medullary (SAM) Axis	Epinephrine (Adrenaline)	Increased heart rate and force of contraction, vasoconstriction in non-essential organs, vasodilation in skeletal muscles, increased blood pressure, bronchodilation, increased glucose release from liver, pupil dilation, increased alertness [20]
Sympathetic-Adreno-Medullary (SAM) Axis	Norepinephrine (Noradrenaline)	Similar effects to epinephrine, also acts as a neurotransmitter in the brain, enhancing arousal and vigilance [20]
Hypothalamic-Pituitary-Adrenal (HPA) Axis	Cortisol	Increased blood glucose, suppression of immune system, regulation of metabolism, anti-inflammatory effects (in short term), changes in mood, motivation, and fear [29]

Table 3: Key Domains of Cognitive Function and Processes

Cognitive Domain	**Primary Cognitive Processes**
Complex Attention	Sustained attention, divided attention, selective attention, processing speed [77]
Executive Function	Planning, working memory, inhibition, cognitive flexibility, problem-solving, decision making [77]
Learning and Memory	Encoding, storage, and retrieval of new information (episodic, semantic, procedural, working memory) [77]
Language	Comprehension and expression of spoken and written language (vocabulary, grammar,

	fluency, naming) [77]
Perceptual-Motor Control	Visual perception, motor planning, coordination, spatial reasoning [77]
Social Cognition	Understanding and processing social cues, emotions, intentions, and social interactions (empathy, theory of mind) [77]

Table 4: Summary of Long-Term Studies on Social Isolation and Cognitive Decline (Illustrative Examples)

Study (Example)	Isolation Measured	Cognitive Outcomes Assessed	Follow-up Duration	Main Findings
Shankar et al. (2013) [99]	Objective (frequency of social activities)	Memory, global cognitive function	4 years	Social isolation, but not loneliness, was associated with cognitive decline.
Holwerda et al. (2014) [99]	Objective (marital status, number of close contacts)	Onset of dementia	6 years	No association between social isolation and onset of dementia.
Evans et al. (2019) [9]	Composite measure of social isolation	Global cognitive function	Varied	Social isolation was negatively associated with cognitive outcomes.
Lara et al. (2019) [9]	Loneliness	Cognitive function	Varied	Loneliness was negatively associated with cognitive outcomes.

Sutin et al. (2020) [9]	Loneliness	Dementia risk	Varied	Loneliness was associated with a higher risk of dementia.
Kuiper et al. (2015) [123]	Social isolation	Dementia	Varied	Social isolation is a risk factor for dementia.
Penninkilampi et al. (2018) [123]	Social isolation	Dementia	Varied	Social isolation is a risk factor for dementia.
Livingston et al. (2020) [123]	Social isolation	Dementia	Varied	Social isolation contributes to the risk of dementia.
Boss et al. (2015) [105]	Social disconnectedness, loneliness	Cognitive decline	Varied	Loneliness, but not consistently social disconnectedness, was associated with cognitive decline.
Evans, Martyr et al. (2019) [105]	Social disconnectedness, loneliness	Cognitive functioning	Varied	Adverse effects of loneliness on cognitive function.
Harrington et al. (2023) [105]	Social disconnectedness, loneliness	Cognitive decline	Varied	Inconclusive association between social disconnectedness and cognition; adverse effects of loneliness.
Kuiper et al. (2016) [99]	Social isolation	Cognitive decline	Varied	Association between social isolation and

				cognitive decline.
Hawkley & Cacioppo (2010) [105]	Loneliness	Cognitive performance, decline, dementia risk	Varied	Loneliness has profound consequences on cognitive health.
Okamoto & Kobayashi (2021) [105]	Social disconnectedness, loneliness	Cognitive reserve, functioning	Varied	Loneliness may limit cognitive reserve and functioning.
Stern (2002, 2012) [105]	Loneliness	Cognitive reserve, functioning	Varied	Loneliness may limit cognitive reserve and functioning.
Li et al. (2018) [105]	Social disconnectedness, loneliness	Cognitive decline	Varied	Social disconnectedness and loneliness may increase dementia risk in older Chinese immigrants.
Zhao et al. (2023) [105]	Social disconnectedness, loneliness	Cognitive decline	Varied	Social disconnectedness and loneliness may increase dementia risk in older Chinese immigrants.
Cassarino & Setti (2015) [105]	Social relationships	Cognitive functioning	Varied	Impact of social relationships on cognitive functioning can vary by neighborhood contexts.

Evans, Llewellyn et al. (2019) [105]	Social disconnectedness, loneliness	Cognitive reserve, decline	Varied	Social disconnectedness poses a risk for cognitive impairment; loneliness may contribute through biological, health behaviors, and psychosocial mechanisms.
Kuiper et al. (2016) [105]	Social disconnectedness	Cognitive impairment	Varied	Inconclusive findings on the association between social disconnectedness and cognition.
Holt-Lunstad et al. (2015) [3]	Social isolation, loneliness	Mortality	Varied	Social isolation and loneliness associated with increased risk of death.
Lam et al. (2021) [3]	Loneliness	Brain structure and activity, Alzheimer's biomarkers	Cross-sectional	Loneliness associated with abnormal brain structure and activity, and higher amyloid burden and tau pathology.
Sutin et al. (2020) [9]	Loneliness	Dementia risk, vascular risk factors	Longitudinal	Loneliness associated with increased risk of dementia and vascular risk factors.

Yang et al. (2020) [9]	Social isolation, loneliness	Cognitive impairment	Longitudinal	Social isolation and loneliness associated with cognitive impairment.
Ismail et al. (2021) [9]	Social isolation, loneliness	Cognitive functioning	Longitudinal	Deleterious effects of COVID-19 related social isolation and loneliness on cognitive functioning, especially in those with dementia.
Shankar et al. (2013) [9]	Social isolation, loneliness	Cognitive decline	Longitudinal	Social isolation, but not loneliness, associated with cognitive decline.
Cacioppo & Hawkley (2009) [9]	Loneliness	Cognitive impairment	Varied	Loneliness associated with more severe cognitive impairment.
Nummela et al. (2011) [9]	Loneliness	Self-rated health, cognitive functioning	Longitudinal	Loneliness may lower self-rated health, leading to reduced cognitive functioning.
Tomaszewski Farias et al. (2018) [9]	Loneliness	Stress reactivity, cognitive functioning	Longitudinal	Loneliness associated with augmented stress reactivity, affecting cognitive

				function.
Bennett et al. (2006) [99]	Social isolation	Memory, dementia	Longitudinal	Social isolation associated with poor memory and dementia.
DiNapoli et al. (2014) [99]	Social isolation	Cognition	Longitudinal	Association between social isolation and cognition.
Rafnsson et al. (2017) [99]	Social isolation	Onset of dementia	Longitudinal	Being not married and having low close contacts associated with dementia onset.
Wilson et al. (2007) [99]	Perceived isolation	Cognitive decline, Alzheimer's disease	Longitudinal	Perceived isolation associated with cognitive decline and Alzheimer's disease.
Andrew and Rockwood (2010) [99]	Social vulnerability	Cognitive decline	Longitudinal	Social vulnerability associated with cognitive decline.
Thomas (2012) [99]	Social engagement	Cognitive decline	Longitudinal	Low initial social engagement and decline over time associated with faster cognitive decline.

Table 5: Protective Factors and Interventions

Category	Examples	Mechanisms/Benefits	Snippet(s)
Social Support & Connectedness	Strong relationships with family and friends, active participation in social networks	Buffers negative effects of isolation on stress and cognition, promotes better cognitive functioning, reduces risk of cognitive decline	3
Meaningful Activities & Cognitive Stimulation	Volunteering, hobbies, learning new skills, arts and crafts, playing musical instruments, physical exercise	Maintains cognitive function, reduces loneliness, provides a sense of purpose, stimulates the brain	101
Psychological Therapies	Cognitive Behavioral Therapy (CBT), Mindfulness-based interventions, Interpersonal Psychotherapy, Group Therapy	Addresses maladaptive social cognitions, reduces negative thoughts about relationships, improves coping mechanisms, reduces loneliness and depression	7
Technology-Based Programs	Videoconferencing, telephone befriending lines, social media (mindful use), online communities, virtual programming	Maintains existing connections, creates new connections, overcomes geographical barriers, provides social support and a sense of community, can boost mood and cognitive health	138
Community-Based Activities	Joining clubs, attending community events, participating	Enhances social engagement, fosters a sense of belonging,	109

	in group hobbies, adult education, exercise classes, support groups	provides opportunities for interaction and support	

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