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# SuperAgers as a Clinical Model of Healthy Cognitive Aging

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**ABSTRACT**

SuperAgers are older adults, typically aged 80 years or older, who demonstrate episodic memory performance comparable to that of individuals decades younger. This phenotype has emerged as a clinically meaningful model of successful cognitive aging and resilience to neurodegenerative processes. The concept challenges traditional deficit-based frameworks of aging and highlights the marked variability of cognitive trajectories in late life. This narrative review provides a clinically oriented synthesis of current evidence on SuperAgers, focusing on their definition, cognitive profile, neurobiological correlates, protective factors, resistance to neurodegenerative pathology, and implications for clinical practice. Across studies, SuperAgers demonstrate preserved delayed recall and relatively intact performance across non-memory cognitive domains, alongside structural brain features consistent with reduced age-related atrophy. Functional imaging studies suggest preserved network integrity, while findings regarding neuropathology remain heterogeneous, with some individuals showing apparent resilience despite typical levels of amyloid or tau burden. Additional evidence points to the relevance of lifestyle and psychosocial factors, including physical activity, social engagement, and educational attainment, as potential contributors to this exceptional aging trajectory. From a clinical perspective, SuperAgers provide a useful reference framework for interpreting neuropsychological performance and identifying early deviations from optimal aging. Although variability in operational definitions and limited longitudinal data remain methodological challenges, the study of SuperAgers offers valuable insights into the mechanisms of cognitive resilience and may inform both clinical practice and future interventional research.

**Keywords:** SuperAgers, Cognitive Aging, Episodic Memory, Neurological Reserve, Brain Maintenance, Cognitive Resilience, Neuropsychology

## INTRODUCTION

Global population aging has substantially increased the clinical and public health relevance of cognitive decline and neurodegenerative disorders. Over the past two decades,

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demographic projections have consistently indicated a marked rise in the prevalence of dementia and related conditions, with Alzheimer's disease (AD) representing the most prevalent form [1-8]. Within this context, understanding the full spectrum of cognitive aging trajectories—including those at the favorable end—has become increasingly important for the development of preventive strategies and clinical benchmarks.

Cognitive aging is typically characterized by gradual, measurable changes in episodic memory, processing speed, and executive functions, even in the absence of explicit neuropathological disease [9,10]. These changes are largely attributable to structural and functional brain alterations associated with normal aging, including cortical thinning, white matter changes, and reduced synaptic density [11]. However, this process is highly heterogeneous, and not all older individuals follow the same trajectory. Variability in cognitive aging has been documented across multiple large cohort studies, suggesting that biological aging and cognitive decline are not synonymous and that individual differences in reserve, lifestyle, and genetics play a substantial moderating role.

Within this framework, a subset of older adults maintains cognitive abilities well into advanced age at levels comparable to those of much younger individuals. This observation has led to the emergence of the concept of "SuperAgers," a term introduced by Rogalski and colleagues at Northwestern University to describe older adults who demonstrate memory performance at or above the normative level of individuals 20 to 30 years younger [12]. Since its introduction, the SuperAger model has attracted considerable research attention as a framework for understanding cognitive resilience and optimal brain aging.

SuperAgers challenge deficit-based models of aging that conceptualize cognitive decline as an inevitable biological outcome of advanced chronological age. Instead, they exemplify a model of active brain maintenance, suggesting that preserved—or even youthful—cognitive function is achievable well into the eighth decade of life and beyond. From a clinical perspective, this phenotype is particularly relevant for differentiating normal aging from early pathological processes such as mild cognitive impairment (MCI) and early-stage Alzheimer's disease, conditions that share phenomenological overlap with typical aging but represent fundamentally different prognoses [13].

This review aims to provide a clinically oriented synthesis of current evidence on the SuperAger phenotype, examining cognitive, structural, and functional characteristics, as well as associated protective factors. The clinical implications of this model for neuropsychological assessment and patient counseling will also be discussed in this review.

## DEFINITION AND CLASSIFICATION

The operational definition of SuperAgers has evolved since its initial formulation but retains core principles across research groups. SuperAgers are most commonly defined as individuals aged 80 years or older who perform on standardized episodic memory tasks at levels equivalent to or above the mean normative performance of adults in their 50s or 60s [12]. The primary instrument used in the original Northwestern SuperAging Project criteria was the Rey Auditory Verbal Learning Test (RAVLT), with SuperAger classification requiring delayed recall scores at or above the mean for the 50–65-year normative group [12].

In addition to superior memory performance, SuperAger criteria typically require that individuals perform within normal limits—generally above the 10th percentile—across other major cognitive domains, including attention, language, and executive functions. This additional criterion ensures that the phenotype reflects global cognitive preservation rather than isolated memory strengths that may occur in the context of an otherwise declined cognitive profile [5]. A brief psychiatric screening is also recommended to exclude confounding affective or behavioral conditions.

Despite general agreement on core principles, considerable definitional variability exists across research groups and published studies. Differences have been documented in age thresholds, neuropsychological instruments used for classification, performance cut-offs, and the specific normative datasets against which older adults are compared (5). Researchers have applied less rigorous age criteria, including participants younger than 80, while others have extended the age range or used different delayed recall paradigms such as the Free and Cued Selective Reminding Test (FCSRT) or the Auditory Verbal Learning Test (AVLT) variants. A systematic review by Dang and colleagues highlighted these inconsistencies and their implications for cross-study comparability [5].

An important conceptual distinction relevant to clinical interpretation is that between SuperAgers and individuals



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with high cognitive reserve. Cognitive reserve refers to the capacity to maintain cognitive function despite the presence of underlying brain changes or pathology, often through the use of compensatory neural strategies [14]. SuperAgers, by contrast, are frequently characterized by preserved brain structure and reduced atrophy, suggesting that their exceptional performance may reflect active brain maintenance rather than compensatory function in the setting of structural loss [2]. However, these mechanisms are not mutually exclusive, and some SuperAgers may benefit from both [4,14].

From a clinical standpoint, the absence of standardized diagnostic criteria means that the SuperAger concept should currently be understood as a research framework and a useful clinical reference model rather than a formal diagnostic category. Ongoing efforts to standardize criteria across research groups may eventually support translation into standardized neuropsychological normative frameworks.

## COGNITIVE PROFILE

The defining cognitive feature of SuperAgers is exceptional episodic memory performance. Studies consistently demonstrate that these individuals perform on delayed recall tasks at levels statistically indistinguishable from those of cognitively healthy adults two to three decades younger, and significantly above the performance of age-matched peers [5,12]. This preservation is particularly notable given that episodic memory—specifically the encoding and delayed retrieval of new verbal information—is among the cognitive domains most sensitive to both normal aging and early AD-related neuropathological processes [9,10].

Beyond episodic memory, the cognitive profile of SuperAgers is generally characterized by preserved performance across multiple non-memory domains. Studies have documented intact or above-average functioning in semantic fluency, attention, working memory, and executive functions, including cognitive flexibility and inhibitory control [5]. This broader preservation distinguishes SuperAgers from individuals who may demonstrate isolated memory strengths attributable to high premorbid intelligence or specific cognitive training without corresponding general cognitive health.

Longitudinal data on cognitive trajectories in SuperAgers are informative. Studies tracking SuperAgers have documented that these individuals maintain stable performance on episodic memory measures and show slower rates of age-related cognitive decline compared to typical older adults [15,16]. Critically, this stability does not appear to represent a ceiling effect or measurement artifact, as it persists when assessed with instruments sensitive to subtle change. These longitudinal findings support the view that SuperAgers represent a genuinely distinct aging trajectory rather than individuals at an earlier stage on a common decline curve.

From a clinical neuropsychological perspective, the SuperAger cognitive profile provides a clinically meaningful reference point for understanding the upper range of normal cognitive aging. Awareness of this performance level can assist clinicians in avoiding the tendency to over-normalize mild memory complaints in older adults, particularly in settings where average-based normative data may obscure early deviation from an optimal trajectory [13]. It also underscores the importance of using age-stratified and education-adjusted normative data when evaluating older adults.

## NEUROBIOLOGICAL CORRELATES

Structural neuroimaging studies have identified several brain characteristics consistently associated with the SuperAger phenotype. Among the most replicated findings is reduced cortical atrophy compared to age-matched older adults, with some regions showing cortical thickness values more typical of individuals 20 to 30 years younger [1,2]. These differences are most pronounced in regions implicated in memory and higher cognitive function, including the anterior cingulate cortex, medial temporal lobe structures (particularly the entorhinal cortex and hippocampus), and lateral prefrontal areas [2].

Longitudinal neuroimaging studies have further demonstrated that SuperAgers exhibit slower rates of cortical thinning over time, supporting the concept of active brain maintenance as a neurobiological mechanism underlying their cognitive preservation [1]. Cook and colleagues reported that SuperAgers showed significantly reduced rates of cortical atrophy over a follow-up period of approximately 18 months compared to normally aging controls, with the most pronounced differences in the anterior cingulate and parahippocampal regions [1]. These findings are consistent with the hypothesis that SuperAgers are not simply cognitively intact at a single time point but are biologically aging more slowly at the neural structural level.

Functional neuroimaging studies have provided complementary evidence regarding network-level mechanisms. Functional MRI (fMRI) studies indicate that



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SuperAgers demonstrate preserved intrinsic connectivity within large-scale brain networks, particularly the default mode network (DMN), whose integrity is closely linked to episodic memory function [3]. Patterns of DMN connectivity in SuperAgers more closely resemble those of younger adults than those of age-matched equals, suggesting that functional network organization, in addition to structural preservation, contributes to the SuperAger phenotype [3]. A study by Keenan and colleagues documented enhanced connectivity between hippocampal and prefrontal nodes in individuals meeting SuperAger criteria [3].

## COGNITIVE RESERVE AND PROTECTIVE FACTORS

The concept of cognitive reserve provides a theoretical framework for understanding why some individuals maintain high cognitive performance despite aging or neuropathological burden. As originally proposed by Stern, cognitive reserve refers to the brain's capacity to cope with pathological processes through the dynamic use of pre-existing cognitive processes or recruitment of compensatory neural resources [14]. Reserve is thought to be accumulated throughout the life course through education, intellectually stimulating occupational activities, and engagement in cognitively demanding leisure activities.

SuperAgers tend to demonstrate characteristics consistent with high reserve. Studies have reported that SuperAgers are more likely to have higher educational attainment, histories of cognitively demanding professional careers, and greater engagement in cognitively stimulating activities in older age compared to typical older adults [5,6]. These associations are consistent with the reserve hypothesis, suggesting that lifelong intellectual engagement may contribute to the development or maintenance of the neural substrates that support exceptional aging [14].

Physical activity and cardiovascular health represent additional domains associated with preserved cognitive function in aging. Aerobic exercise has been linked to hippocampal volume preservation, angiogenesis, and elevated levels of brain-derived neurotrophic factor (BDNF), a protein essential for synaptic plasticity and neuronal survival [17]. Although direct evidence specifically in SuperAger samples is limited, available data suggest that SuperAgers engage in higher levels of regular physical activity compared to age-matched peers and report better overall cardiovascular health profiles [6]. These findings are consistent with broader evidence linking aerobic fitness to structural brain health in older adults.

Social engagement and psychological well-being have also emerged as relevant factors. Studies examining subjective well-being and personality traits in SuperAgers have documented higher scores on measures of positive affect, lower rates of depressive symptoms, and greater social network satisfaction compared to typical older adults [6]. The mechanisms through which social engagement may protect against cognitive aging remain to be fully elucidated but likely involve both psychological pathways—including reduced stress and enhanced sense of purpose—and neurobiological mechanisms related to the maintenance of network-level brain function.

Genetic factors also contribute to the SuperAger phenotype, although specific variants have not yet been definitively identified. The APOE ε4 allele, the strongest known genetic risk factor for late-onset AD, appears to be underrepresented in SuperAger cohorts relative to the general population, though sample sizes have been insufficient to draw definitive conclusions [4,5]. Emerging evidence suggests that genetic contributions to exceptional cognitive aging may involve variants related to synaptic function, inflammatory regulation, and neurovascular integrity [18].

## RESISTANCE TO NEURODEGENERATIVE PATHOLOGY

One of the most clinically significant and theoretically complex aspects of the SuperAger phenotype is its relationship to the neuropathological changes characteristic of Alzheimer's disease and related dementias. Amyloid plaques and neurofibrillary tau tangles, the histopathological hallmarks of AD, accumulate progressively with age in the general population, often decades before the onset of clinically evident cognitive impairment [19]. Understanding how SuperAgers respond to this accumulation—if it occurs—has important implications for both our understanding of AD pathophysiology and for the clinical utility of biomarker-based screening in cognitively preserved older adults.

Evidence regarding neuropathological burden in SuperAgers is heterogeneous. Some postmortem and in vivo imaging studies suggest that SuperAgers have lower amyloid and tau burden compared to age-matched individuals with typical cognitive performance, consistent with the hypothesis that their exceptional aging reflects genuinely reduced pathological accumulation [4,19]. However, a subset of SuperAgers in reported series has demonstrated amyloid or tau levels within ranges typically associated with preclinical or early AD in the broader population while continuing to

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perform at youthful cognitive levels. This dissociation between pathological burden and cognitive performance is a striking example of what is increasingly conceptualized as cognitive resilience—the maintenance of functional cognitive output in the face of neuropathological challenge [20].

The mechanisms underlying this resilience are not yet well understood but likely involve multiple interacting factors. Structural brain maintenance may provide a degree of reserve that delays the functional expression of pathology. Alternatively, SuperAgers may benefit from more efficient synaptic function, enhanced clearance of amyloid, or reduced neuroinflammatory responses that limit the consequences of pathological protein accumulation. Dominguez and colleagues, examining a cohort of cognitively high-performing older adults, reported that a proportion of top cognitive performers demonstrated significant Alzheimer-type pathology at autopsy while having maintained normal to superior cognitive function in life, supporting the existence of genuine pathological resilience rather than absence of pathology [4].

From a clinical perspective, this literature reinforces the importance of interpreting biomarker findings—including cerebrospinal fluid (CSF) amyloid and tau levels, amyloid PET, and tau PET—in the context of an individual's overall cognitive and functional profile rather than in isolation. The presence of biomarker positivity does not automatically imply imminent or inevitable cognitive decline, particularly in the context of exceptional cognitive performance and favorable structural imaging findings. Clinicians should be attentive to this complexity when communicating biomarker results to patients and their families.

## CLINICAL IMPLICATIONS

The SuperAger model has several meaningful implications for clinical practice in geriatric neurology, neuropsychology, and psychiatry. First, it provides a reference framework for understanding the upper range of cognitive performance achievable in late life, which can inform the interpretation of neuropsychological assessments in older adults. Standard normative data for neuropsychological tests are typically adjusted against population averages, which may lead to a normalization of performance levels that, in a specific individual, could represent early decline relative to their premorbid optimal trajectory. Awareness of the SuperAger performance range encourages clinicians to consider individual cognitive history when interpreting current performance and to use age-appropriate normative comparisons thoughtfully [13].

Second, the SuperAger model supports a paradigm shift toward earlier detection of cognitive decline by encouraging comparison not only with average aging trajectories but also with optimal ones. An individual who previously functioned at a high cognitive level but has declined to the population average may warrant closer monitoring and evaluation than current average-referenced criteria would suggest. Longitudinal cognitive tracking tools that capture within-person change may be particularly valuable in this context [16].

Third, the evidence on protective factors associated with the SuperAger phenotype provides a practical basis for patient counseling around modifiable lifestyle behaviors that may support cognitive health in aging. Physical activity, social engagement, cognitive stimulation, cardiovascular risk factor management, and adequate sleep are all supported by convergent evidence from the aging literature as potentially beneficial [17,6]. While no single intervention has been demonstrated to produce the SuperAger phenotype, these recommendations align with broader evidence-based guidelines for dementia prevention and healthy aging [8].

Fourth, the SuperAger model may contribute to the optimization of clinical trial design in the field of cognitive aging and dementia prevention. Identifying individuals with exceptional cognitive performance and studying their biological and lifestyle characteristics prospectively could yield novel insights into modifiable pathways that support cognitive resilience. Such data would be particularly valuable for the development of targeted preventive interventions in middle-aged and early older adults who have not yet manifested cognitive changes.

## LIMITATIONS AND FUTURE DIRECTIONS

Despite its conceptual and clinical value, research on the SuperAger phenotype remains subject to several important limitations that must be acknowledged in any synthesis of the evidence. First and foremost, the lack of standardized, consensus-based definitional criteria across research groups limits cross-study comparability and the generalizability of findings. Differences in age limits, neuropsychological test selection, performance cut-offs, and normative datasets result in heterogeneous samples that may not represent the same



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phenotype across studies [5]. The development of harmonized operational criteria represents a priority for the field.

Second, most existing SuperAger studies have been conducted in relatively small samples recruited through convenience or volunteer-based methods, which introduces selection bias and limits statistical power. Wealthier and more highly educated are probably overrepresented in many cohorts, raising questions about the generalizability of findings to diverse aging populations. Longitudinal cohorts with more representative sampling strategies are needed to address this gap [5,6].

Third, longitudinal follow-up periods in published SuperAger studies have generally been insufficient to characterize the long-term cognitive trajectory of these individuals with confidence. It remains unclear whether SuperAgers eventually follow typical aging decline trajectories at an advanced age, whether a subset progresses to MCI or dementia, and if so, whether the rate and pattern of decline differ from those of typical older adults. Extended follow-up studies with high retention rates and frequent cognitive assessments are necessary to resolve these questions.

Finally, the translation of SuperAger research into actionable clinical tools—such as revised normative frameworks that incorporate optimal aging trajectories or screening algorithms for identifying resilience profiles—represents an important but largely unaddressed practical goal. Interdisciplinary collaboration between researchers, clinicians, and regulatory organizations will be required to bridge the gap between research findings and clinical application.

## CONCLUSION

SuperAgers represent a compelling and clinically valuable model of healthy cognitive aging. Their preservation of episodic memory and other cognitive domains at youthful levels, sustained over time and accompanied by reduced cortical atrophy and maintained functional network integrity, provides important insight into the mechanisms by which the aging brain can resist both normative and pathological cognitive decline. The phenotype challenges reductionist models that conceptualize cognitive aging as a unidirectional decline and instead supports a view of late-life cognition as a dynamic interplay of biological, psychological, and environmental factors.

From a clinical perspective, the SuperAger model enriches the neuropsychological assessment of older adults by providing an upper reference point that complements population-average normative frameworks. It also supports the identification and promotion of lifestyle factors associated with cognitive resilience, including physical activity, social engagement, and ongoing intellectual stimulation. Although the field is constrained by definitional heterogeneity, sample size limitations, and the need for longer longitudinal follow-up, converging evidence from structural and functional neuroimaging, neuropathology, and cognitive science consistently supports the biological reality and clinical relevance of exceptional cognitive aging.

The study of SuperAgers holds considerable promise for identifying modifiable determinants of cognitive resilience and informing both preventive and therapeutic strategies in aging populations. A deeper understanding of why some individuals age exceptionally well may ultimately prove as instructive as the study of why others do not.

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