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Aging online: Rethinking the aging decision-maker in a digital era

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Introduction: the aging individual in cyberspace

An increasingly digitalized and globally connected world confronts the aging individual with drastically new decision-making contexts. The new challenges require a profound reconceptualization and reassessment of the aging decision-maker. This novel perspective is necessary to shed light on the aging individual in cyberspace, where the range of malicious activities perpetrated by malevolent actors is regrettably wide and, in many cases, triggered by poor decision-making, with often severe personal and societal consequences. Many of these threats involve deception in online communications that take place via email and, more recently, social media messaging platforms. These new media are expanding the cyberfraud ecosystem from the more conventional phone and phone text messaging scams and can result in the distribution of malicious software (e.g., ransomware) and spam, perpetration of scams, and manipulation of people's opinions via misinformation and fake news.

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Technology use can contribute to increasing social connectedness (e.g., keeping in touch with family and friends living away, forming new social networks; Hülür & Macdonald, 2020; Moore & Hancock, 2020) and can be crucial in today's tech-driven world (Isele & Rogoff, 2014). Older adults are relatively new to cyberspace (Anderson, 2019; Silver et al., 2019); and, even though getting larger in number and diversity of use as well as more comfortable online (Clement, 2020; Smith, 2014a, 2014b), they often still lack the experience necessary to use technology securely and are comparatively less experienced with digital devices as well as have lower confidence in their IT skills than young adults (Dyck & Smither, 1994; Marquié et al., 2002). Further, often they possess large assets accumulated over their lifetime and make consequential decisions for themselves and others. Together these factors may render them attractive targets for malevolent actors. This, combined with the wide spectrum of normal age-related declines in cognitive functions as well as changes in socioemotional capacities and neurobiological processes, may lead to poor decision-making online and may increase online victimization of seniors in the future. Surprisingly, however, older adults are still largely neglected in research on cybersecurity.

In this chapter, we argue that these emerging, fast-changing, modern world contexts require an extensive broadening of our view on the aging decision-maker. We propose that rethinking adulthood and aging in a digital era will open fascinating new opportunities to describe and study the aging individual and to equip them for successful and safe engagement with cyber-based resources. Toward this goal, this chapter presents literature on cognitive, socioemotional, and neurobiological influences on deception detection and fraud risk susceptibility; and integrates this information within a biopsychosocial model of the aging decision-maker in cyberspace. We integrate self-report, behavioral, and neurobiological research as well as lab-based and "in the wild" data collection methods to propose cyber-vulnerability profiles. We believe that this scientific knowledge integration is critically necessary to inform the design of tailored risk surveillance as well as fraud prevention solutions and support safe decision-making online for older adults.

Among older adults, losses due to fraud have reached epidemic proportions

In 2010, as many as 4% of older Americans fell victim to some form of financial fraud, with the majority of perpetrators strangers, costing older adults billions of dollars (MetLife, 2011). Despite these shockingly high estimates, these statistics likely underestimate the actual prevalence of elder financial exploitation[1] due to under-reporting, out of fear of appearing cognitively impaired or conforming to a negative aging stereotype (Federal Bureau of Investigation, 2016; Lachs & Berman, 2011; National Research Council, 2003). In fact, financial fraud represents one of the most common forms of elder maltreatment (Acierno et al., 2010; Amstadter et al., 2011; DeLiema, 2018; Peterson et al., 2014; Roberto, Teaster, & Duke, 2004; Wood & Lichtenberg, 2017). Combined with the rapidly growing proportion of older adults in many nations worldwide and the dramatic effects of adverse financial events in old age on health and independent living (Alexander et al., 2012; Button, Lewis, & Tapley, 2014; Carr, 2011; Dong & Simon, 2013a, 2013b; Karbach & Verhaeghen, 2014; Lantz, House, Mero, & Williams, 2005; Templeton & Kirkman, 2007; Weissberger et al., 2020), age-related decision-making deficits will bring devastating consequences for a large segment of the population, harming victims, the healthcare system, and the economy; rendering increased financial exploitation in the elderly a burgeoning public health crisis (Schwandt, 2014). This crisis will only worsen in the coming decades as the baby boomers, the wealthiest generation in American history, continue their march into older age and become a lucrative target population for fraud. Further exacerbating this already dire situation, an increasing number of older adults suffer from Alzheimer's disease (Matthews et al., 2019), a potent risk factor for financial exploitation (Lichtenberg, 2016; Marson, 2001; Marson et al., 2009; Sherod et al., 2009).

Modern deception and fraud increasingly occur online in the cyberspace

While undoubtedly the global digital connectedness of our modern world offers unprecedented opportunity in social, economic, and innovation spheres (Hülür & Macdonald, 2020; Moore & Hancock, 2020), these advances also come with considerable risk of cyberfraud. Online fraudsters have learned to deceive people into providing personal information, downloading malicious software, or bias their beliefs and knowledge using a host of social engineering techniques, which aim at influencing the individual, often against their best interest (Carr, 2011). The Federal Trade Commission (2020) and the Federal Bureau of Investigation (2020) warn that scammers increasingly use cyberplatforms, including email, websites, social media, and text messages, for their scams.

One such dangerous and costly type of modern cyberfraud is phishing—malicious messages distributed via diverse communication methods (e.g., email, text, phone) to influence an individual into a maladaptive action that will go against their best interests and will benefit the perpetrator. For email or text (SMS; smishing) phishing, this could entail fraudsters convincing older adults to click on a malicious link, open a malicious attachment, and/or provide personal information on fake websites. One of the classic types of phishing involves fraudsters contacting the victim and suggesting that there is something wrong with their checking account and that they need to provide their account number for resolution of the problem. Vishing (Ollmann, 2007) is phone-based phishing that often leverages advantages of new technologies (e.g., robocalls) to lure a victim into providing information that can then be used by the scammer for criminal activities such as identity theft. Typical consequences of falling for phishing for the victim include having their computer or device compromised by malware, personal information (e.g., passwords) or data stolen, and financial loss.

Phishing has become extremely popular as an attack vector because it is simple, effective, and difficult to trace, with immense costs to the individual and society. The consequences of acting on one scam phone call can result in a dramatic downward spiral of entanglement with fraudsters, sometimes over years. Similarly, a single click on just one phishing email or text message link can lead to extortion via malicious encryption of electronic information and other fraud. And despite technological solutions, such as spam filters and other automatized protections, many attacks evade detection, thus rendering these social engineering techniques extraordinarily common and dangerous.[2]

The COVID-19 pandemic has further highlighted potential risks from fraud and other cyberattacks, including among older adults (see also Han & Mosqueda, 2020 for a reflection on increased elder abuse in the COVID-19 era). In fact, there has been an alarming increase in phishing attacks impersonating the WHO and the Centers for Disease Control and Prevention (CDC) in attempts to take advantage during the COVID-19 pandemic. Also, robocalls have been one of the leading fraudulent behaviors during the COVID-19 pandemic (The United States Department of Justice, 2020). During social isolation, feelings of loneliness increase and people are turning to social media and online platforms to fulfill their social needs (Le Couteur, Anderson, & Newman, 2020) as well as perform activities of daily life (e.g., banking, submission of medical forms). This can be particularly challenging for older adults who have less digital and/or media literacy (Buckingham, 2019; Moore & Hancock, 2020), and thus are often less knowledgeable of suspicious cues in malicious messages (e.g., in phishing emails). Additionally, lower digital fluency can leave older adults more vulnerable to misinformation distributed via fake news on various social media platforms (Brashier & Schacter, 2020).

Human factors in cybersecurity research

Only recently has research on cybersecurity started to investigate human factors that contribute to greater online deception risks. This research suggests that the extent to which individuals use the internet (Moody, Galletta, & Dunn, 2017; Vishwanath, 2015; Vishwanath, Harrison, & Ng, 2018) and familiarity with the sender of deceptive messages (Benenson, Gassmann, & Landwirth, 2017; Jagatic, Johnson, Jakobsson, & Menczer, 2007) were associated with susceptibility to deception (Mohebzada, Zarka, Bhojani, & Darwish, 2012; Snyder, Reiter, & Kanich, 2016). This research has also shown that individuals are typically not aware of their susceptibility (Hong & Cha, 2013; Lin et al., 2019), which may render them even more vulnerable to fraud. In addition, greater susceptibility to phishing was associated with greater trust (Friend & Fox Hamilton, 2016; Uebelacker & Quiel, 2014), greater curiosity (Benenson et al., 2017; Moody et al., 2017), as well as higher commitment or obedience to authority (Workman, 2007). Phishing susceptibility has been shown to vary by gender (Hong & Cha, 2013; Jagatic et al., 2007; Sheng, Holbrook, Kumaraguru, Cranor, & Downs, 2010) and age, with older women constituting a particularly at-risk demographic (Lin et al., 2019). Ebner et al. (2020) further demonstrated that low cognitive functioning and low positive affect were associated with higher phishing susceptibility and lower susceptibility awareness observed among the oldest individuals in their study. However, older age so far has been largely neglected as a risk factor in research on cybersecurity.

Despite diverse and growing risks online, older adults have been largely ignored in cybersecurity research

The relative paucity of research on cyberfraud in later life is striking in light of evidence that deception detection may be particularly impaired among older adults (Carr, 2011; Stanley & Blanchard-Fields, 2008; Sweeney & Ceci, 2014). Reduced deception detection may be associated with general age-related decline across a broad range of fluid cognitive abilities, including processing speed, episodic, semantic, and working memory (Hedden & Gabrieli, 2004; Spreng & Turner, 2019; Verhaeghen & Salthouse, 1997). This decline leads to altered decision-making ability, leaving older adults vulnerable to false information (Jacoby, 1999) and deception (Boyle et al., 2012; Denburg et al., 2007; Han et al., 2016a; James, Boyle, & Bennett, 2014). Further, while sensitivity to untrustworthy information and deceptive cues declines with age (Bailey & Leon, 2019; Boyle, Yu, Schneider, Wilson, & Bennett, 2019; Castle et al., 2012;

Frazier et al., 2020; Frazier, Lighthall, Horta, Perez, & Ebner, 2019; Ruffman, Murray, Halberstadt, & Vater, 2012), this occurs in the context of increased interpersonal trust in older age (Bailey et al., 2015; Zebrowitz, Boshyan, Ward, Gutchess, & Hadjikhani, 2017; Zebrowitz, Franklin, Hillman, & Boc, 2013).

Importantly, fraud is transactional, involving decisions about potential losses and rewards, and detecting others' intentions. Thus, socioemotional changes in aging likely play a similarly important role as determinants of fraud susceptibility; however the contribution of these factors to fraud susceptibility remain largely understudied (Ebner et al., 2020; Spreng, Ebner, Levin, & Turner, in press; Spreng, Karlawish, & Marson, 2016). Finally, age-related cognitive and socioemotional changes occur in the context of changes in brain structure and function as well as neurotransmitter and hormonal changes both in normal aging and brain disease. While these neurobiological factors contribute to changes in decision-making, deception detection and trust, relatively little is known about their impact on financial exploitation risk, specifically in cyberspace.

Toward a biopsychosocial model of deception risk in aging

This idea of multifactorial influences contributing to susceptibility risk, i.e., a dynamic interplay between cognitive, socioemotional, and neurobiological influences on decision-making related to deception detection, is depicted in Figure 4.1. This *Biopsychosocial Model of Deception Risk in Aging* offers a multifaceted framework for organizing existing knowledge about influences on deception detection and can guide future work on the aging decision-maker, including in the unsafe cyberspace. Within the organization of this framework, leveraging from the broader field of deception detection research, we next reflect on interindividual differences in cognitive, socioemotional, and

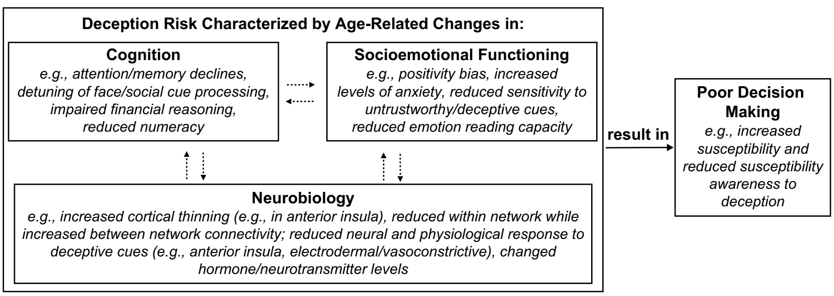

Figure 4.1 Biopsychosocial model of deception risk in aging.

neurobiological factors characterizing the human target/victim of deception. The goal is to identify risk profiles with relevance for improved surveillance and design of tailored decision-supportive solutions that counter fraud victimization in later life.

Cognitive, socioemotional, and neurobiological influences, and their interplay, on deception detection

Interindividual differences in cognition, socioemotional functioning, and neurobiology have been associated with the ability to detect deception and may impact fraud susceptibility. Current knowledge regarding these influences, and their dynamic interplay, has not yet been well integrated in research on the aging decision-maker, including in cyberspace.

Cognitive factors

One prominent model with relevance to decision-making, including in the context of deception detection, is the dual-processing model. This model proposes a quick and intuitive processing mode (called *System 1*) and a slow and deliberate processing mode (called *System 2*; Chaiken, 1987). System 1 is associated with reliance on cognitive heuristics when making decisions (i.e., mental shortcuts based on prior knowledge/beliefs; Evans, 2002, 2008; Kahneman, Slovic, & Tversky, 1982). System 2, in contrast, involves careful and systematic consideration of information. System 1 triages or streamlines decision-making, because the individual cannot permanently operate in System 2 as it is resource-intensive (Kahneman et al., 1982). The majority of everyday life decisions rely on System 1; which, however, can be flawed (Gilovich, Griffin, & Kahneman, 2002) and could lead to poor deception detection. For example, deception detection has been shown to decrease with increases in *truth bias*—the human tendency to believe that others are more likely to tell the truth than a lie (Bond & DePaulo, 2006; Kraut, 1980). Similarly, *confirmation bias* (i.e., the tendency to seek information that confirms one's views; Darley & Gross, 1983) was associated with poor deception detection.

The ability to process information at the intuitive level (System 1) remains relatively preserved, while deliberative processing (System 2) becomes less efficient with age (Drolet, Jiang, Mohammad, & Davis, 2018; Queen & Hess, 2010; Reyna & Brainerd, 2011). Relatedly, there is evidence of age-related decline in processing speed, working memory, and executive functions (Braver

& West, 2008; Lustig, Hasher, & Zacks, 2008; Verhaeghen & Salthouse, 1997) which limit information processing and decision-making associated with conscious deliberation in aging. In contrast, implicit and automatic processes (based on heuristics) remain relatively stable through later life (Peters, Hess, Västfjäll, & Auman, 2007; Zacks, Hasher, & Li, 2000). This greater reliance on System 1 over System 2 may increase susceptibility to deception in aging. Indeed, a recent study found that reduced conscious deliberation (measured via executive functioning ability) was associated with lower deception detection in older adults with the strongest associations observed in those individuals over 80 years (Calso, Besnard, & Allain, 2020).

Of note, while cognitive processes involved in financial capacities and exploitation among the elderly have been increasingly studied in more recent years (see Spreng et al., in press), the specific impact of cognitive influences on online fraud risk is still understudied (but see Ebner et al., 2020 for evidence that low memory function is associated with increased email-based phishing susceptibility among older individuals). Socioemotional influences on deception risk in aging have been the subject of even less inquiry, despite the transactional nature of deception and the likely role for these capacities in detecting, and therefore avoiding, deception.

Socioemotional factors

Various aspects of socioemotional functioning have been found to influence deception detection. Negative mood has been associated with enhanced deception detection: individuals with greater feelings of sadness and distress (dysphoric mood) compared to non-dysphoric individuals were better at lie detection (Lane & Depaulo, 1999). Similarly, negative mood increased, while positive mood decreased skepticism and deception detection (Forgas & East, 2008; Matovic, Koch, & Forgas, 2014; but see LaTour & LaTour, 2009). These results are consistent with findings that positive mood fosters reliance on System 1, while negative mood fosters reliance on System 2 (for reviews see Bless, 2001; Schwarz & Clore, 2003).

Furthermore, higher emotional intelligence, such as reflected in better perspective taking (Stewart, Wright, & Atherton, 2019), was related to enhanced deception detection (see also Riggio, Tucker, & Throckmorton, 1987; Wojciechowski, Stolarski, & Matthews, 2014), including improved lie detection (Ruffman et al., 2012). Emotional intelligence also partially mediated age-related differences in scam susceptibility, in that older participants who scored higher in emotional intelligence were more sensitive to risk and less susceptible to scams (Mueller, Wood, Hanoch, Huang, & Reed, 2020). In addition, low self-control was associated with higher likelihood of disclosing personal information, risk-taking, and responding to scam offers (Lee, 2014; Reisig, Pratt, & Holtfreter, 2009). It is possible that low self-control limits the ability to assess risk severity and personal risk vulnerability (Holtfreter, Reisig, Piquero, & Piquero, 2010).

Finally, personality factors more broadly influence deception detection. For example, individuals high on agreeableness were less proficient in deception detection in a task requiring identification of false memories (Campbell & Porter, 2002). In addition, high threat-sensitive individuals, who are generally suspicious and score low on agreeableness, were more accurate in lie detection than individuals low on threat-sensitivity (Ein-Dor & Perry, 2014).

While aging research has extensively addressed socioemotional functioning (Ebner & Fischer, 2014; Gutchess & Samanez-Larkin, 2019; Scheibe & Carstensen, 2010), comparatively little research exists on the role of these processes in financial exploitation risk in later life (Lichtenberg et al., 2016), and particularly in the realm of online fraud. Pioneering this field of research, Ebner et al. (2020) found that low positive affect was associated with increased susceptibility to phishing attacks among older individuals.

Neurobiological factors

Emerging literature suggests that neurobiological mechanisms, including psychophysiology, peripheral and brain chemistry, as well as brain structure/function play a role in deception detection.

Psychophysiology

The literature supports that interoceptive awareness—the ability to accurately read internal physiological signals (e.g., "gut feelings")—was associated with greater physiological reaction (e.g., arousal) to liars than truth-tellers, which in turn led to improved deception detection (ten Brinke, Lee, & Carney, 2019). Thus, individuals with greater interoceptive awareness may be better decision-makers, consistent with evidence in gambling paradigms showing a positive association between interoception ability and financial decision-making related to rejection of unfair offers in the Ultimatum game (Dunn, Evans, Makarova, White, & Clark, 2012; Kirk, Downar, & Montague, 2011).

Neurochemistry

Hormones can influence deception detection, possibly through their impact on risk-taking behavior (Apicella et al., 2008) and social processes (Bos, Panksepp, Bluthé, & Honk, 2012). For example, individuals with high levels of steroid hormones (specifically the sex hormones testosterone and estrogen) took greater financial risks than individuals with lower steroid hormone levels (Durante, Griskevicius, Cantú, & Simpson, 2014; Stanton, Liening, & Schultheiss, 2011; Van Honk et al., 2004; see Stanton, 2017 for a review). Increased levels of cortisol were associated with reduced risk-taking behavior (i.e., cortisol-related risk aversion; Hardy et al., 2014). This effect held for both financially disadvantageous (i.e., Iowa Gambling Task; Preston, Buchanan, Stansfield, & Bechara, 2007) and financially advantageous (i.e., Balloon Analogue Risk Task; Lighthall et al., 2012) risk-taking.

Increased levels of the neurotransmitters serotonin and dopamine reinforced impulsive and risky behavior under uncertainty (for a review see Rogers, 2011), which may impact deception detection and response to deceptive messages/scams. For example, higher serotonin levels were associated with increased preference for risky choices in gambling tasks (Heitland et al., 2012). Also, increased incidence of compulsive gambling in Parkinson's disease patients who take dopamine agonists supports dopaminergic involvement in risky decision-making (Dodd et al., 2005; Driver-Dunckley, Samanta, & Stacy, 2003).

The neuropeptide oxytocin has been associated with prosociality, including trust, and thus may play a role in deception detection. Intranasal oxytocin (compared to placebo) administration decreased the ability to correctly classify statements as truth vs. lie (Pfundmair, Erk, & Reinelt, 2017). Similarly, intranasal oxytocin reduced the ability to predict whether contestants in a TV show would cooperate or decline cooperation (Israel, Hart, & Winter, 2014). It appears that, more generally, oxytocin attenuates response to aversive social stimuli (see Ebner, Maura, MacDonald, Westberg, & Fischer, 2013; Grace, Rossell, Heinrichs, Kordsachia, & Labuschagne, 2018; Horta, Kaylor, Feifel, & Ebner, 2020; for overviews), such as angry faces (Quintana et al., 2016; Radke et al., 2017), fear (Kirsch et al., 2016), and social betrayal of trust (Baumgartner, Heinrichs, Vonlanthen, Fischbacher, & Fehr, 2008; Chen et al., 2016; de Dreu, Dussel, & Ten Velden, 2015; Frazier et al., 2020; Rilling et al., 2014; but see Chen, Gautam, Haroon, & Rilling, 2017; Nave, Camerer, & McCullough, 2015).

Role of brain structure and function. Evidence regarding neural substrates of deception detection has been derived primarily from patient case studies.

Winner, Brownell, Happé, Blum, and Pincus (1998) showed that patients with brain damage to the right hemisphere performed worse than healthy controls in distinguishing lies from jokes. Freedman and Stuss (2011) found that patients with lesions in medial frontal regions, particularly in the right ventral area, were impaired at deception detection. Right frontal regions are involved in social-cognitive abilities such as perspective taking and empathy (Happé, Brownell, & Winner, 1999)—processes relevant in deception detection. Ventral medial frontal regions may also be involved in deception detection given their strong connections with the amygdala and other limbic structures in emotion processing and emotion regulation (Motzkin, Philippi, Wolf, Baskaya, & Koenigs, 2015).

Neuroimaging studies in healthy participants further confirmed involvement of limbic and paralimbic brain regions in deception detection. The amygdala and the rostral anterior cingulate cortex, for example, were activated during judgement of deceptive intention (Grèzes, Frith, Passingham, & Grezes, 2004). Lissek et al. (2008) found that orbitofrontal and medial prefrontal regions were involved in the understanding of mental states of cartoon characters engaging in deception.

There is a very recent literature that specifically examines the role of brain structure and function on deception detection in aging. Supporting the link between age-related brain structural decline and risk for financial exploitation, older adults who had become victims of financial fraud in their real life had lower cortical volumes in insula and superior temporal regions than older adults who had successfully avoided exploitation. These exploited individuals also showed reduced connectivity within the default mode network, while they showed increased connectivity between the default mode network and the salience network (Spreng et al., 2017). These networks have been implicated in domains relevant to memory functioning (Andrews-Hanna, Smallwood, & Spreng, 2014), risky decision-making, particularly when ambiguity and doubt are high (e.g., financial decision-making; Asp et al., 2012; Denburg et al., 2007; Samanez-Larkin & Knutson, 2015), and impression formation (Cassidy, Leshikar, Shih, Aizenman, & Gutchess, 2013). Thus, structural and functional changes in brain regions implicated in these networks may be an indicator of reduced deception detection ability. Finally, there is evidence that older compared to younger adults have reduced insula activity to cues of untrustworthiness (Castle et al., 2012). This suggests that older adults may be less sensitive to deceptive cues, which could underlie poorer deception detection in aging (Frazier et al., 2020; Lin et al., 2019).

These influences of psychophysiology, brain chemistry, and brain structure/function on deception detection are likely exacerbated in pathological aging (Boyle et al., 2019; Han, Boyle, James, Yu, & Bennett, 2016b). For example, financial capacity has been associated with lower cortical volumes in the angular gyrus in amnestic mild cognitive impairment (often a precursor of Alzheimer's disease; Griffith et al., 2010) and medial and dorsal frontal cortex cortical volumes in early Alzheimer's disease (Stoeckel et al., 2013).

Challenges and frontiers for future research and practice

As evident from the breadth of literature reviewed here, perhaps the greatest challenge for future research in the area of aging and cyberfraud will be in constructing integrative, multifaceted fraud susceptibility profiles to guide early surveillance and intervention. Advances in this field will necessitate interdisciplinary collaboration spanning psychology, sociology, criminology, neuroscience, computer science, data science/machine learning, engineering, law enforcement agencies, policymakers, and other disciplines. This work will gain from integration of research on age-related changes in brain and behavior with research on decision-making in the cyber era. Ultimately these cross-disciplinary efforts will inform design of decision-supportive, real-life interventions, which are currently lacking, that adopt an age-tailored approach, as opposed to a "one-size-fits-all" solution, as different age groups might be targeted by different schemes and by different methods. The long-term goal of this emerging research agenda will be risk reduction of fraud in later life. In this spirit, we will conclude this chapter with a discussion of several lines of what we deem fruitful future avenues to promote understanding of the basic mechanisms underlying cyberfraud risk in aging and this research's practical impact.

Studying fraud susceptibility in the "wild"

There appears to be an important misconception in current research on fraud susceptibility—namely, that individuals are aware of their deception risks and would subsequently adjust their behavior in light of the anticipated risks they see themselves exposed to. This misconception emerges from previous research almost exclusively relying on self-report; which not only is based on the assumption that individuals have adequate insight/introspection but also often suffers from demand characteristics and other response tendencies. Thus, self-report can lead to artificial and static data and seems to result in lower estimates of susceptibility than behavioral (Lin et al., 2019) and in-lab (Grilli et al., 2021) assessments. Actual fraud and exploitation statistics, as noted above, as well as work on susceptibility in real life (Lin et al., 2019; Oliveira et al., 2019), depict a different situation, with high numbers of individuals falling for fraud, even repeatedly and despite training and advice; and a discrepancy between self-reported phishing susceptibility awareness and actual susceptibility behavior particularly among older adults (Lin et al., 2019). Some of this discrepancy could also be due to shame and embarrassment of admitting having become a victim as well as concern, especially among older individuals, that admitting to having been defrauded may lead to their independence being taken away. Further, emotional reaction, such as depression, might impact reporting among fraud survivors. This emphasizes the importance of anonymous as well as behavior-based examinations, and avoidance of exposing terminology (e.g., "fraud", "victim") in future research to derive at more accurate and convergent numbers.

Also, along these lines, moving forward it will be critical to thoroughly study susceptibility behavior to online fraud and deception "in the wild"; that is unobtrusive and takes place in the natural contexts of individuals' everyday lives. One challenge in this context is that while the total number of individuals who have fallen for fraud seems staggeringly high, the overall base rate is not that high. For example the most recent mass-market consumer fraud in the U.S. report showed that for the fraud with the highest prevalence (i.e., having paid for an item that was never received) only just over 7% of consumers experienced it during the year before they were surveyed (Anderson, 2019). This low base rate is making it difficult to spot and study associated naturalistic behavior, requiring very large samples of randomly chosen individuals to get useful results.

Research based on the Naturalistic Decision Making (NDM) framework (Klein, 2008; as an alternative to rational decision-making model; Kahneman et al., 1982) examined the quality of decisions made in fast-paced complex and often-dangerous situations by experts (e.g., fire fighters, military leaders) in real-world settings. Given that (online) fraud typically occurs in naturalistic, highly complex contexts and based on evidence that knowledge and expertise such as accumulated over the lifespan promotes successful decision-making (e.g., in the financial realm; Li et al., 2015), the NDM research approach may be fruitful in future study of the aging decision-making in cyberspace. This will require development of reliable and ecologically valid, openly accessible behavioral paradigms that allow the study of complex decision-making in aging, in fast-changing contexts (i.e., new threats arise or mutate continually, and before automatic detection and prevention is in place; e.g., zero-day exploits; Bilge & Dumitras, 2012; Zhang, Wang, Jajodia, Singhal, & Albanese, 2016).

Assessing intraindividual variability in fraud susceptibility

While the impact of interindividual differences on deception detection has been acknowledged, within-person variations are currently understudied. Cognitive aging research has shown that individuals vary in performance even over very short retest intervals (Hertzog, Dixon, & Hultsch, 1992; Li, Aggen, Nesselroade, & Baltes, 2001). Also, daily levels of negative affect predicted individual differences in cognitive interference among older adults, both between- and within-person (Stawski, Mogle, & Sliwinski, 2011). Thus, moving forward, the study of within-person variability on different aspects of functioning (i.e., cognitive, socioemotional, neurobiological) will advance understanding of susceptibility to online deception in aging, and will importantly inform prevention and defense solutions (e.g., closer surveillance and more frequent warning at certain times of the day).

Capturing the dynamic interplay between human targets and deceptive cues

Previous research has documented that deception detection depends on an interplay between characteristics of the human target and characteristics of the deceptive cues. For example, perceived similarity and greater familiarity between the sender and the receiver of a message improves deception detection, as found in Slessor, Phillips, Ruffman, Bailey, and Insch (2014), in that older adults were more confident in making judgments about the truthfulness of older compared to younger speakers. Certainly, any of these insights can be leveraged by fraudsters who likely adjust their practices to be the most effective (e.g., sending messages to victims from senders they are familiar with); thus requiring for successful defense practice to always be "a step ahead of the game".

Additionally, individuals who process information intuitively (i.e., low cognitive reflection) were more likely to change their attitude (Chaiken & Maheswaran, 1994) and detect deception (e.g., fake news; Pehlivanoglu et al., 2021) when information was provided from a reputable source (i.e., news article paired with a reputable source outlet such as the *Washington Post* as opposed to a non-reputable outlet such as True Pundit). Of course, in the context of fraudulent offers, it is important to keep in mind that the fraudster is attempting to appear reputable since no one will fall for the attack if they understand that it is malicious. Therefore, techniques such as impersonation, where the fraudster engages in an act of pretending to be somebody else (e.g., a reputable business or a bank), are frequently used for the purpose of fraud; or utilizing reputable outlets for distribution of misinformation (e.g., politically misleading newspaper fliers in the *Miami Herald* during the 2020 presidential election). These techniques that leverage human target and deceptive cue characteristics and their interplay need to be specifically targeted in successful warning and defense solutions moving forward.

In the context of aging, older adults have been shown to prioritize positive over negative information ("positivity bias"; Carstensen, Mikels, & Mather, 2006; Reed, Chan, & Mikels, 2014), while young adults prioritize negative over positive information (Baumeister, Bratslavsky, Finkenauer, & Vohs, 2001; Rozin & Royzman, 2001). Thus, it is possible that older adults are more likely to fall for particularly positively-framed deceptive messages (i.e., gains) but are less vulnerable to negatively-framed messages (i.e., loss); a hypothesis that future research will be able to test. We propose that future research on online fraud susceptibility that considers this dynamic interplay between human and deceptive cues characteristics will be crucial to advance effectiveness of warning and training solutions.

Tailored training and design of decision-supportive tools

Automated detection (e.g., spam filters) alone has proven insufficient in mitigating exploitation (e.g., phishing), as they are never perfect (Dada et al., 2019) and also because new, undetected threats reach the human target before defense solutions can be implemented (Bilge & Dumitras, 2012; Zhang et al., 2016). Rather effective defense solutions need to involve human decision-making capacity. Typical current trainings for the human Internet user include educational games (Arachchilage & Cole, 2016; Sheng et al., 2007), simulated phishing attacks (Caputo, Pfleeger, Freeman, & Johnson, 2014), embedded techniques (such as short trainings immediately following successful simulated phishing attacks; Kumaraguru, Cranor, & Mather, 2009; Kumaraguru et al., 2007; Mohebzada et al., 2012), and provision of training literature/warning examples (Zielinska et al., 2014). Habituation (Egelman, Cranor, & Hong, 2008; Richards, 2020), overconfidence (Kumaraguru et al., 2007), and/or forgetfulness (Caputo et al., 2014), or even just the ability to reach older adults (and other vulnerable target populations), however, limit effectiveness of these trainings, and longer-term risk reduction has not yet been achieved.

We argue that a better matching between trainee characteristics and training content/scheme is warranted. For example, evidence from cognitive training research, that supports older adults' benefit from spaced and multi-session training (Baltes & Baltes, 1993), should inform the scheduling scheme of phishing training programs for older adults. It is even possible that novel training techniques using brain stimulation and neurofeedback, which directly change brain–behavior connections (Sitaram et al., 2016) and have recently been implemented among older adults (Rana et al., 2016), are fruitful in protecting against online risks. Certainly, any such future training approaches need to consider the lack of cues commonly present in interpersonal interactions such as voice / intonation, body language, and microexpressions (DePaulo et al., 2003; Zuckerman, Kernis, Driver, & Koestner, 1984), which further challenge deception detection in cyberspace.

Finally, one of the most important tasks for future research is to generate reliable fraud susceptibility profiles that can inform who is at particular risk and needs to be targeted in interventions. These approaches could benefit from leveraging our proposed biopsychosocial model of the aging decision-maker to assure multifaceted nature of the profiling. Moving forward, clinical tools (e.g., interviews and questionnaires that are intended to assess susceptibility to various scams and underlying cognitive / socioemotional mechanisms; see Spreng et al., in press) as well as rigorous statistical and novel machine-learning methodology will be crucial in this effort toward comprehensive risk profiling, effective risk surveillance, and design of decision-supportive tools for older adults to counter online fraud.

For example, age-tailored defense solutions could be developed to offer on-the-spot warning about potentially deceptive online messages (in SMS, email, social media platforms) using natural-language and image-based machine-learning algorithms. These applications should apply user-friendly, age-tailored designs and could be specifically based on individual risk profiles (e.g., more frequent and explicit warnings for users at higher risk). Such personalized automated cueing has tremendous potential to assist in the decision-making process, reducing the burden of detecting deception for the individual.

Conclusions

Cyberfraud risk continues to grow as individuals navigate through a complex computerized, connected world. Though evidence is still mixed, older adults may be a particular target of deception online with risks for this population likely further increasing in the future. They have (often large) assets accumulated over a lifetime that they increasingly manage online, while being lower in computer literacy, decision-making capacity, sensitivity to deception cues, as well as experiencing various socioemotional and neurobiological changes (e.g., positivity bias). But although older adults constitute a fast-growing segment of the population in many nations worldwide, older adults, and those among them with age-related pathology, are currently neglected in cybersecurity research. With this chapter, we have offered a reflection and integration of the multifactorial influences on online fraud susceptibility, introducing a biopsychosocial framework within which the aging decision-maker in a fast-developing digital era can be better understood.

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Notes

1 Elder financial exploitation (i.e., committed by individuals in positions of trust) and elder fraud (i.e., committed by predatory strangers) constitute two forms of financial victimization in older adults (DeLiema, 2018) that are used interchangeably for the purpose of this chapter.

2 Also highly prevalent, but not separately addressed in this chapter, are mass-market consumer frauds, where consumers are deceived into purchasing deceptively promoted goods and services (e.g., see Anderson, 2019). This fraud also quite frequently occurs online, with 62% of fraudulent goods purchased through the internet (Anderson, 2019). While mass-market consumer fraud is distinct from phishing, for the purpose of this chapter a differentiation between these two concepts is not necessary.

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