Cognitive and Neuroimaging Correlates of Financial Exploitation Vulnerability in Older Adults without Dementia: Implications for Early Detection of Alzheimer's Disease

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Introduction

Currently, one in nine older adults are living with Alzheimer’s disease (AD), and it is estimated that the costs related to AD will total over $1.1 trillion in 2050 if disease modifying treatments or disease prevention measures are not developed (“2021 Alzheimer’s Disease Facts and Figures,” 2021). However, AD treatment and prevention are complicated by the fact that brain changes associated with AD such as vascular dysfunction and the accumulation of AD pathology (β-amyloid plaques and neurofibrillary tau tangles) begin years, and possibly even decades, before cognitive changes are detectable on standard neuropsychological measures (Jack et al., 2013; Sperling et al., 2011; Zlokovic 2011). Accumulation of β-amyloid plaques are commonly followed by tau tangle deposition, neurodegeneration, and finally cognitive impairments which manifest clinically as AD (Jack et al., 2013). Given this long preclinical phase, identifying the earliest detectable signs of disease, before significant neurodegeneration has occurred, is a public health priority.

Financial exploitation vulnerability (FEV) due to impaired decision making has recently emerged as a potential early warning sign of future conversion to Mild Cognitive Impairment (MCI) and AD (Boyle et al., 2019). Thus, a thorough understanding of links between FEV, cognition, and brain health is important not only for identifying, empowering, and protecting older adults susceptible to financial abuse, but also for identifying individuals at risk for AD. Financial exploitation is the most common form of elder abuse (Amstadter et al., 2011; Lachs & Berman, 2011) resulting in an estimated loss of $3 billion to $36 billion annually (Roberto & Teaster, 2011; *The True Link Report on Elder Financial Abuse*, 2015). Despite the significant public health issue posed by this form of abuse, research on FEV in older adults is limited. Several studies have, however, investigated relationships between measures related to financial exploitation (e.g., self-report measures of scam-susceptibility, decision making measures, and reports of financial exploitation) and cognition (Boyle et al., 2012; Han et al., 2016a; James et al., 2014; Spreng et al., 2017; Ueno et al., 2021; Yu et al., 2021), neuroimaging markers (Han et al., 2016c; Lamar et al., 2019; Spreng et al., 2017; Weissberger et al., 2020a), neuropathology (Boyle et al., 2019; Kapasi et al., 2021), and incidence of MCI and AD (Boyle et al., 2019). This review summarizes the research associating FEV with cognition and brain health in older adults *without* dementia (i.e., cognitively healthy individuals and individuals with MCI), and proposes a theoretical model of FEV as an early behavioral manifestation of AD.

We begin with a short summary of the types of financial exploitation older adults may encounter, and highlight consequences of financial exploitation. Next, we review studies investigating the associations of various measures of FEV with cognition, neuroimaging markers, and neuropathological data. We then synthesize findings into a proposed theoretical model in which accumulating pathological brain changes (e.g., β-amyloid) impairs older adults' ability to engage in complex processes required for effective financial decision making (e.g., drawing on prior experiences, considering future outcomes, weighing options, making social judgments), thus increasing risk for financial exploitation. This leads to a discussion of clinical implications, including the possibility that FEV is a potentially sensitive, but not specific, behavioral indicator of underlying neuropathology characteristic of AD, signaling increased risk of conversion to MCI and AD. Finally, implications and recommendations for research will be discussed.

While the focus of the current review is on cognitive and neuroimaging correlates of FEV, it should be noted that there is also evidence for associations between FEV and gender, physical and mental health, and social and environmental factors. Briefly, greater FEV has been cross-sectionally associated with being male (Wood et al., 2016), increased frailty (Axelrod et al., 2020), lower levels of psychological well-being and social support (James et al., 2014), and higher levels of depressive symptoms (Beach et al., 2010; Weissberger et al., 2020b). Additionally, longitudinal studies have identified psychological vulnerability (i.e., depressive symptoms and low social-needs fulfillment) and interpersonal dysfunction (i.e., dissatisfaction with relationships and/or loneliness) as significant predictors of financial exploitation vulnerability in older adults (Lichtenberg et al., 2016; Lim et al., 2022). These findings underscore the importance of considering contextual factors related to FEV and highlight possible points of intervention to reduce FEV.

Financial exploitation of older adults

Consistent with previous definitions of financial exploitation (e.g., the Centers for Disease Control and Prevention's definition; Hall et al., 2016), we use the term financial exploitation to encompass instances when an older adult's resources are improperly used by a trusted other for the benefit of someone other than the older adult. We include financial fraud and scams in this definition because the older adult has a presumption of trust, although the scammer may be previously unknown to the victim (Wood & Lichtenberg, 2017). For example, in the "sweepstakes" scam, a perpetrator will attempt to convince an older adult that they have won a prize, which they can only collect after paying a fee. Although the perpetrator in this scenario is unknown to the older adult, the successful execution of the scam still relies on some degree of trust. Thus, we define financial exploitation as instances when an older adult's resources are improperly used by a trusted other, or by an individual previously unknown to the older adult who attempts to gain trust in order to engage in a scam or fraud.

Prevalence estimates suggest that financial exploitation is widespread and warrants further attention. In a study of financial abuse of individuals aged 60 or older, 5.2% of respondents reported current financial abuse by a family member (Acierno et al., 2010). A meta-analysis of 12 studies reported a financial fraud-scam 1-year prevalence of 5.6%, meaning that as many as one in 18 community-dwelling older adults are affected by financial fraud and scams every year (Burnes et al., 2017). The scope is likely even larger than these estimates suggest, as a study conducted in New York found that only one in every 44 incidents of financial elder abuse was reported (Lachs & Berman, 2011).

While older age itself does not necessarily make one more susceptible to financial exploitation, aging is often accompanied by factors that can make older adults attractive and vulnerable to perpetrators. From a practical perspective, older adults hold a significant portion of the nation's wealth (Agarwal et al., 2009). According to data from the federal reserve, the median net worth of older adults in the United States aged 65 and above in 2019 was over $200,000 (Board of Governors of the Federal Reserve System, 2020). Additionally, factors such as cognitive impairment, social isolation, and medical and functional impairments can confer greater FEV (Lachs & Han, 2015). In their framework of degraded rationality, Boyle et al. (in press) suggest that aging-related changes and declining brain health can result in impaired decision making, thereby increasing vulnerability to exploitation. When financial exploitation does occur, it can be particularly devastating due to the fact that older adults often live on fixed income and have limited opportunities to earn back lost funds and assets (Dessin, 1999). From a health perspective, financial exploitation is associated with poor mental health (Weissberger et al., 2020b), increased incidence of MCI and dementia (Boyle et al., 2019), and increased mortality (Lachs et al., 1998). These sobering facts and findings highlight the need to better understand the underlying mechanisms involved in financial exploitation of older adults.

Cognitive correlates

A large body of research on the associations of cognition and FEV comes from the Rush Alzheimer's Disease Center (RADC). The RADC utilizes a self-report measure of scam susceptibility that assesses the tendency to engage in behaviors associated with victimization, reasoning that higher scam susceptibility scores likely indicate an increase in one's risk of financial exploitation (James et al., 2014). The measure consists of five-items on which participants rate their agreement with statements using a 7-point Likert scale. The statements were created based on findings and statements from the American Association of Retired Persons (AARP) and the Financial Regulatory Authority Risk Meter (FINRA) (AARP, 1999; Financial Industry Regulatory Authority, 2013), and assess openness to sales pitches and risky investments, and awareness that older adults are often targeted by perpetrators. The measure has an intraclass correlation coefficient of 0.63, indicating moderate reliability.

To our knowledge, only one study to date has investigated longitudinal associations between cognition and FEV. In order to investigate whether increased susceptibility to scams and exploitation is a consequence of declining cognitive function, but not yet warranting a diagnosis of dementia, Boyle et al. (2012) utilized cognitive data collected from 400 community-dwelling participants (M(SD) age: 83.5 (7.4), 76% female, 89.3% non-Hispanic White) in the Rush Memory and Aging Project over an average of 5.5 years. Following the 5.5 years of annual cognitive data collection, participants completed an assessment of decision making (a 12-item version of the Decision-Making Competence Assessment tool designed to closely reflect real world decisions faced by older adults) and scam susceptibility (utilizing the measure described above). Analyses revealed that rate of cognitive decline was significantly associated with both decision making and scam susceptibility, with those declining more rapidly exhibiting poorer decision making and greater scam susceptibility. These associations remained even with adjustment for age, sex, education, and baseline cognition. Furthermore, even when the cohort was restricted to only those free from MCI (i.e., cognitively healthy older adults), associations remained significant. This suggests that subtle declines in cognition, prior to detectable signs of MCI and/or dementia, may result in impaired decision making and increased scam susceptibility, thus making older adults more vulnerable to financial exploitation. The authors of the study further posited that the impaired decision making and increased scam susceptibility observed in study participants with steeper declines in cognition may be a result of underlying neurological changes occurring in subclinical AD.

Cross-sectional findings have further supported an association between cognition and FEV. Utilizing the same measure of scam susceptibility, James et al. (2014) found that, in a sample of 639 community-dwelling older adults without dementia (M(SD) age: 82.4 (7.6), 76.8% female, 91.2% non-Hispanic White) enrolled in the Rush Memory and Aging Project, higher susceptibility to scams was significantly associated with worse global cognition, episodic memory, semantic memory, perceptual speed, and working memory. Global and domain specific cognitive scores were created from 19 standard neuropsychological tests, using z-transformations and averaging across the study sample. This was one of the earliest studies to investigate concurrent cognitive correlates of scam susceptibility in community dwelling older adults, and findings supported the notion that the subtle changes in cognitive functioning that can occur in the period prior to dementia diagnosis may put older adults at risk for financial exploitation.

These associations were replicated in a second cross-sectional study which looked at correlates of scam susceptibility in black, community-dwelling, older adults (Yu et al., 2021). The sample included 383 participants (M(SD) age: 77.7 (6.5), 82.3% female, 100% Black), 30.3% of whom were categorized as having MCI. Utilizing the same five-item, self-report measure of scam susceptibility and cognitive domain scores derived from 18 neuropsychological tests, poorer performance in all five cognitive domains (episodic memory, semantic memory, visuospatial ability, perceptual speed, and working memory) were significantly associated with higher scam susceptibility. When all five domains were included in a single model, only semantic memory and working memory were significantly associated with scam susceptibility. The study also found that the older adults with a diagnosis of MCI were significantly more susceptible to scams than the cognitively normal older adults. This confirmed findings from a prior study of 730 older adults (M(SD) age: 81.8 (7.6), 75.8% female, 91.9% White) which investigated the associations between scam susceptibility in the context of MCI and found that older adults with a diagnosis of MCI demonstrated significantly higher susceptibility to scams compared to cognitively normal older adults (Han et al., 2016a). Linear regressions conducted within the individuals with MCI revealed that worse global cognition and poorer performance within the domains of episodic memory and perceptual speed were associated with higher scam susceptibility scores. Together, these cross-sectional findings support the idea that susceptibility to scams is associated with cognitive performance in older adults free from dementia, and that these associations are stronger in individuals with MCI.

Notably, however, not all studies have found clear evidence for significant associations between FEV and cognitive correlates in older adults without dementia. In a study comparing 13 cognitively healthy older adults who had experienced financial exploitation (M(SD) age: 70.2

(5.9), 53.8% female) to 13 cognitively healthy older adults who had avoided financial exploitation (matched on age, gender, education, and global cognitive status), Spreng et al. (2017) found no significant differences in overall cognitive function, crystallized cognition, or fluid cognition (measured via the NIH Cognition Toolbox). Additionally, in a study investigating associations between self-reported scam vulnerability and cognition in both cognitively impaired (n = 50) and cognitively healthy (n = 51) older adults (M(SD) age: 76.1 (5.8), 52.9% female), Ueno et al. (2021) found no significant relationships between scam vulnerability and general cognition, inhibition, or executive function within the cognitively healthy group.

Taken together, the findings described above support the idea subtle cognitive changes prior to the diagnosis of dementia are associated with increased FEV. Studies that include older adults with MCI consistently report associations between cross-sectional measures of cognition and FEV (Han et al., 2016a; James et al., 2014; Yu et al., 2021). Evidence for an association between cognition and FEV in cognitively healthy older adults free from dementia and MCI is more equivocal. However, it should be noted that the studies explicitly excluding older adults with MCI have consisted of small sample sizes, thereby limiting their power.

In addition to low powered studies, another possibility for the lack of association between cognition and FEV in cognitively healthy older adults is that FEV may reflect declining functions that are not fully captured by traditional neuropsychological measures. For example, a dissociation between cognition and processes of decision making has been reported previously by Han et al. (2016b). In a sample of over 600 community-dwelling older adults (M(SD) age: 81.8 (7.6), 76.8% female, 93.3% White), 23.9% demonstrated a statistically significant difference between measures of global cognition and decision making (Han et al., 2016b). This suggests that, in older adults, cognition and decision making may be separate constructs. Given that standard neuropsychological measures do not seem to fully capture abilities involved in financial decision making (Damasio, 1996) and brain changes may precede functional behavioral changes by many years (Beason-Held et al., 2013), neuroimaging may be an effective way to detect FEV ahead of noticeable cognitive decline in older adults. Next, we will review the relevant neuroimaging literature.

Neuroimaging Correlates

A brief summary of implicated brain regions and networks will provide a framework through which findings of neuroimaging correlates of FEV can be interpreted. Decision making is a broad construct, so it is helpful to focus on specific aspects of decision making that are relevant to FEV. In their model of decision making in the aging brain, Samanez-Larkin and Knutson (2015) highlight the role of affective and motivational circuits and describe the importance of the nucleus accumbens and anterior insula for determining approach and avoidance behavior, and the medial prefrontal cortex (the anterior hub of the DMN) for evaluating more complex considerations (e.g., multiple options, reward likelihood). The authors also suggest the involvement of the medial temporal lobe-dorsolateral prefrontal cortex circuit in choices involving the integration of prior experiences.

The ways in which age-related changes in these brain circuits influence decision making can vary by context. For example, evidence suggests that older adults, compared to younger adults, show similar nucleus accumbens activity in response to gain anticipation, but exhibit lower levels of anterior insula activity in response to loss anticipation (Samanez-Larkin et al., 2007). Lower activation of the insula has also been associated with older adults rating untrustworthy faces as significantly more trustworthy and approachable compared to ratings by younger adults (Castle et al., 2012). Within the context of a financially risky task paradigm, older adults have been shown to make more mistakes than younger adults when seeking risk (i.e., selecting stocks), but not when avoiding risk (i.e., selecting bonds) (Samanez-Larkin et al., 2010). Increased variability of nucleus accumbens activity was associated with these age-related differences in risk seeking mistakes. These studies provide insight into how changes in neural circuits relevant to loss anticipation, evaluations of trust, and risky decision making may put older adults at increased risk for financial exploitation in the contexts of ambiguous gain and/or loss.

The default mode network (DMN), which includes the medial prefrontal cortex, lateral frontal cortex, medial parietal cortex, medial temporal lobe, lateral parietal cortex, and lateral temporal cortex, has also been implicated in decision making relevant to FEV (Spreng et al., 2016). While originally conceptualized as a network involved in passive thought, the role of the DMN in decisions that require drawing on prior memories, imagining future scenarios involving the self, and reflecting on the mental states of others is now widely accepted (Andrews-Hanna et al., 2014). Converging evidence for the importance of these processes in financial decision making has led researchers to hypothesize that changes in the DMN may serve as a biomarker for increased FEV (Spreng et al., 2016).

Structural correlates of FEV

A small but growing body of research on structural correlates of FEV in older adults free from dementia generally supports a central role of the DMN and insula. In a study of over 300 community dwelling, older adults (M(SD) age: 81.6 (7.3), 74.1% female, 88.5% White), voxelwise-based morphometry revealed a significant negative association between total grey matter volume and self-reported scam susceptibility, adjusting for age, sex, education and global cognition (Han et al., 2016c). Region-specific clusters were identified within the frontal and temporal lobes, with clusters in the right medial temporal lobe (parrahippocampal, hippocampal, fusiform) surviving adjustments for global cognition. Authors of the study highlighted the role of medial temporal lobe regions in the representation of past actions and outcomes in prospection, positing that disruption of these functions may explain the association between decreased grey matter volume and increased scam susceptibility. A study by the same group, investigating associations between white matter integrity (measured using diffusion tensor imaging) and scam susceptibility, also implicated the temporal lobe (Lamar et al., 2019). In the study of 305 non-demented community dwelling older adults (M(SD) age: 81.4 (7.5), 75.7% female, >95% non-Hispanic White), scam susceptibility was inversely related to white matter integrity within right temporal-parietal pathways and bilateral occipital-temporal regions, even after adjusting for global cognition. Finally, in a study by Spreng et al. (2017) that compared 13 cognitively healthy older adults who had experienced financial exploitation to 13 cognitively healthy older adults who had avoided financial exploitation, the financially exploited group exhibited reduced cortical thickness in the right anterior insula cortex and right posterior superior temporal cortices. Taken together, this research supports an association between FEV and both grey matter volume and white matter integrity in the right hemisphere.

Functional correlates

Two studies to date have investigated functional correlates of FEV in older adults free from dementia. In addition to investigating cognitive and structural correlates of financial exploitation, Spreng et al. (2017) also investigated functional connectivity differences between the older adults who had been financially exploited and those who had avoided financial exploitation. Older adults who had experienced financial exploitation displayed lower functional connectivity between the left anterior insula and other regions of the salience network (important for the detection of behaviorally relevant stimuli (Uddin, 2015)), and lower functional connectivity between regions of the DMN. The financially exploited group also exhibited higher across-network connectivity between the default and salience networks. These findings provided the first evidence that financial exploitation of cognitively healthy older adults is associated with alterations in neural connectivity.

In the second study to investigate functional correlates of FEV, Weissberger et al. (2020a) compared the functional connectivity of 16 cognitively healthy older adults who self-reported a history of financial exploitation (M(SD) age: 70.5 (13), 62.5% female, 68.8% non-Hispanic White) and 16 demographically matched older adults with no self-reported history of financial exploitation. Whole brain voxelwise analyses prespecified to the medial frontal cortex, hippocampus, and insula revealed between group differences in connectivity for all three regions, adding support to the possibility that altered network connectivity between the insula and between brain regions in the DMN may underlie FEV.

Neuropathological correlates & conversion to MCI and AD

Arguably the most convincing evidence in support of an association between FEV and AD comes from studies utilizing autopsy data. In the first study on this topic, Boyle et al. (2019) investigated the association between scam susceptibility and incidence of both MCI and AD in a sample of 935 community dwelling older adults (M(SD) age: 81.2 (7.5), 76.9% female, largely White) free from dementia at baseline. Over an average of 5.7 years, 255 participants went on to develop MCI and 151 developed AD. Proportional hazard models adjusted for age, sex, education, and global cognition revealed that higher scam susceptibility was significantly associated with incidence of both MCI and dementia. In the 264 deceased participants with neuropathology data available (some of whom had converted to MCI or AD), regression models were conducted to examine the relationship between scam susceptibility measured at baseline assessment and β-amyloid and tau measured post-mortem. Higher scam susceptibility was associated with a greater burden of β-amyloid in the brain, but not tau tangles. In region specific analyses, higher scam susceptibility was significantly associated with β-amyloid levels in the neocortex, entorhinal cortex, and hippocampus, and with tau tangles in the entorhinal cortex. Notably, the entorhinal cortex is one of the earliest sites of tau accumulation (Braak & Braak, 1991).

In the second study, the same group investigated the relationships of AD pathology (measured post-mortem) with decision making and scam susceptibility in a group of 198 older adults (M(SD) age at death: 90.2 (6.2), 68.7% female, largely White) free from dementia both at baseline assessment and post-mortem (Kapasi et al., 2021). As with the first study (Boyle et al., 2019), a higher burden of β-amyloid pathology but not tau tangles throughout the brain was significantly associated with higher scam susceptibility and lower decision making scores. Additionally, Phosphorylated transactive response DNA-binding protein 43 (TDP-43) pathology was significantly associated with scam susceptibility (Kapasi et al., 2021). These findings provide evidence that FEV may be sensitive to neuropathology even in older adults free from dementia.

FEV and AD risk

Together, the findings presented in this review point to the possibility that FEV is a very early behavioral manifestation of preclinical AD. Studies investigating cognitive correlates of FEV have reported associations between self-reported scam susceptibility and both global and domain specific cognition, particularly in older adults with MCI. The identification of associations between domains of semantic and episodic memory is particularly notable, as declines within these domains often occur early in the disease progression (Bäckman et al., 2005; Vogel et al., 2005). Furthermore, findings from Boyle et al. (2012) suggest that steeper rates of decline in cognition lead to increased FEV years later. This is important, as there is evidence to suggest that steeper declines in cognition among cognitively normal older adults also predict increased risk for dementia (Nation et al., 2019). Therefore, increased FEV may be a way in which these subtle declines in cognition, often failing to reach clinical significance on neuropsychological assessments, manifest behaviorally and can be detected.

Brain regions and networks implicated in findings from studies of neuroimaging correlates of FEV largely map onto the DMN, a known area of early β-amyloid accumulation (Buckner et al., 2005). Although β-amyloid is only modestly correlated with cognition measured via traditional neuropsychological assessment (Hedden et al., 2013), early β-amyloid accumulation within regions of the DMN is associated with alternations in functional connectivity even before neurodegeneration or clinically significant alternations in cognition occur (Hahn et al., 2019; Hedden et al., 2009; Palmqvist et al., 2017). We hypothesize that this altered connectivity may have downstream consequences on cognitive processes involved in financial decision making not typically captured through neuropsychological assessment. Neuroimaging studies have also pointed to a role of the insula in FEV. Although the insula is not known as an area of early β-amyloid accumulation, there is evidence that β-amyloid deposition is not limited to the DMN, but also occurs in brain regions high in connectivity (i.e., hubs) such as the insula (Grothe & Teipel, 2016).

Considering this limited but converging evidence, we propose a theoretical model in which FEV manifests as an early behavioral sign of underlying AD neuropathology, thereby signaling an increased risk for conversion to MCI and AD (Figure 1). We hypothesize that early neuropathological accumulation (e.g., β-amyloid) within the DMN results in disrupted neural connectivity between brain regions integral for effective decision making and avoidance of scams including, but not limited to, impression formation (Cassidy et al., 2013), assessment of risk (Han et al., 2012), value judgements of immediate versus delayed rewards (Han et al., 2013), and learning dependent decision making processes (Samanez-Larkin et al., 2014), thereby increasing FEV. Our specific focus on an association between FEV and β-amyloid stems from the observed associations between FEV and β-amyloid measured post-mortem (Boyle et al., 2019; Kapasi et al., 2021), the DMN's reputation as a site of early β-amyloid accumulation (Buckner et al., 2005), and evidence for the role of DMN in financial decision making (Andrews-Hannah et al., 2014; Spreng et al., 2016). However, it is likely that other pathological brain changes (e.g., vascular dysfunction) coincide with or even precede early β-amyloid accumulation and may be contributing to the observed association between FEV and β-amyloid. These β-amyloid independent brain changes warrant further investigation.

We suggest that early functional changes, in addition to structural changes, of brain regions relevant to decision making (e.g., the insula, medial temporal, and medial prefrontal structures), precede and contribute to subtle changes in cognition. Given the lack of association reported between cognition and FEV in studies of cognitively healthy older adults free from MCI (Spreng et al., 2017; Ueno et al., 2021) and the dissociation between cognition and decision making observed in some older adults (Han et al., 2016b), the relationship between cognition and FEV may vary across the course of preclinical AD. For example, the association between cognition and FEV may be present, but weaker earlier in the disease course. We hypothesize that cognitive changes (presumably driven by tau deposition and accumulating neuronal injury) occurring later in preclinical AD are more likely to influence decision making and FEV, as evidenced by stronger associations between cognition and FEV in samples that included participants with MCI (Han et al., 2016a; James et al., 2014; Yu et al., 2021).

Importantly, the model hypothesized above is based on limited data and should be interpreted cautiously. While we believe that FEV has the potential to serve as a valuable tool for identifying individuals in early stages of preclinical AD, there is also evidence for impaired DMN connectivity in healthy aging, independent of β-amyloid pathology (Andrews-Hanna et al., 2007) suggesting that FEV may be a sensitive but not a specific marker of preclinical AD. Therefore, important next steps will be the dissociation of neural changes indicative of preclinical AD from those seen in normal aging, and a determination of how each influence FEV. Additionally, because as many as 30% of cognitively normal 80-year-olds have high levels of β-amyloid in their brain (Jansen et al., 2015), longitudinal studies are needed to elucidate the clinical trajectories of cognitively normal, neuropathology positive individuals who exhibit FEV. Ultimately, it is unlikely that a behavioral measure of FEV will be sufficient to detect early preclinical AD. Rather, FEV may serve as one important piece of a risk profile.

Furthermore, many of the studies reviewed characterized FEV using a single 5-item self-report measure of scam susceptibility. The measure's specific focus on scams limits our ability to generalize findings to other types of FEV (e.g., being exploited of by a friend or family member) or to determine what degree of susceptibility might indicate a trajectory towards AD. We are aware of two studies that have reported relationships between FEV (characterized as self-reported financial exploitation) and structural brain regions and functional connectivity (Spreng et al., 2017; Weissberger et al., 2020a), lending support to the idea that the relationships between FEV and neuroimaging correlates extend beyond self-reported scam susceptibility. However, both studies had very small sample sizes. Therefore, it will be important to replicate the findings in larger sample sizes and to determine whether the relationships between FEV (measured via self-reported scam susceptibility) and cognition persist when using broader characterizations of FEV." Below, we highlight next steps for both clinicians and researchers.

Clinical implications

Clinicians (e.g., geriatricians, neuropsychologists, neurologists) are in a unique position to detect signs of FEV in older adults. The importance of early detection cannot be understated as it has the potential to: 1) empower older adults to avoid abuse, thereby helping them to evade devastating physical, mental, and financial consequences; 2) identify older adults who are at increased risk for MCI and AD, and at a point in the disease progression when intervention efforts may be most effective; 3) reduce public health costs associated with the severe health consequences of financial exploitation. Therefore, it is critical that clinicians assess for and attend to signs of FEV.

Assessment for FEV is complicated by the fact that standard neuropsychological assessments do not measure the function of some brain regions involved in social cognition and decision making (Damasio, 1996). As a result, it is recommended that clinicians utilize the clinical interview to assess for signs of FEV, and probe further when appropriate. The 5-item Susceptibility to Scams measure has been used in several robust research studies of older adults and may hold promise as a clinical measure. Lachs and Han (2015) provide a list of potential factors that are likely to contribute to Age-Associated Financial Vulnerability (AAFV), which clinicians may find useful as a framework for characterizing risk. Screening tools such as the Financial Exploitation Vulnerability Scale (FEVS), which consists of 17 self-report items shown to differentiate individuals who had been victims of financial exploitation from those who had not, may also prove useful (Lichtenberg et al., 2020). Additionally, the Lichtenberg Financial Decision Rating Scale (LFDRS; Lichtenberg et al., 2015) was specifically designed to take a person-centered approach to assessment of real-world financial decision making capacity. Regardless of the method used, it is important to balance a desire to protect with a respect for autonomy, and to avoid falling victim to the stereotype that old age is inherently associated with diminished financial decision making capacity.

In situations in which FEV is detected, it is important that older adults are provided with appropriate resources. For example, information on how to avoid and report financial exploitation which can be found on the Consumer Financial Protection Bureau, National Center on Elder Abuse, and Department of Justice websites (Consumer Financial Protection Bureau, 2022; National Center on Elder Abuse, 2022; The United States Department of Justice, 2021). Additionally, as evidence suggests that FEV may serve as an indicator of preclinical AD, clinicians may consider recommending a neuropsychological assessment, depending on the context in which the vulnerability is identified. However, given the limited and emerging nature of the evidence, all possible factors contributing to FEV should be considered (e.g., psychosocial and environmental factors). That is, clinicians should view FEV as a potentially sensitive, but nonspecific behavioral manifestation of preclinical AD. The determination of when to recommend follow up tests, and which might be most appropriate will therefore depend on a combination of knowledge of the research literature and clinical judgement.

Research implications

Given the early state of this research area and the compelling initial findings, there are many exciting questions left to pursue. In our opinion, three areas are of particular importance: 1) the development of neuropsychological and other measures sensitive to the integrity of brain regions and networks implicated in FEV; 2) longitudinal studies with concurrent measures of FEV and in-vivo AD pathology; 3) the investigation of relationships between FEV and other AD-associated pathologies. Additionally, because participants in the studies included in the current review, apart from Yu et al. (2021), were largely White, female and well educated, it is important to replicate the findings in more diverse cohorts. The future research endeavors described below must also include participants of diverse racial backgrounds, socioeconomic factors, and education levels. This will allow for the findings to be broadly relevant to the population. We now expand upon these three areas that we deem to be of critical research importance.

With regard to the first area, current neuropsychological assessments fail to capture the function of brain regions and networks implicated in social cognition and decision making (Damasio, 1996). As a result, individuals with neuronal injury to the medial prefrontal cortex (the anterior hub of the DMN) and/or insula can appear cognitively normal when assessed with standard cognitive batteries (Damasio, 1996; Gasquoine, 2014). When these subtle impairments in social cognition and decision making are missed, so too is the opportunity to intervene (e.g., provide appropriate resources, implement preventative strategies). Therefore, the development and validation of a neuropsychological measure sensitive to the functioning of brain regions and networks implicated in FEV should be actively pursued. Given accumulating evidence that FEV is a behavioral sign of underlying AD pathology, a validated neuropsychological measure of FEV could also be a significant contribution to the AD field. Relatedly, establishing validated clinical cutoffs for FEV according to various measures will be important to help identify those at greatest risk of experiencing financial exploitation. This will aid research studies focused on examining the link between FEV and AD as it will help classify those individuals most vulnerable to financial exploitation.

Longitudinal cohort studies with measures of both FEV and AD pathology will be critical to our understanding of the temporal relationship between neuropathology and FEV. While evidence from prospective cohort studies suggest that FEV precedes conversion to MCI and AD, the lack of in-vivo measurements of AD pathology limits our ability to infer directionality in the relationship between neuropathology and FEV. It is possible, for example, that some third unmeasured variable (e.g., social isolation or sleep disruption) explains the relationship. A longitudinal study with regular measures of FEV and AD pathology (via Positron Emission Tomography, cerebrospinal fluid, or blood) would help to determine whether increased neuropathology does indeed result in increased FEV and would allow researchers to explore the cognitive trajectories of those who do exhibit FEV. If such a study also collected fMRI data, disrupted connectivity within the DMN, or between the DMN and insula, could be investigated as a potential mediator of this relationship. These types of future studies may also elucidate whether FEV demonstrates linear or non-linear links to AD pathology. For example, longitudinal data would allow an investigation of whether there is an inflection point in the course of preclinical AD when FEV increases significantly. Longitudinal approaches would also facilitate the investigation of potential modifiers (e.g., lifestyle factors) of the relationship between AD pathology and FEV, which could have important implications for intervention efforts to reduce risk of financial exploitation in older adults.

Finally, studies investigating relationships between FEV and multiple other AD-associated pathological changes are needed. According to the two-hit hypothesis of AD, vascular risk factors resulting in blood brain barrier dysfunction and reduced cerebral blood flow represent the initiating step in the progression towards AD and contribute to the accumulation of β-amyloid (Zlokovic, 2011). Given the increasing evidence for a role of vascular dysfunction early in AD (Sweeney et al., 2019), it will be important to investigate associations between FEV and biomarkers of vascular dysfunction, in addition to the in-vivo measurements of other AD pathology described above. This will allow for a deeper understanding of the physiological mechanisms involved in the relationship between FEV and AD risk, and an investigation into potential additive or synergetic effects of various individual AD-associated pathologies on FEV.

Conclusion

In this review, we have summarized evidence for associations between FEV and: 1) cognition (measured via standard neuropsychological measures); 2) neuroimaging markers; and 3) neuropathological data in older adults without dementia. Much of this data supports a model in which pathological brain changes (e.g., β-amyloid accumulation) manifests behaviorally as FEV due to disrupted connectivity within the DMN, and between the DMN and other brain regions such as the insula (a key node of the salience network). However, much work remains to be done. Valid, reliable measures of the complex social and financial decision making processes involved in FEV are needed. Additionally, longitudinal studies with diverse samples and other

AD biomarkers are necessary. However, clinicians should not wait for these advancements before assessing for and attending to FEV given the significant impact on health, wellbeing, and independence of older adults.

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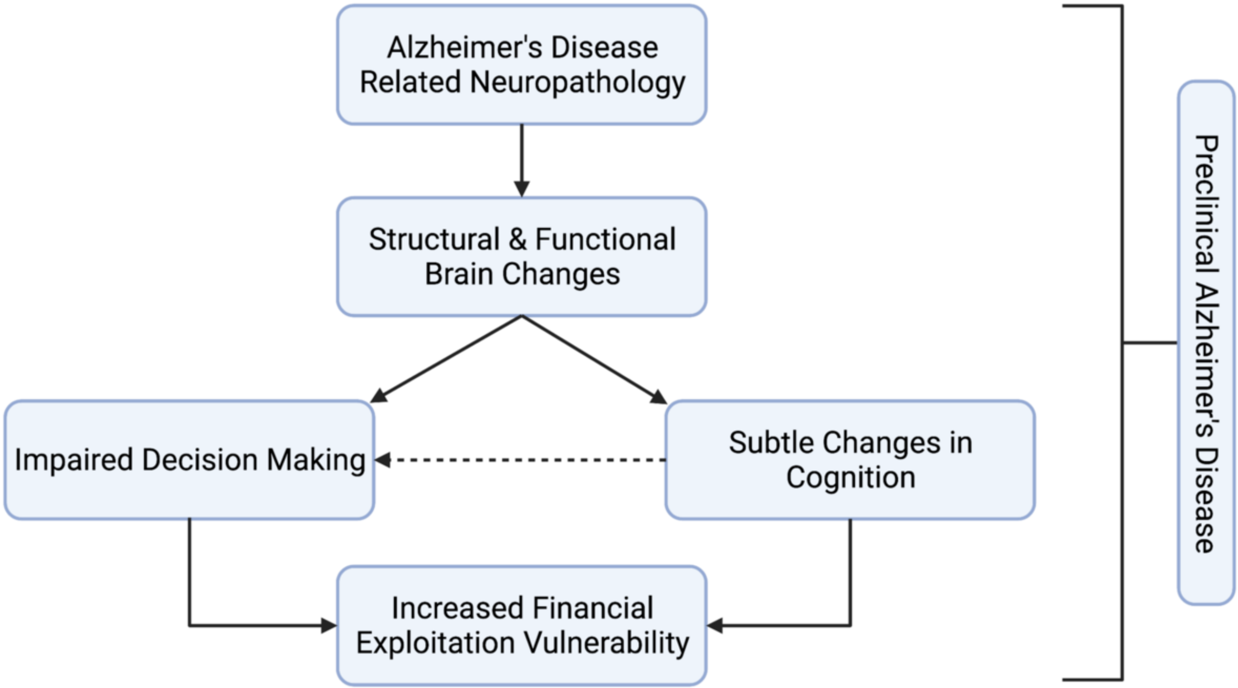
Figure Caption

Figure 1. Theoretical model in which financial exploitation vulnerability manifests as an early behavioral sign of underlying Alzheimer's disease related neuropathology


Alzheimer's Disease Related Neuropathology
Structural & Functional Brain Changes
Impaired Decision Making
Subtle Changes in Cognition
Increased Financial Exploitation Vulnerability
Preclinical Alzheimer's Disease