

Article

Opportunity Costs, Cognitive Biases, and Autism

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Abstract: Do individuals with autism overlook opportunity costs? Using an AI-generated simulation rather than human-participant data, we explore whether a model-based association can be generated between opportunity-cost processing, cognitive-bias parameters, and simulated RAADS-R scores. Cognitive biases can severely distort the accurate calculation of opportunity costs, which is essential for making optimal decisions by clearly understanding the trade-offs involved in pursuing a particular course of action. In turn, biased information processing may contribute to developmental disorders such as autism that are marked by difficulties with social interaction, communication, and restricted or repetitive behaviors. We developed a 20-question scale to assess the neglect of opportunity costs, targeting specific cognitive biases, and compared the results with the RAADS-R autism scale. In this particular AI-generated dataset, higher raw opportunity-cost questionnaire totals co-varied with higher simulated RAADS-R totals. Because the two sets of item responses were independently generated, this association is hypothesis-generating and should not be interpreted as evidence about human participants or clinical autism.

Keywords: autism; autism spectrum disorder; opportunity costs; cognitive biases



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1. Introduction

Opportunity cost refers to the potential benefits an individual, investor, or business misses out on when choosing one alternative over another. It represents the value of the next best alternative that is forgone in making a decision. Essentially, it is what you give up in order to pursue a certain option. The concept of opportunity cost is fundamental in economics and decision-making, as it helps to ensure that scarce resources are allocated efficiently.

The ability to assess opportunity costs has shaped human decision-making throughout history. Early *Homo sapiens* likely made decisions that involved trade-offs between different survival strategies, which would have carried direct implications for their fitness and reproductive success. However, while these evolutionary adaptations were advantageous in the Pleistocene, modern decision-making involves more complex and abstract choices, particularly in environments where fast, intuitive thinking (System 1) is often less effective than slower, more deliberate thinking (System 2) [1,2]. As a result, understanding how opportunity cost neglect manifests in individuals today, particularly in populations with unique cognitive profiles like individuals with autism, has significant implications for fields like psychiatry, economics, and social policy. Here, we assume that cognitive biases [1,3,4] can severely impair the accurate computation of opportunity costs in today's world, which is crucial for making optimal decisions by considering what must be given up to pursue a certain course. Identifying cognitive biases in opportunity cost evaluations can help

develop better decision-making frameworks, improve public policies, and design inclusive environments that account for neurodiversity.

The classic and foundational remarks on opportunity costs include those by Wieser [5], Marshall [6], Samuelson [7], Hayek [8], Solomons [9], and Mas-Colell et al. [10]. Wieser was one of the first economists to openly describe the concept of opportunity cost, sometimes known as the “cost of foregoing”. His work paved the way for future theoretical developments. However, before Wieser, the concept of opportunity cost was shaped and gradually developed by Cantillon, von Thunen, Ricardo, Mill, Patten, Macvane, Green, and Davenport [11]. Marshall’s textbook explored in greater detail opportunity costs in the context of economic behaviors and decisions. Samuelson incorporated opportunity cost into mainstream introductory economic analysis. Hayek showed how price mechanisms account for opportunity costs and aid in the effective allocation of resources without centralized control. Solomons’ work was precise in addressing how opportunity costs influence production and commercial decision-making, offering a comprehensive accounting approach. Mas-Colell et al.’s textbook is a graduate economics standard that extensively covers the implications and applications of opportunity cost. Classic references on opportunity costs also include Alchian [12], Buchanan [13], Nozick [14], and Becker et al. [15]. Recent research has looked into many aspects of opportunity costs. These include health system opportunity costs [16], local health service spending [17], economic drivers of legume production [18], resource constraints and competing projects during competitive bids [19], the role of profit calculation in manufacturing contexts [20], credit evaluation [21], and firm asymmetries [22]. In biology, opportunity costs have been used to map the economic costs and advantages of conservation [23] as well as achieving conservation [24].

Opportunity costs are frequently neglected when consumers are not explicitly reminded of them during decision-making processes, leading to inefficient outcomes [25]. Cognitive biases can distort an individual’s perception of reality, leading to the misinterpretation of information, and decisions become rationally bounded [1,3,4]. Opportunity cost neglect, influenced by various cognitive biases, can itself be considered a cognitive bias. For example, to accurately assess the opportunity costs of a purchase, consumers must actively generate the alternatives that it would replace. However, many consumers fail to do so [25]. Cognitive biases might be at play here. When opportunity costs are made more explicit, individuals’ willingness to buy consumer goods typically decreases [25–27]. This implies that people generally overlook opportunity costs, leading to suboptimal and less efficient decision-making in both personal and public contexts. A meta-analysis indicates that while the impact of opportunity cost neglect across different areas is smaller than initially thought, it remains a robust bias [28].

Consideration of opportunity costs is a fundamental principle of choice [29]. However, both theoretical and empirical evidence indicate that opportunity costs are overlooked in practice because they are implicit at the decision-making stage [30–32]. Opportunity cost neglect has been studied in healthcare priority-setting and public policy decisions, showing significant variations in its impact across different domains [33]. This bias in public policy can lead to an artificially high demand for public spending. Furthermore, both high-income and low-income consumers exhibit an equally strong decrease in willingness to buy when reminded of opportunity costs, indicating that both groups neglect opportunity costs [30]. This finding contrasts with the notion that low-income individuals, due to budget constraints, should be more likely to spontaneously consider opportunity costs because of their increased focus on trade-offs. Opportunity cost neglect can influence criminal punishment judgments, because the costs associated with convictions can affect participants’ recommendations [34]. This indicates that the implications of opportunity cost neglect extend beyond consumer choices, impacting legal and judicial decisions. Additionally, a

study on the effect of opportunity cost salience on repeated evaluations of options, such as experience and consumption goods, found that continuous reminders of opportunity costs are necessary to sustain their impact in repeated decision-making scenarios [35]. This finding suggests the need for persistent and context-specific interventions to counteract opportunity cost neglect over time.

According to the cognitive model of psychosis, biased information processing may be the cause of psychotic symptoms [36]. This model implies that individuals with full psychotic symptoms [37] and sub-threshold symptoms [38] are more vulnerable to cognitive biases [39]. Similarly, we propose that developmental disorders characterized by challenges with social interaction, communication, and restricted or repetitive behaviors, such as autism, may also stem from biased information processing. These neurodevelopmental disorders, marked by social cognitive deficits, could originate from biased interpretations of social information, leading to interpersonal difficulties.

In sum, studies have shown that the neglect of opportunity costs can lead to suboptimal decision-making, as individuals often fail to accurately assess trade-offs in various scenarios, from consumer behavior to legal judgments. However, research specifically examining how these biases manifest in individuals with autism spectrum disorder (ASD) remains limited. While there is a growing body of work exploring decision-making in autistic individuals, much of it focuses on areas such as social cognition, risk aversion, or executive functioning. Few studies have directly investigated how autistic individuals process opportunity costs or whether they are more prone to neglect these costs due to cognitive biases.

Some research suggests that individuals with ASD exhibit a heightened focus on specific details and may struggle with broader decision-making processes that require weighing multiple options or considering long-term consequences. For example, autistic individuals show less susceptibility to framing effects, which suggests they approach decision-making differently than neurotypical individuals [40]. Additionally, the cognitive profiles of autistic individuals, particularly in relation to executive function, may impact their ability to assess trade-offs and think flexibly about alternative courses of action [41]. These characteristics suggest a potential predisposition toward neglecting opportunity costs, as opportunity cost assessment requires the ability to generate and evaluate alternatives, a cognitive process that may be more challenging for those with autism. Despite these indicators, there has been no comprehensive exploration of this potential relationship.

Opportunity cost neglect may have a particular impact on individuals with ASD, whose cognitive profiles include unique processing styles that favor a specific detail orientation and systematic approaches [40]. While these traits can reduce susceptibility to certain biases, such as the framing effect, they may also restrict flexibility in evaluating alternative options—an essential aspect of opportunity cost assessment. Exploring this intersection of opportunity cost neglect and autism not only broadens our understanding of cognitive biases but also holds the potential for improving decision-making frameworks and policy interventions tailored to neurodiverse populations [35,41].

Although the studies reviewed above support our hypothesis that individuals with ASD may be inclined to neglect opportunity costs due to cognitive biases, alternative perspectives in the literature offer a different view. Some research proposes that autistic individuals' ability to thoroughly analyze specific information without being distracted by irrelevant details could, in fact, help them evaluate trade-offs between different options more effectively. The cognitive strengths associated with autism, such as systematic thinking and reduced susceptibility to biases like the framing effect, might enable autistic individuals to assess opportunity costs with greater accuracy, especially in structured decision-making scenarios [41]. However, these strengths may not consistently apply to more abstract or emotionally influenced decisions, where greater cognitive flexibility is

required. Therefore, while certain cognitive traits in autism may enhance decision-making in some situations, the overall effect of these traits on opportunity cost evaluation remains uncertain and merits further exploration.

By focusing on opportunity cost neglect in individuals with autism, this study fills a critical gap in the literature. Our research contributes to the understanding of how autistic individuals approach economic decision-making, particularly in terms of trade-offs and resource allocation. Furthermore, it addresses the broader implications of cognitive biases in this population, offering insights into how these biases might affect decisions in everyday contexts, such as financial choices, career planning, and social interactions. This study also aims to provide practical applications by suggesting interventions that can help mitigate the effects of cognitive biases on decision-making in autistic individuals, with potential benefits for education, workplace inclusion, and public policy.

ASD is a multifaceted neurodevelopmental disorder distinguished by distinctive strengths and differences, as well as difficulties in social interaction, communication, and repetitive behaviors [41,42]. The classification of autism has evolved over time, and its understanding is multi-dimensional. In medical contexts, autism is commonly classified as a mental disorder [43]. This classification is used primarily in diagnostic contexts to describe the varied ways in which autism manifests, often focusing on the challenges or impairments associated with it. However, autism may also represent a form of cognitive evolutionary adaptation [44]. This perspective posits that certain autistic traits, such as heightened focus and detailed-oriented thinking, may have been advantageous in certain environmental contexts or contribute to human diversity and innovation. This view appreciates the strengths that autistic individuals can bring to a community. Furthermore, autism can be seen as a lack of adaptation to the social and sensory environments typical of modern society, which often does not cater to the needs of autistic individuals. This does not necessarily imply a negative view but highlights the mismatch between individual neurology and societal norms or expectations.

However, ASD may influence survival and reproduction through various behavioral, social, and communication challenges associated with the condition. Speculating on these impacts requires a careful consideration of both biological and social factors. For example, one of the core features of autism is difficulty with social interactions, which can impact the formation of social bonds that are crucial for survival in communal living situations. Historically, humans have relied heavily on social groups for mutual aid in gathering food, defense against predators, and other survival-related activities. For individuals with autism, challenges in social reciprocity and the potential for social isolation could have made these cooperative dynamics more difficult. Moreover, many individuals with autism experience heightened sensory sensitivities, such as hypersensitivity to sounds, lights, or tactile sensations. In an evolutionary context, such sensitivities might have been a double-edged sword. On one hand, heightened sensory awareness might have led to an increased awareness of environmental cues, like the approach of predators or changes in the natural landscape. On the other hand, overwhelming sensory input could lead to avoidance behaviors, limiting exposure to the varied experiences and opportunities necessary for survival. In addition, communication impairments and difficulty with social cues can also impact the formation of intimate relationships and finding a mate, which are essential for reproduction. The social complexities of mating behaviors, including interpreting subtle cues and engaging in socially expected interactions, could be more challenging for individuals on the autism spectrum. It is important to note that autism is also associated with unique cognitive strengths in some individuals, such as enhanced pattern recognition, attention to detail, and deep focus on areas of interest. These traits could have been advantageous in certain evolutionary contexts, such as tracking, hunting,

gathering, or creating detailed art or tools. These specialized skills could compensate for social and sensory challenges in some environments. In short, while autism might present certain impairments in terms of traditional evolutionary pressures like survival and reproduction, it is also accompanied by a set of strengths that could have been selectively advantageous in specific contexts. The diverse manifestations of autism mean that its impact on survival and reproduction would vary widely among individuals. This might explain why evolutionary pressures did not eliminate autism.

In modern society, many of the survival pressures of the Pleistocene are no longer present, and the challenges faced by individuals with autism may be different. Today, survival often depends more on navigating complex social systems and less on immediate environmental threats. Modern medical care, social services, and increased societal awareness about autism can help mitigate some of the challenges associated with ASD. Autism, with its unique attributes and diversity of skills, can be highly beneficial in various aspects of modern society. For example, many individuals with autism possess exceptional abilities in pattern recognition, memory, and concentration. These skills are particularly useful in fields such as data analysis, software development, and scientific research, where precision and attention to detail are crucial. The ability to notice anomalies in datasets or focus intensely on coding tasks for extended periods can lead to innovations in technology and science. Furthermore, autism often brings a different perspective to problem-solving, which can lead to novel solutions that might not be immediately obvious to neurotypical thinkers. This cognitive diversity is invaluable in creative industries, including design, art, and multimedia. In strategic roles, such as in business development or organizational strategy, this unique perspective can lead to innovative approaches that improve efficiency. In addition, individuals with autism often excel in tasks that require consistency and adherence to rules or patterns. This makes them particularly adept in roles that might be seen as repetitive or highly structured, such as administrative support, archiving, or assembly line work in manufacturing. Their precision and ability to maintain focus without distraction are assets in any work environment that values accuracy and order.

The inclusion of individuals with autism in the workforce encourages a broader culture of diversity and acceptance. Organizations that actively engage in creating inclusive work environments for people with autism often benefit from lower turnover rates and higher employee satisfaction. Furthermore, these inclusive practices can enhance the company's reputation, making it more attractive to a diverse range of customers and potential employees. In particular, the technology sector has recognized the unique abilities of many individuals with autism, leading to the creation of specific programs to recruit neurodiverse talent. Companies like Microsoft and SAP have pioneered autism hiring programs, which not only provide valuable employment opportunities but also tap into the strengths that individuals with autism can bring to highly technical and innovative fields.

Understanding how individuals with autism learn and process information has influenced educational methodologies and training programs. This deeper understanding helps tailor educational approaches that benefit a wider range of learning styles, thereby improving educational outcomes not only for individuals with autism but for all learners. Therefore, autism can be viewed through a lens of neurodiversity that recognizes different neurological conditions as variations in human cognition rather than deficits. This perspective highlights that individuals with autism bring valuable and unique contributions to society, particularly in environments that value diversity and harness the strengths of all individuals. If our hypothesis that individuals with autism find it difficult to ignore opportunity costs is confirmed, this information can be leveraged to better integrate these individuals into a neurodiverse culture.

In today's environment, the pervasive cognitive bias of FOMO—the fear of missing out (as discussed later)—has paradoxically weakened our ability to focus intentionally. In an age where digital stimuli and abundant opportunities continuously vie for our focus, many individuals find themselves distracted by the constant lure of alternative engagements, making it difficult to fully commit to a chosen task [45]. By contrast, the focused attentional style often observed in autistic individuals may serve as a compensatory strength. This capacity to concentrate despite the barrage of competing stimuli minimizes the disruptive effects of FOMO—a skill that would have been less relevant in the relatively constrained decision-making landscape of the Pleistocene. Thus, while FOMO can lead to decision paralysis and fragmented attention in the neurotypical mind, the tendency of autistic individuals to “tune out” irrelevant alternatives may offer a unique advantage in navigating today's complex economic and social choices. Thus, if individuals with autism are prone to neglect opportunity costs, this inclination may actually function as an adaptive advantage by lessening the disruptive impact of FOMO in today's world.

Beyond characterizing autism as a multifaceted neurodevelopmental condition, it is useful to view it within a broader continuum of related disorders. Evolutionary psychiatry provides a framework in which traits associated with autism—such as heightened attention to detail and focused processing—are seen as part of a spectrum of cognitive and social adaptations. Similar adaptive trade-offs may be present in related conditions, including ADHD and schizophrenia spectrum disorders, where both strengths and vulnerabilities emerge from the interplay of genetic, environmental, and social factors. This integrative view suggests that these disorders are not entirely distinct entities but rather represent variations in the balance of adaptive traits shaped by our evolutionary history [44]. This expanded conceptual model enriches our understanding of neurodiversity and lays a foundation for future research exploring the shared and unique mechanisms underlying these conditions.

The RAADS-R is a self-report screening instrument that may assist the clinical assessment of adults suspected of ASD; it is not a stand-alone diagnostic tool [46]. The RAADS-R addresses a gap in the diagnostic toolkit for adults, particularly those with higher-functioning ASD. By enhancing the questions and adding sections on sensory-motor dimensions and limited interests, the RAADS-R improves upon its predecessor, the Ritvo Autism Asperger Diagnostic Scale [47], increasing both diagnostic sensitivity and specificity. The scale was administered to a diverse cohort of 779 participants from three continents, including both individuals diagnosed with ASD and comparison groups. The RAADS-R's diagnostic efficacy was further supported by its high sensitivity (97%) and specificity (100%) in distinguishing ASD from non-ASD participants. Additionally, it showed exceptional internal consistency and test-retest reliability. Therefore, the RAADS-R is a valuable adjunctive instrument for clinicians who are evaluating ASD in adults. It is particularly useful in diverse clinical settings due to its robust international validation. The development of this scale is a reflection of the ongoing changes in the psychiatric diagnostic landscape, particularly the merging of Autistic and Asperger's Disorders into a single category of ASD by the DSM-V criteria. This points out the necessity of diagnostic tools that are both precise and adaptable to evolving standards [47].

Previous evidence suggests a more complex relationship. Autistic traits may reduce susceptibility to certain biases and improve consistency in structured decisions, while cognitive rigidity or restricted attentional focus may affect the evaluation of alternatives in other contexts. The relationship between autistic traits and opportunity-cost processing should therefore be treated as an open empirical question. Therefore, we hypothesize the following:

Hypothesis: *Simulated autistic-trait scores may be associated with systematic differences in opportunity-cost processing, although the existence and direction of this relationship remain to be established in human ASD and neurotypical samples.*

To test this hypothesis, we developed a 20-question scale designed to assess the neglect of opportunity costs, with each question targeting specific cognitive biases that might predispose individuals to overlook these costs. We then used the established RAADS-R autism scale for comparison. Our hypothesis suggests that respondents who score low on the opportunity cost scale, due to these cognitive biases, are likely to score higher on the RAADS-R, indicating that their decision-making biases align with traits typically observed in the autism spectrum.

Therefore, in addition to our primary hypothesis that autistic individuals tend to ignore opportunity costs, we put forward specific predictions. First, within the simulated dataset, we examine whether simulated RAADS-R totals co-vary with simulated opportunity-cost questionnaire totals. This model-based prediction does not imply clinical ASD status or describe an empirically observed human population. Second, there will be a significant positive correlation between the degree of opportunity cost neglect and the severity of autistic traits. Third, specific cognitive biases—such as present bias and status quo bias—are expected to mediate the relationship between autistic traits and opportunity cost neglect.

We anticipate that our study will reveal a significant relationship between autism and opportunity cost neglect, with individuals on the autism spectrum showing a higher likelihood of overlooking alternative options in decision-making scenarios. However, given the unique cognitive strengths associated with autism, such as attention to detail and systematic thinking, our results may also show that these individuals perform better in specific structured decision-making tasks. The broader implications of this research could extend to refining educational strategies, improving workplace accommodations, and informing public policy to better support decision-making processes in neurodiverse populations, particularly those with autism.

The potential practical significance of these findings is substantial. By understanding how individuals with autism process opportunity costs, this research could contribute to more effective educational approaches tailored to the cognitive strengths of and challenges faced by people with ASD. For example, educational programs could emphasize teaching methods that help individuals on the spectrum better recognize and evaluate trade-offs in decision-making. Moreover, the insights from this study could improve workplace inclusion efforts, particularly by helping employers design roles and environments that leverage the unique cognitive profiles of autistic individuals while minimizing decision-making biases. In public policy, this research could inform the creation of policies that promote inclusivity and neurodiversity by acknowledging the specific ways that individuals with autism approach economic decisions, leading to more equitable outcomes in areas such as employment, healthcare, and financial literacy. Overall, the findings could pave the way for interventions that support autistic individuals in navigating complex decision-making contexts, ensuring better personal and professional outcomes.

Based on our previous discussion, individuals with autism may possess other abilities that compensate for their potential tendency to neglect opportunity costs. These compensatory strengths, such as enhanced attention to detail or heightened pattern recognition, could mitigate the impact of cognitive biases in certain contexts. Therefore, when evaluating the decision-making capabilities of autistic individuals regarding opportunity costs, it is essential to adopt a comprehensive perspective that acknowledges both their potential challenges and unique strengths. This holistic approach not only deepens our

understanding of autism but also underscores the importance of tailoring interventions that leverage these strengths in education, workplace inclusion, and public policy.

The remainder of this paper is organized as follows: Section 2 describes the materials and methods, Section 3 presents the results, Section 4 discusses the findings, Section 5 outlines the study's limitations, and Section 6 concludes the paper.

2. Materials and Methods

2.1. AI-Driven Experiment

We employed online AI tools and computational simulations to generate hypothetical parameter values and model-based questionnaire responses for exploratory hypothesis development. No questionnaires were administered to human participants, and the generated responses should not be interpreted as estimates of how real individuals would respond [48]. ChatGPT calibrated hypothetical parameter values for cognitive biases based on a comprehensive review of behavioral economics and cognitive psychology literature. Specifically, our prompts included predefined numerical ranges and weight factors (e.g., 0.1 to 0.5 for biases like overconfidence and anchoring) drawn from consensus estimates in prior studies. ChatGPT generated its predictions by drawing on its extensive training on online sources, books, journals, and research, relying on published findings, theoretical models, and empirical studies across multiple disciplines.

To ensure transparency, we detail our methodological choices: we used a chain-of-thought prompting strategy via the ChatGPT web interface (version 4o) to guide the model step by step rather than using a single-shot approach, and academic papers were uploaded as references to align outputs with the existing literature. Additionally, independent replication by the different authors under identical conditions was performed to verify the consistency of the results, and all robustness tests were conducted independently of the AI after the study's completion. Detailed information on these parameters and methodological choices is provided in the Python 3.12 code available at Figshare.

It is important to acknowledge that while our experiment exclusively uses data generated by ChatGPT to parameterize and simulate responses, such AI-driven outputs cannot fully encapsulate the multifaceted nature of real-world decision-making. Factors such as cultural background, individual life experiences, and momentary emotions play critical roles in shaping behavior—elements that our current model does not incorporate. Accordingly, our study is positioned as an exploratory, hypothesis-generating effort, with future work planned to integrate real-world data and alternative AI models to enhance its ecological validity.

Although our study relies solely on ChatGPT for data generation, it is important to emphasize that the outputs are grounded in a comprehensive body of established knowledge rather than reflecting isolated idiosyncrasies. ChatGPT synthesizes information from a wide range of literature in cognitive science and behavioral economics, thereby supporting the observed relationships between cognitive biases, opportunity cost neglect, and autism. Nevertheless, we recognize the limitation inherent in using a single model and suggest that future studies include multiple models to enhance the robustness and generalizability of the findings.

2.2. Questionnaires

After examining opportunity costs with ChatGPT 4o, we directed it to create a 20-question survey (Table 1). Subsequently, we instructed the AI to identify cognitive biases related to each question that might hinder participants from considering opportunity costs (Table 2). In our study, we employed a prompt engineering strategy to target specific cognitive biases in the opportunity cost questionnaire. To guide ChatGPT in identifying

and associating relevant biases with each survey question, we supplied it with a PDF file containing data from the Wikipedia page on the list of cognitive biases (https://en.wikipedia.org/wiki/List_of_cognitive_biases) (accessed on 20 March 2025). This approach helped ensure that the detection of biases was systematic and consistent with established theoretical frameworks. Compared to traditional methods that rely on expert assessment or manual coding, our method offers a reproducible and transparent alternative for bias identification. Each simulated case was assigned an item score from 1 to 5, corresponding to the questionnaire’s Likert response categories from strongly disagree to strongly agree. An assignment of a cognitive bias to each of the 20 questionnaire items most likely affects one participant’s fast System 1 response to that particular question. This lowers an answer on the Likert scale.

Table 1. Opportunity costs questionnaire.

1. I consider what I might miss out on financially by choosing a more expensive vacation over a less costly one.
2. When deciding to go back to school, I think about the income I could lose by not working during this time.
3. If I choose to renovate my kitchen, I assess the alternative ways I could have used the money.
4. I evaluate the benefits of accepting a higher-paying job that requires longer hours against staying in my current position with more free time.
5. When considering paying for a gym membership, I think about other health improvements I could invest in with that money.
6. I weigh the cost of buying tickets to a concert against what else I could do with the money.
7. Before buying the latest smartphone, I consider what else I could achieve with the funds needed for the purchase.
8. I compare potential returns from investing in stocks to other investment vehicles like bonds or real estate.
9. When choosing to invest more in my retirement, I contemplate the immediate lifestyle changes I would have to make.
10. Before deciding whether to replace my current vehicle, I distinguish unrecoverable past spending on its purchase, repairs, or maintenance from the future costs and benefits of keeping versus replacing it.
11. As a business owner, I consider the opportunity costs of expanding my business versus investing the funds elsewhere.
12. When choosing between public and private schooling for my children, I think about the financial impact of each option.
13. I assess the benefits of taking out a loan for a major purchase versus saving up and buying it later.
14. I evaluate whether attending a social event is worth the time and money compared to other potential activities.
15. When deciding to eat out frequently, I consider the savings I could amass by cooking at home instead.
16. When offered a job in a new city, I think about the cost of living and social changes compared to my current situation.
17. I weigh the costs and benefits of spending money on personal development courses versus self-study.
18. I consider the impact of donating to one charity over another, based on what each contribution could achieve.
19. I evaluate whether subscribing to multiple streaming services is worth the expense over other entertainment options.
20. I think about what I might gain or lose by spending my time on one activity over another.

The item-to-bias associations are provisional theoretical mappings generated with AI assistance; they have not been established through expert validation or psychometric testing and should not be interpreted as exclusive classifications.

It is important to acknowledge that a full psychometric evaluation of the new scale (Table 1) was not conducted. In particular, reliability measures such as internal consistency and test–retest reliability were not assessed due to the reliance on simulated data. We recognize that establishing reliability is a necessary precursor to a comprehensive evaluation of validity. Future research will focus on obtaining real-world data to rigorously examine the reliability and, subsequently, the validity of the scale.

We utilized the RAADS-R [45] for the ASD test (Table 3). The RAADS-R is a self-report questionnaire designed to identify adults with subclinical autism, particularly those whose mild symptoms often lead to an undiagnosed condition. It is intended for adults aged 16 and older who are suspected of having ASD level 1 or subclinical autism and have a normal-range IQ (≥ 80) [46]. The RAADS-R assesses developmental symptoms across three DSM-5 categories—language, social relatedness, and sensory–motor—and includes an additional subscale for circumscribed interests. The questionnaire comprises 80 statements, with four response options for each: “true now and when I was young”, “true now only”, “true only when I was younger than 16”, “never true”. Scores range from 0 to 240. A score over 64 suggests a likelihood of autism, as no neurotypical individuals have scored higher in studies [45]. Scores below 65 indicate a lower likelihood of autism, though further testing is recommended for a definitive diagnosis. For 63 of the statements, the scoring is

as follows: 3 points for “true now and when I was young”, 2 points for “true now only”, 1 point for “true only when I was younger than 16”, 0 points for “never true”.

Table 2. Cognitive biases associated with the questions in Table 1.

1. Vacation planning	Present bias [49]: Prioritizing immediate enjoyment over financial savings.
2. Higher education	Loss aversion [50]: The fear of losing income during a study period might outweigh potential long-term gains from further education.
3. Home improvement	Endowment effect [51–53]: Overvaluing the current state of the home, leading to hesitancy in making significant changes.
4. Career advancement	Status quo bias [50,54]: Preference for current job stability over potentially more demanding but lucrative alternatives.
5. Health investments	Mental accounting [55]: Assigning different values to money depending on its intended use, such as health improvement.
6. Entertainment choices	Opportunity cost neglect [25,28]: Failing to adequately consider what other pleasures or benefits could be achieved with the money spent on a concert.
7. Tech purchases	Overconfidence [56–58]: Overestimating the necessity or utility of having the latest technology.
8. Investment opportunities	Anchoring [59,60]: Influenced heavily by initial impressions or past performances of different investment types.
9. Retirement planning	Hyperbolic discounting [61–63]: Undervaluing the benefit of future financial security in favor of present spending.
10. Vehicle upgrades	Vehicle replacement: Sunk-cost bias [64]: unrecoverable prior expenditures on the current vehicle may improperly influence the decision to keep or replace it.
11. Business expansion	Confirmation bias [65,66]: Looking for information that supports pre-existing beliefs about business growth or alternative investments.
12. Educational choices for children	Affect heuristic [67–69]: Emotional attachment to the perceived quality of education influencing financial decisions.
13. Borrowing decisions	Loss aversion [50]: The focus on potential losses from interest payments overshadowing the benefits of the purchase.
14. Social engagements	Fear of missing out [70,71]: The anxiety about missing enjoyable events can override the consideration of opportunity costs.
15. Dining out	Present bias [49]: The immediate gratification of eating out overshadowing the long-term savings from cooking at home.
16. Job relocation	Status quo bias [50,54]: The comfort of current living conditions making the cost of moving seem more daunting.
17. Personal development	Opportunity cost neglect [25,28]: Not properly evaluating the benefits of alternative ways to spend on self-improvement.
18. Charitable donations	Affect heuristic [67–69]: Emotional responses to charities can influence decisions without considering the impact thoroughly.
19. Subscription services	Mental accounting [55]: Viewing subscription costs as minor expenses without considering their cumulative impact.
20. Time management	Hyperbolic discounting [61–63]: Preferring immediate leisure activities over potentially more beneficial but future tasks.

Table 3. The RAADS–R.

1. I am a sympathetic person.
2. I often use words and phrases from movies and television in conversations.
3. I am often surprised when others tell me I have been rude.
4. Sometimes I talk too loudly or too softly, and I am not aware of it.
5. I often don't know how to act in social situations.
6. I can “put myself in other people's shoes”.
7. I have a hard time figuring out what some phrases mean, like “you are the apple of my eye”.
8. I only like to talk to people who share my special interests.
9. I focus on details rather than the overall idea.
10. I always notice how food feels in my mouth. This is more important to me than how it tastes.
11. I miss my best friends or family when we are apart for a long time.
12. Sometimes I offend others by saying what I am thinking, even if I don't mean to.
13. I only like to think and talk about a few things that interest me.
14. I'd rather go out to eat in a restaurant by myself than with someone I know.
15. I cannot imagine what it would be like to be someone else.
16. I have been told that I am clumsy or uncoordinated.
17. Others consider me odd or different.
18. I understand when friends need to be comforted.

Table 3. *Cont.*

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19. I am very sensitive to the way my clothes feel when I touch them. How they feel is more important to me than how they look.
 20. I like to copy the way certain people speak and act. It helps me appear more normal.
 21. It can be very intimidating for me to talk to more than one person at the same time.
 22. I have to “act normal” to please other people and make them like me.
 23. Meeting new people is usually easy for me.
 24. I get highly confused when someone interrupts me when I am talking about something I am very interested in.
 25. It is difficult for me to understand how other people are feeling when we are talking.
 26. I like having a conversation with several people, for instance around a dinner table, at school or at work.
 27. I take things too literally, so I often miss what people are trying to say.
 28. It is very difficult for me to understand when someone is embarrassed or jealous.
 29. Some ordinary textures that do not bother others feel very offensive when they touch my skin.
 30. I get extremely upset when the way I like to do things is suddenly changed.
 31. I have never wanted or needed to have what other people call an “intimate relationship”.
 32. It is difficult for me to start and stop a conversation. I need to keep going until I am finished.
 33. I speak with a normal rhythm.
 34. The same sound, color or texture can suddenly change from very sensitive to very dull.
 35. The phrase “I’ve got you under my skin” makes me uncomfortable.
 36. Sometimes the sound of a word or a high-pitched noise can be painful to my ears.
 37. I am an understanding type of person.
 38. I do not connect with characters in movies and cannot feel what they feel.
 39. I cannot tell when someone is flirting with me.
 40. I can see in my mind in exact detail things that I am interested in.
 41. I keep lists of things that interest me, even when they have no practical use (for example sports statistics, train schedules, calendar dates, historical facts and dates).
 42. When I feel overwhelmed by my senses, I have to isolate myself to shut them down.
 43. I like to talk things over with my friends.
 44. I cannot tell if someone is interested or bored with what I am saying.
 45. It can be very hard to read someone’s face, hand and body movements when they are talking.
 46. The same thing (like clothes or temperatures) can feel very different to me at different times.
 47. I feel very comfortable with dating or being in social situations with others.
 48. I try to be as helpful as I can when other people tell me their personal problems.
 49. I have been told that I have an unusual voice (for example flat, monotone, childish, or high-pitched).
 50. Sometimes a thought or a subject gets stuck in my mind and I have to talk about it even if no one is interested.
 51. I do certain things with my hands over and over again (like flapping, twirling sticks or strings, waving things by my eyes).
 52. I have never been interested in what most of the people I know consider interesting.
 53. I am considered a compassionate type of person.
 54. I get along with other people by following a set of specific rules that help me look normal.
 55. It is very difficult for me to work and function in groups.
 56. When I am talking to someone, it is hard to change the subject. If the other person does so, I can get very upset and confused.
 57. Sometimes I have to cover my ears to block out painful noises (like vacuum cleaners or people talking too much or too loudly).
 58. I can chat and make small talk with people.
 59. Sometimes things that should feel painful are not (for instance when I hurt myself or burn my hand on the stove).
 60. When talking to someone, I have a hard time telling when it is my turn to talk or to listen.
 61. I am considered a loner by those who know me best.
 62. I usually speak in a normal tone.
 63. I like things to be exactly the same day after day and even small changes in my routines upset me.
 64. How to make friends and socialize is a mystery to me.
 65. It calms me to spin around or to rock in a chair when I’m feeling stressed.
 66. The phrase, “He wears his heart on his sleeve”, does not make sense to me.
 67. If I am in a place where there are many smells, textures to feel, noises or bright lights, I feel anxious or frightened.
 68. I can tell when someone says one thing but means something else.
 69. I like to be by myself as much as I can.
 70. I keep my thoughts stacked in my memory like they are on filing cards, and I pick out the ones I need by looking through the stack and finding the right one (or another unique way).
 71. The same sound sometimes seems very loud or very soft, even though I know it has not changed.
 72. I enjoy spending time eating and talking with my family and friends.
 73. I can’t tolerate things I dislike (like smells, textures, sounds or colors).
 74. I don’t like to be hugged or held.
 75. When I go somewhere, I have to follow a familiar route or I can get very confused and upset.
 76. It is difficult to figure out what other people expect of me.
 77. I like to have close friends.
 78. People tell me that I give too much detail.
 79. I am often told that I ask embarrassing questions.
 80. I tend to point out other people’s mistakes.
-

The remaining 17 “normative” questions have reversed point values. As observed, in the RAADS-R, 17 out of the 80 statements are normative (reverse scoring), where “never true” yields the highest score of 3. Statements that are typically not “never true” for most autistic individuals are highlighted in bold in Table 4.

Table 4. RAADS-R questions with reverse scoring.

1. I am a sympathetic person.
6. I can “put myself in other people’s shoes”.
11. I miss my best friends or family when we are apart for a long time.
18. I understand when friends need to be comforted.
23. Meeting new people is usually easy for me.
26. I like having a conversation with several people, for instance around a dinner table, at school, or at work.
33. I speak with a normal rhythm.
37. I am an understanding type of person.
43. I like to talk things over with my friends.
47. I feel very comfortable dating or being in social situations with others.
48. I try to be as helpful as I can when other people tell me their personal problems.
53. I am considered a compassionate type of person.
58. I can chat and make small talk with people.
62. I usually speak in a normal tone.
68. I can tell when someone says one thing but means something else.
72. I enjoy spending time eating and talking with my family and friends.
77. I like to have close friends.

In this study, the RAADS-R autism scale was chosen because of its widespread use and straightforward scoring methodology in assessing neurodevelopmental traits. Although alternative autism scales exist, the RAADS-R was considered most appropriate for our exploratory analysis given its compatibility with the simulation framework and support from previous studies. We recognize that additional scales may offer further comparative insights.

To assess how individuals prone to specific cognitive biases (identified in the 20 questions of the opportunity cost questionnaire in Table 2) might score on the RAADS-R, particularly scores above 64, we analyze each bias and theorize its potential correlation with autism spectrum traits. This analysis helps us hypothesize potential patterns in RAADS-R scores among individuals exhibiting these biases. As observed, we utilize ChatGPT to analyze the collected data through an AI-driven methodology.

Here is an example of an AI-driven experiment applied to this issue: We tasked Chat-GPT to list the 10 greatest minds, top 10 physicists, and top 10 biologists of all time without overlapping individuals. Based on the list and historical accounts and biographical information, a detailed RAADS-R scoring was conducted. Each individual’s potential autistic traits were evaluated using the RAADS-R framework in Table 3. For the greatest minds of all time: Leonardo da Vinci exhibited intense focus on detailed work, deep curiosity, and occasional social isolation, likely scoring high on questions related to detailed focus and specialized interests. Aristotle, methodical and logical with an intense focus on philosophical concepts, might score high on detailed thinking and specific interests. Nikola Tesla, eccentric and obsessive with his work, showing social difficulties and sensory sensitivities, would likely score high across multiple sections, particularly social interaction and sensory responses. Sigmund Freud, intensely focused on psychoanalysis and socially unconventional, would potentially score high on social relatedness and circumscribed interests. Plato, with a philosophical focus and introspective nature, might score high in abstract thinking and social difficulties. Socrates, known for his questioning nature and challenging social norms, would likely score high in social interaction and specialized

interests. Thomas Edison, persistent and highly focused on inventions, sometimes isolated, would likely score high on repetitive behaviors and specialized interests. Immanuel Kant, with rigid routines and a focus on specific philosophical interests, would likely score high in routine adherence and specific interests. Ludwig van Beethoven, intensely focused on music and showing social difficulties and sensory sensitivities, would likely score high in the sensory-motor and social interaction sections. William Shakespeare, deeply focused on writing and theater with less known social traits, might score high in language and circumscribed interests.

Among the physicists, Albert Einstein, with his deep focus and innovative problem-solving approach, may score high in detailed focus and social interaction. Isaac Newton, known for his intense dedication to work and social isolation, likely scores high in specialized interests and social relatedness. Galileo Galilei, with a strong focus on astronomy, physics, and norm-challenging, may score high in specific interests. Stephen Hawking, with his concentration on theoretical physics and social challenges, likely scores high in specialized interests. Richard Feynman, recognized for his unique problem-solving style, might score similarly in specialized interests. Niels Bohr, focused on quantum mechanics with limited social documentation, and James Clerk Maxwell, dedicated to electromagnetism, may also score high in specific interests. Erwin Schrödinger, intensely focused on theoretical physics, likely scores similarly, while Max Planck's work in quantum theory may reflect high scores in detailed thinking. Finally, Marie Curie, deeply invested in her research, likely scores high in specialized interests and repetitive behaviors.

Regarding the biologists: Charles Darwin, known for meticulous research on evolution, might score high in detailed thinking and specialized interests. Gregor Mendel, with an intense focus on genetics and less documented social traits, likely scores high in specific interests. Louis Pasteur, focused on microbiology and vaccination, may score high in specialized interests. James Watson, known for his focus on DNA structure and controversial social traits, might score high in specific interests. Francis Crick, focused on molecular biology, likely scores high in specialized interests. Barbara McClintock, with an intense focus on cytogenetics and working in isolation, likely scores high in specialized interests and social interaction. Rosalind Franklin, with a deep focus on X-ray crystallography and facing social challenges, likely scores high in specialized interests. Alexander Fleming, focused on bacteriology and antibiotics, might score high in specific interests. Jane Goodall, known for detailed observations of primates, likely scores high in detailed thinking. Carl Linnaeus, focused on taxonomy, might score high in detailed thinking and specialized interests.

Based on the detailed RAADS-R assessment and historical biographical information, the following individuals are likely to score higher than 65 on the RAADS-R test, indicating significant potential autistic traits: Leonardo da Vinci, Nikola Tesla, Immanuel Kant, Ludwig van Beethoven, Albert Einstein, Isaac Newton, Stephen Hawking, Richard Feynman, Barbara McClintock, and Rosalind Franklin. A detailed RAADS-R assessment of these historical great achievers suggests that their remarkable contributions to their respective fields may be partly attributed to the unique cognitive and behavioral characteristics associated with autism. This analysis provides a nuanced understanding of the interplay between neurodiversity and exceptional intellectual achievements.

Table 5 provides our research workflow.

Table 5. Summary of the research workflow for the AI-driven experiment.

Step	Development
1. Online AI Tool Integration	ChatGPT 4o is used to assist in questionnaire design, model predictions, and parameter calibration based on cognitive biases.
2. Parameter Calibration Based on Cognitive Biases	ChatGPT is tasked with predicting hypothetical parameter values for cognitive biases, using insights from behavioral economics and the related literature.
3. Opportunity Cost Questionnaire Development	A 20-question survey is created to assess how participants consider opportunity costs, with each question tied to a cognitive bias.
4. RAADS-R Autism Test Application	The RAADS-R test is utilized to assess the likelihood of autism spectrum traits in artificial participants.
5. Data Collection from Artificial Participants	Artificial participants, generated through AI simulations, respond to the opportunity cost questionnaire and the RAADS-R test.
6. Simulation and Analysis	Simulations are run using the AI-generated data, incorporating the cognitive biases and RAADS-R test results for analysis.
7. Evaluation of Results	The data from the simulations are evaluated to understand the relationship between cognitive biases, opportunity cost neglect, and autism traits.
8. Interpretation and Conclusion	The findings are interpreted to draw conclusions about the impact of cognitive biases and how individuals with autism might handle opportunity costs differently.

3. Results

Considering the biases in Table 2 for each of the 20 questions in Table 1, we tasked ChatGPT with a first exploration of the possible impact of these biases on the RAADS-R in Tables 3 and 4. The output is shown in Table 6.

Next, we tasked ChatGPT with conducting the correlational analysis between the opportunity cost questionnaire and the RAADS-R. The AI followed these steps: (1) Data preparation: The opportunity cost questionnaire consists of 20 questions targeting specific cognitive biases, while the RAADS-R comprises 80 diagnostic questions, with 17 reverse-scored items as specified in Table 4. (2) The dataset was generated entirely by code and was not collected from human respondents. Item-level scores were generated for 30 simulated cases for both questionnaires and were then summed after applying the specified reverse scoring to the RAADS-R items. Scores were computed for both the opportunity cost questionnaire and the RAADS-R, applying reverse scoring for the specified RAADS-R items. (3) Correlation analysis: Python was used to calculate the correlation between the scores from the opportunity cost questionnaire and the RAADS-R. (4) Hypothetical data and correlational analysis: Using NumPy with random seed 42, the code independently drew opportunity-cost item scores from the integers 1 to 5 and RAADS-R item scores from the integers 0 to 3. The 17 specified RAADS-R items were then reverse-scored, and the item scores were summed. No cross-scale dependency was imposed; consequently, any observed correlation is specific to this random realization and should not be interpreted as an empirical or model-imposed relationship.

Table 6. ChatGPT’s predictions on the impact of cognitive biases on opportunity cost neglect on RAADS-R scores.

Question from Table 2	Impact on the RAADS-R Score
1. Vacation planning (present bias)	Individuals with present bias may have difficulty with long-term planning, a trait sometimes seen in autism, potentially affecting their RAADS-R scores in sections related to future-oriented thinking.
2. Higher education (loss aversion)	The focus on immediate losses over long-term gains could parallel challenges with abstract or future-oriented thinking in autism, possibly leading to higher RAADS-R scores.
3. Home improvement (endowment effect)	The overvaluation of current possessions might relate to resistance to change, a common autism trait, suggesting a potential for higher RAADS-R scores.
4. Career advancement (status quo bias)	A preference for stability and routine is a noted feature in autism, possibly correlating with higher scores on questions about adherence to a routine.
5. Health investments (mental accounting)	Compartmentalizing finances may relate to difficulties in integrating information, a challenge noted in autism, potentially leading to elevated RAADS-R scores.
6. Entertainment choices (opportunity cost neglect)	This neglect might indicate a broader pattern of missing subtle social and environmental cues, a common issue in autism, suggesting higher scores.
7. Tech purchases (overconfidence)	Overconfidence could overlap with unusual social confidence levels sometimes observed in autism, affecting social interaction scores on the RAADS-R.
8. Investment opportunities (anchoring)	Difficulty adjusting one’s initial beliefs could relate to rigid thinking in autism, possibly influencing higher RAADS-R scores.
9. Retirement planning (hyperbolic discounting)	Prioritizing immediate rewards over future benefits is relevant to some autistic traits, such as challenges in long-term planning.
10. Vehicle upgrades (sunk cost fallacy)	Persistence with ineffective strategies could mirror repetitive behaviors in autism, leading to specific patterns in RAADS-R responses.
11. Business expansion (confirmation bias)	Seeking information that only supports pre-existing beliefs might correlate with specific interests and repetitive behaviors in autism.
12. Educational choices for children (affect heuristic)	Emotional decision-making could reflect the intense focus on specific interests or emotional attachments seen in autism.
13. Borrowing decisions (loss aversion)	Similar to what occurs in the higher-education question, this bias may affect the RAADS-R scores where long-term planning and decision-making are involved.
14. Social engagements (fear of missing out)	This could reflect impaired social interaction strategies, potentially resulting in elevated RAADS-R scores in social-related questions.
15. Dining out (present bias)	Similar to the vacation-planning question, difficulties with foreseeing long-term health or financial outcomes might reflect broader autism traits.
16. Jog relocation (status quo bias)	Like the career advancement question, a preference for familiar settings could correlate with autism spectrum traits noted on the RAADS-R.
17. Personal development (opportunity cost neglect)	Not evaluating all options might reflect a narrow focus or specialized interests common in autism.
18. Charitable donations (affect heuristic)	Decisions driven by emotions over logical assessment could align with the emotional processing traits scored on the RAADS-R.
19. Subscription services (mental accounting)	Viewing expenses compartmentally could relate to challenges in a broader financial or social understanding in autism.
20. Time management (hyperbolic discounting)	Preferring immediate leisure could relate to difficulties in time management and planning seen in autism.

The correlational analysis between the opportunity cost questionnaire and the RAADS-R scores shows a Pearson correlation coefficient of approximately 0.60, with a p -value of 0.0004 (Figure 1). In this particular simulated dataset, higher raw opportunity-cost questionnaire totals co-varied with higher simulated RAADS-R totals ($r = 0.60$, $p = 0.0004$). Because higher raw questionnaire totals indicate greater consideration of opportunity costs and because the two scales were independently generated, this result does not support an inference that opportunity-cost neglect is greater among people with autistic traits. In psychological studies, a Pearson correlation coefficient of 0.60 is generally considered to be a moderate to strong correlation [72].

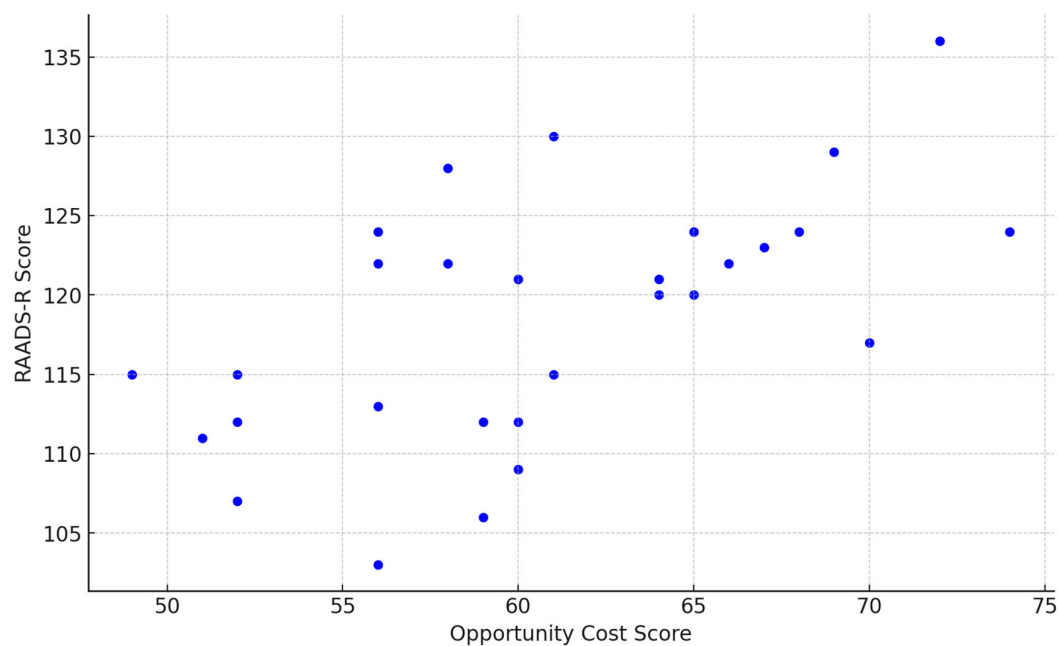


Figure 1. Correlation between raw opportunity-cost questionnaire totals and simulated RAADS-R totals for 30 AI-generated cases. Two cases have identical coordinates (Opportunity Cost Score = 51 and RAADS-R Score = 111) and therefore overlap completely, leaving 29 distinct markers visible. Pearson $r = 0.60$, $p = 0.0004$.

Although the observed Pearson correlation ($r = 0.6$) between opportunity cost neglect and RAADS-R scores indicates a moderate positive association, it is important to note that this does not establish a causal link between the two variables. Correlation, by itself, does not confirm causation, and other confounding factors may contribute to the relationship. Therefore, our findings should be regarded as preliminary, forming a basis for future research that employs rigorous causal inference methods to more definitively determine the direction and mechanisms underlying this association.

All 30 simulated RAADS-R totals exceeded the stated threshold of 64. The generated dataset therefore contains only one RAADS-R category and does not support a between-category ANOVA or a meaningful chi-square test. Accordingly, the chi-square and ANOVA results are omitted. The association in the generated dataset is described only using the continuous questionnaire totals, while recognizing that the two variables were independently generated. A simple regression of simulated RAADS-R totals on raw opportunity-cost totals yielded $b = 0.701$, $R^2 = 0.363$, $F(1, 28) = 15.96$, and $p = 0.0004$; this result describes only the particular generated dataset.

A sample size of 30 was selected pragmatically for this exploratory simulation. For the generated dataset, the regression residuals showed no evidence of departure from normality in a Shapiro–Wilk test ($W = 0.977$, $p = 0.753$), and a Spearman rank correlation produced a similar association ($\rho = 0.591$, $p = 0.0006$). These diagnostics do not substitute for formal power analysis or validation in human samples.

A Python script that simulates the impact of cognitive biases (from Table 2) on RAADS-R scores (Tables 3 and 4), including a parameterized model to adjust RAADS-R scores based on hypothetical impact weights for each bias, is available on Figshare. Additionally, the Python code necessary to replicate the analyses can also be accessed there.

After ChatGPT completed its analysis, we conducted a stress test to thoroughly evaluate the robustness of the findings, aiming to avoid over-reliance on correlation-based results that may weaken as synthetic data scale up. Thus, to examine the robustness of the observed relationship between cognitive biases related to opportunity costs and RAADS-

R scores, we opted for a stress test using progressively larger sample sizes with paired *t*-tests. We moved away from correlation analysis because, as the sample size increased, the previously observed correlations diminished, likely due to the nature of the artificially generated participant data. Artificial data generation often relies on preset parameters and simplified distributions that may not adequately capture the nuanced variability of real-world responses, potentially leading to a reduced correlation strength with larger samples. Additionally, artificial datasets lack the individual-level variability and interactions that real-world samples naturally exhibit, which are crucial for preserving correlation patterns as sample sizes grow. By focusing on paired *t*-tests, we aimed to explore score adjustments more directly, evaluating mean differences across samples and allowing for a more stable measure of the cognitive bias impact on RAADS-R scores under varying sample sizes.

We selected three sample sizes—30, 100, and 1000 artificial participants. Baseline RAADS-R scores were calculated for each participant based on responses to the 80 RAADS-R items. A bias-adjusted simulation index was derived by adding hypothetical weighted bias effects to the baseline simulated RAADS-R total. Because this derived index is not constrained to the RAADS-R range of 0 to 240, it is not a valid RAADS-R score and must not be interpreted clinically. This adjustment process enabled us to examine the potential influence of cognitive biases on RAADS-R scores when integrated into each participant's assessment. For each sample, paired *t*-tests were performed to compare baseline and adjusted RAADS-R scores, with means and standard deviations calculated to assess the score distribution and variability across sample sizes.

Table 7 displays the mean and standard deviation values for baseline and adjusted RAADS-R scores across samples of 30, 100, and 1000 participants. Paired *t*-tests reveal statistically significant differences between the baseline and adjusted scores, emphasizing the impact of cognitive biases related to opportunity cost on the RAADS-R scores. The results were consistent across all sample sizes, with an observed increase in mean RAADS-R scores after adjustment for these biases. This trend persisted across groups, from 30 to 1000 participants, suggesting a stable influence of cognitive biases on RAADS-R scores. Additionally, the adjusted scores exhibited a slight rise in standard deviation across all sample sizes, indicating the variability introduced by bias adjustments. This added variability suggests that the impact of cognitive biases is meaningful and varies among the participants. Paired *t*-tests confirmed significant differences between the baseline and adjusted scores across all sample sizes, with *t*-statistics and *p*-values growing stronger with larger samples (e.g., $t = -257.95$, $p \approx 0$ for 1000 participants), reinforcing the consistency of the bias-related impact and showing increased statistical power with larger samples.

Table 7. Stress test: comparison of baseline and bias-adjusted simulation-index values across increased sample sizes.

Sample Size	Baseline Mean	Bias-Adjusted Simulation-Index Mean	Baseline Std. Dev.	Adjusted Std. Dev.	t-Statistic	p-Value
30	208.07	306.10	49.03	50.63	−46.54	<0.0001
100	208.68	303.29	38.73	40.81	−79.35	<0.0001
1000	205.70	300.54	38.40	41.54	−257.95	<0.0001

Note: The bias-adjusted index is an unbounded derived simulation measure and is not a RAADS-R total. Values exceeding 240 therefore have no clinical RAADS-R interpretation.

4. Discussion

First, it is important to note that the AI-generated data used in our study do not capture complex internal thought processes or provide a clinical diagnosis of individuals, particularly in neurodiverse populations. The AI-generated patterns are preliminary and hypothesis-generating; they do not constitute clinical evidence and do not substitute for human neurocognitive assessment.

Having acknowledged these limitations, we now connect our findings to the established opportunity cost literature. As seen in the opportunity costs literature, Frederick et al. [25] introduce the concept of opportunity cost neglect, showing that consumers frequently overlook the alternatives forgone when making a purchase. In this paper, we argue that opportunity cost neglect is largely driven by cognitive biases such as limited attention and cognitive load, which impede the active consideration of alternatives. Our main contribution to the literature is to further examine how opportunity cost neglect can stem from or interact with other cognitive biases. For example, the availability heuristic intensifies this neglect by emphasizing immediate examples over abstract alternatives. Anchoring leads to a fixation on initial prices, reducing adjustments for alternative uses of money, while mental accounting causes individuals to treat money differently depending on its source or intended purpose.

Frederick et al. [25] emphasize that even under conditions encouraging cognitive effort, consumers frequently neglect opportunity costs unless these are explicitly shown. This phenomenon, which we can see as a distinct cognitive bias, can also interact with other biases, such as present bias and status quo bias, independently affecting consumer behavior. Understanding these cognitive mechanisms shows the necessity of creating interventions, such as nudges and boosting, that emphasize opportunity costs, thereby enhancing consumer decision-making and promoting more rational economic behavior.

Frederick et al. [25] argue that even when consumers are encouraged to exert a cognitive effort, they frequently overlook opportunity costs. We emphasize the persistent nature of opportunity cost neglect, which implies that just asking customers to think more carefully about their decisions is insufficient to overcome this bias. The persistence of opportunity cost neglect, despite increasing cognitive effort, shows how deeply established this cognitive bias is. It suggests that interventions aimed at mitigating this negligence should go beyond merely encouraging customers to seek alternatives. Instead, these interventions should include methods that make opportunity costs more visible and accessible, such as verbal reminders or contextual cues.

Frederick et al. [25] argue that individual differences, such as the “pain of paying” experienced by tightwads versus spendthrifts, can influence the susceptibility to opportunity cost cues. Tightwads, who feel greater discomfort when spending money, are naturally more attuned to opportunity costs and thus less affected by external prompts to consider them. In contrast, spendthrifts, who experience less pain when spending, are more susceptible to interventions that emphasize opportunity costs. This distinction shows the importance of personal traits in economic decision-making. Future research should recognize the variability in consumer behavior and the need for tailored approaches in designing interventions. It also emphasizes that understanding these individual differences matters for developing effective strategies to mitigate opportunity cost neglect, as one-size-fits-all solutions may not be equally effective across diverse consumer profiles. A straightforward agenda would entail the examination of the individual distinctions that arise from varying cognitive abilities, as exemplified by System 1 vs System 2 thinking, as captured by the cognitive reflection test [2].

Frederick et al. [25] also show that explicit cues to consider opportunity costs can significantly alter consumer choices, making consumers more likely to factor in the alternatives

their spending would displace. We observe that this finding suggests that interventions designed to make opportunity costs more salient, such as nudges and boosting techniques, can help mitigate the neglect of these costs. By explicitly being presented opportunity costs, whether through visual aids, reminders, or framing techniques, consumers are better able to recognize and evaluate the trade-offs involved in their decisions.

Furthermore, Frederick et al. [25] discuss how their findings on opportunity cost neglect have practical implications for marketing strategies, particularly for economy and premium brands. For economy brands, emphasizing the opportunity costs of choosing more expensive alternatives can make their products more appealing by highlighting the benefits of saving money for other uses. We add that this strategy can be particularly effective when appealing to consumers' sense of positional consumption, where the desire to achieve a higher status with less expenditure becomes a motivating factor [73]. Conversely, premium brands can counteract this by downplaying opportunity costs or framing their higher prices as justified by superior quality, long-term benefits, and the enhanced status that comes with owning a premium product.

In the ASD literature, Hans Asperger first described "autistic psychopathy" in 1944, observing challenges in social integration, nonverbal and idiosyncratic verbal communication, unusual interests, empathy deficits, and clumsiness, though without specifying diagnostic criteria [74]. Lorna Wing later translated and renamed the condition as Asperger's syndrome, emphasizing traits such as a lack of interest in people, delayed speech, and the absence of imaginary play [75]. Gillberg's criteria further expanded the diagnostic features to include social impairments, narrow interests, repetitive routines, speech peculiarities, nonverbal communication difficulties, and motor clumsiness [76].

The inclusion of Asperger's syndrome in the ICD-10 [43] and DSM-IV [42] brought widespread clinical recognition to the syndrome, now referred to as Asperger's disorder. The term "disorder", however, is debated from an evolutionary perspective, as noted [44]. Autism is not a disease needing a cure; rather, it is society that must adapt to fully embrace neurodiversity. This "deficit" perspective on autism has faced challenges [77,78]. Although genetic variations are believed to account for 50 percent of autism cases [79], only about 5 percent of this heritability is linked to rare mutations [80]. Given this, along with the fitness costs associated with autism, it is hypothesized that the traits or alleles associated with autism may confer certain selective advantages from an evolutionary standpoint [44]. In the DSM-IV-TR, speech and language difficulties were excluded from the diagnostic criteria, expanding the definition beyond that used by Asperger, Wing, and Gillberg [81]. This broader, but less precise, definition has fueled ongoing debates regarding the distinction and overlap between autism and Asperger's disorder [74,75,82,83].

Our study explores the intersection of neurodevelopmental disorders, specifically autism and Asperger's disorder, and cognitive biases. Diagnosing these conditions in adults poses considerable challenges, as their symptoms often overlap with other DSM-IV-TR disorders, including social anxiety disorder, obsessive-compulsive disorder, and schizoaffective disorder [81,84–86]. Moreover, the distinction between autism and Asperger's disorder traditionally depends on early developmental indicators such as language and cognitive milestones—information that is frequently unavailable for adults, further complicating accurate diagnosis [74,82]. Furthermore, boys are more likely to be diagnosed with autism than girls [87]; thus, autism may be associated with an "extreme male brain" profile [88]. Understanding the role of cognitive biases in this context may provide additional tools to refine diagnostic criteria, shedding light on how these biases impact both the expression and perception of neurodevelopmental traits.

Our research extends the concept of opportunity cost neglect, traditionally examined in economic contexts, to individuals with autism. We hypothesized that individuals with

autism would be more likely to overlook opportunity costs due to cognitive biases, such as limited attention and cognitive load. This hypothesis was supported by findings from our AI-driven experiment, which indicated a correlation between opportunity cost neglect and higher RAADS-R scores. A practical implication of these findings is that understanding the cognitive biases affecting individuals with autism can guide the development of more effective educational and therapeutic interventions. For example, providing consistent reminders of opportunity costs in decision-making scenarios could help to reduce these biases over time [35].

Our study also suggests the importance of considering individual differences in economic decision-making. Personal traits, such as the “pain of paying”, can affect sensitivity to opportunity cost cues, emphasizing the need for personalized approaches in interventions aimed at reducing opportunity cost neglect [25]. This variability suggests that strategies should be tailored to individual cognitive profiles to enhance decision-making processes. Future research should further explore these connections and develop customized interventions to support decision-making in this population.

Finally, our work presents a fresh perspective on autism and opportunity cost, contributing to interdisciplinary dialogue in psychiatry and behavioral economics. By focusing on cognitive biases and opportunity cost in individuals with autism, this study makes a meaningful contribution to the literature; however, the broader applicability of these findings requires further empirical validation.

In our analysis, the positive correlation between opportunity cost neglect scores and RAADS-R scores should not be interpreted as direct evidence that cognitive biases cause low scores on the opportunity cost scale. Other confounding factors, such as variations in individual motivation or overall task engagement, may also play a role in these results. To firmly establish a causal relationship, future studies will need to employ more rigorous experimental or longitudinal designs and utilize causal inference methods like instrumental variable analysis or randomized controlled trials. Therefore, our findings are presented as a preliminary, hypothesis-generating step, providing a basis for further investigation into the specific causal mechanisms at work.

The practical implications of our study extend to everyday life and clinical practice. Our findings indicate that the tendency to overlook opportunity costs—especially among individuals with higher autistic traits—could be addressed through targeted interventions. For example, tailored cognitive training programs and educational strategies might help people better recognize and evaluate trade-offs, leading to improved decision-making. Workplace accommodations that take these cognitive biases into account could also boost job performance and overall quality of life for neurodiverse populations.

At the same time, given the exploratory nature of our study, these recommendations should be seen as a starting point rather than definitive clinical or policy interventions. Our findings are preliminary, and relying solely on these early results could be risky without further validation. Therefore, we stress the need for additional research using rigorous causal inference methods to confirm and expand upon our initial findings before any direct interventions are implemented.

5. Limitations and Future Directions

While this study demonstrates the potential of AI-driven experiments to explore complex cognitive phenomena, it is important to acknowledge the limitations of using artificial data. Although our simulated data were generated using parameters carefully selected from the existing literature, they may not fully capture the variability and complexity of real-world responses. Consequently, our findings should be considered preliminary,

highlighting the need for future validation studies with human participants to improve their generalizability.

Our study has several additional limitations. First, the correlational nature of our findings does not imply causation; the observed moderate positive correlation between opportunity cost neglect and higher RAADS-R scores does not establish a causal relationship. Longitudinal or experimental designs are needed to explore potential causal links. Second, while we examine cognitive biases and their impact on opportunity cost neglect, we do not account for other factors influencing decision-making in individuals with autism, such as environmental influences, comorbid conditions, and individual differences in cognitive and emotional processing. Third, diagnosing autism in adults is inherently complex due to symptom overlap with other conditions and the frequent absence of early developmental data, which can affect the accuracy of RAADS-R scores and our analysis. Lastly, the use of an experiment with AI-generated data, although valuable for theoretical exploration, lacks the nuance of real-world decision-making behavior. Future research should validate these findings in real-world settings to enhance their empirical relevance.

To evaluate the reliability of our estimates, we conducted a stress test by simulating sample sizes of 30, 100, and 1000 participants. The analysis revealed consistent, statistically significant results across all sample sizes, indicating that the estimates are robust within the simulation framework. Nonetheless, because these findings are based on simulated data, further validation with real-world participant data is necessary to fully confirm the reliability of our estimates.

A final reflective observation is warranted. While our study introduces a novel, AI-driven simulation approach to explore the associations between autistic traits and opportunity cost neglect, several limitations warrant consideration. First, the data used in this investigation were entirely simulated using ChatGPT 4o. Although this method allowed us to rapidly generate and analyze hypothetical responses based on the established literature, it does not replace the nuanced variability observed in real human data. Consequently, our findings should be regarded as hypothesis-generating, providing a preliminary framework for understanding potential cognitive biases rather than definitive evidence of their manifestation in clinical populations.

Additionally, the current methodology employs ChatGPT as both a tool for generating simulated data and for assigning cognitive biases, which may limit the generalizability of our findings and raise concerns about a potential drift in accuracy. The reliance on a single language model may limit the generalizability and reliability of our results. Future studies should consider comparing outputs across multiple large language models, such as Perplexity or Gemini, particularly those capable of generating verifiable scientific sources. This multi-model approach would provide a more robust evaluation of sensitivity and specificity regarding the assignment of cognitive biases and help ensure that our findings are not artifacts of a single AI system's idiosyncrasies.

Moreover, while our prompts and parameter settings were informed by a thorough literature review, the lack of explicit, independently verifiable scientific sources and a published source code for ChatGPT's outputs poses an additional limitation. We acknowledge that rigorous validation—ideally through the collection of real human data and standardized measures of validity and reliability—is necessary to further substantiate this innovative approach. Such efforts will be critical for establishing this methodology as a reliable tool for psychological research.

In summary, despite these limitations, our work provides a creative and promising starting point for integrating AI simulations into the study of cognitive biases and neurodevelopmental traits. We anticipate that future research, incorporating human-normed

datasets and multi-model comparisons, will refine and validate this approach, ultimately enhancing its utility in both academic research and applied settings.

6. Conclusions

Using a pilot AI-driven experiment, we explore the relationship between cognitive biases and neurodevelopmental disorders, with a focus on how these biases manifest in individuals with autism. Our study specifically examines opportunity cost neglect and the cognitive biases that contribute to it. We developed a 20-question scale to assess opportunity cost neglect and compared artificial participants' responses with RAADS-R autism scores. In the particular simulated dataset, higher raw opportunity-cost questionnaire totals co-varied with higher simulated RAADS-R totals. This model-generated pattern should not be generalized to human participants and, because higher raw totals indicate greater opportunity-cost consideration, it does not establish the hypothesized association with opportunity-cost neglect. The simulation provides a framework for formulating a hypothesis to be tested in appropriately designed samples of autistic and neurotypical participants; it does not establish that autistic individuals are more prone to overlooking opportunity costs..

The implications of our findings are multifaceted. First, understanding the cognitive biases that affect individuals with autism can inform the development of more effective educational and therapeutic interventions. Continuous reminders and tailored interventions can help mitigate these biases over time, improving decision-making processes for individuals on the autism spectrum. Additionally, our study suggests the necessity of considering individual differences in economic decision-making. Personal traits, such as the “pain of paying”, can influence the susceptibility to opportunity cost cues, showing the importance of personalized approaches in interventions aimed at reducing opportunity cost neglect.

Our approach minimizes the reliance on real-world participants under constrained conditions, although it does not replace the insights gained from actual experiments. Future research should extend these findings by involving real participants and developing tailored interventions to enhance decision-making in this population. Nevertheless, by integrating insights from behavioral economics and neurodevelopmental studies, our work contributes to a more nuanced understanding of the cognitive processes unique to individuals with autism, ultimately fostering a more inclusive environment for neurodiverse individuals.

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