Internet and Cognition-Based Decision Making: A Survey

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ABSTRACT

Digital technologies represented by the Internet have influenced micro-economic agents' cognitive decisions. We review the effects of Internet technologies on the cognitions and decisions of microeconomic agents systematically. For individuals, the Internet has reshaped their cognition with the information shock, the "Google effect," and social networks. Individual decisions depend on personal cognitions; hence we further clarify the impact of the Internet on individual behavior and decisions, such as fertility decisions, house purchasing decisions, and financial investment decisions. For enterprises, we consider Internet Big Data-assisted decision-making. Enterprises can make relevant business decisions such as targeted advertising, product improvement, and price discrimination by mining big data and using artificial intelligence algorithms. We find that internet technology can directly impact human intelligence (cognition) and influence individual decisions. Internet technology such as artificial intelligence algorithms can also assist individual decisions.

CCS CONCEPTS

• **Social and professional topics** → Professional topics; Computing and business; Economic impact.

KEYWORDS

Internet Technology, Cognition, Big Data, Decision Making, Crowd Intelligence Network

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1 INTRODUCTION

The Crowd Intelligence Network is a network with multiple intelligent subjects, including individuals, enterprises, governments, intelligent robots, intelligent objects. In previous research work, Feng et al. (2021) proposed a metric framework of crowd intelligence based on crowd intelligence networks, as well as a summary of four representative forms of intelligence and their evolution stages, thereby adding to the existing crowd intelligence research [1]. Further, human cognition is the thinking and intelligence behind human behavior and decision-making [2], and the human cognitive structure includes aspects such as concentration, control ability, and memory. However, little research has systematically explored the issue of how Internet technology, the underlying structure of Crowd Intelligence Network connection, affects individual cognition and decision-making. Individual decision-making has a profound impact on macroeconomic operations, and the optimization and enhancement of individual decision-making is an essential driver for improving overall social welfare. Hence, exploring the influence of the Internet development on individual cognition and decision-making is both theoretically and practically significant.

The framework of the paper unfolds as shown in Figure 1. We consider the direct impact of the Internet on cognition-based decision making and how Internet Big Data technologies assist in decision making. The Internet has reshaped individual cognition, with the information of the Internet, social networking, and the Google effect influencing all aspects of individual cognition and further influencing individual decision-making. For companies, big data technologies can be used to assist in decision-making, including targeted advertising, product improvement, and price discrimination to optimize corporate decision-making processes.

The paper proceeds as follows. Section 2 demonstrates the effects of the Internet use on cognitions. Section 3 reviews the effects of the Internet use on decision-making. Section 4 explores how Big Data on the Internet assist Decision-making. Section 5 presents conclusions.

2 THE EFFECTS OF THE INTERNET ON COGNITION

A highly specialized collection of mental operations known as cognition, which allows us to interpret environmental information and effectively create adaptive actions, is crucial to humans' successful adaptations. These cognitive processes, as well as the physical structures that underpin them, are adaptable to behavioral and environmental changes throughout our lifetimes. [3]. Technological advancements, such as any instrument, method, or skill meant to make daily tasks easier, allow humans to extend their cognitive abilities even further. Technological advancements can have a tremendous impact on our highly plastic cognitive systems, resulting in long-term changes in our behaviors and surroundings. Indeed, the introduction of tool manufacturing [4], language [5], and arithmetic systems [6] have modified cognitive processes throughout human evolution. However, little literature has focused on the effects of

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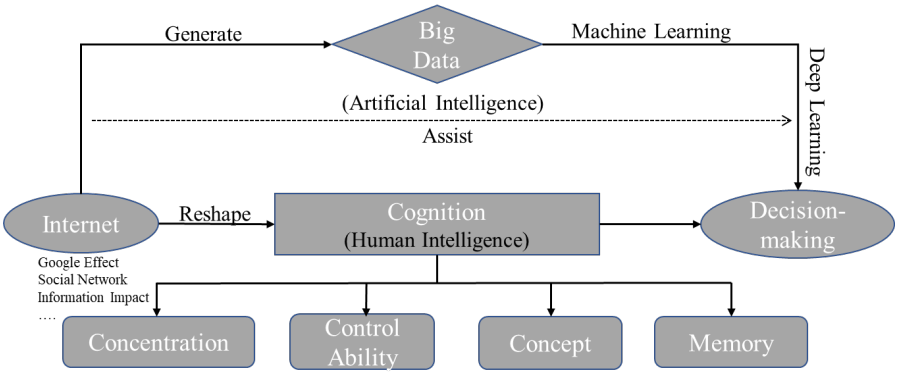

Figure 1: Internet and cognition-based decision making

the Internet use on human cognition. Through using the Internet, people can achieve daily tasks efficiently. For example, with an efficient online search engine (such as Google and Baidu), people can immediately access any information they need. However, Internet users tend to engage in "shallow" information processing practices distinguished by quick concentration shifting and reduced consideration. Multitasking habits in humans have been linked to increased distractibility and poor executive control abilities. Digital natives also have a higher incidence of Internet-related addictive behaviors, indicating that their reward-processing and self-control mechanisms have changed [7].

Besides, the relevant literature shows that Internet use impacts memory, which is a crucial component of our cognitive structure. When confronted with challenging problems, the findings of four research imply that humans are firstly to think about computers for help. People exhibit lower rates of memory of the information itself and increased recollection of where to acquire it when they expect to have future access to it. The Internet has evolved into a fundamental kind of external or transactive memory, in which information is stored collectively outside of oneself [8]. The Internet harms personal memory, diluting it and thus creating a "Google effect."

Finally, social networks on the Internet also have an impact on human cognition [9]. Firstly, people with the same cognition are more likely to interact socially on the Internet. Secondly, social interactions (including information shocks) may also change people's stable cognition, which further profoundly impacts the behavior and decisions of micro-subjects.

3 THE EFFECTS OF THE INTERNET ON DECISION-MAKING

The introduction of the Internet as a new kind of mass communication has dramatically altered the mass media market. Information can be disseminated at a rapid rate, at low cost and in a much more comprehensive range of forms, which brings more equal opportunities for the production and consumption of information [10]. At the same time, the Internet offers new entertainment opportunities that may compete for consumers' time, which has a significant impact on individual behavior and decision-making. We further review relevant research on the effects of the Internet on the behavior and decision-making of microeconomic agents.

House Purchasing Decision (+). Bailey et al. (2018) showed how data from online social networking platforms can enable researchers better to understand the effects of social interactions on economic decision-making. They combine anonymized data from Facebook, the most popular online social network, with housing transaction data to investigate the structure and consequences of social networks. People whose geographically distant friends experienced more significant recent house price increases are more likely to shift from renting to owning. Survey data shows that these causal relationships are driven by the effects of social interactions on individuals' housing market expectations [11].

Fertility Decision (+/-). Billari et al. (2019) investigated whether Internet access affects fertility decisions in Germany. They discover the positive relationships between the fertility of highly educated women aged 25–45 and Internet access. They indicate that Internet access boosts the number of women who work from home or part-time. They also find the positive effects of Internet access on spending time with children and overall happiness [12]. Guldi and Herbst (2017) found that increased broadband access explained at least 7% of the decline in teenage fertility in the United States between 1999 and 2010. The mechanisms are the availability of more information about fertility via the Internet and the effects of online social networks on sexual partner search. Online social networks may replace face-to-face social interactions and thus reduce the frequency of sex. They may also lead to increased consumption of Internet pornography and thus increase risky sexual behavior [13]. Hence the impact of Internet access on fertility decisions is ambiguous in different countries and needs to be explored further.

Stock Market Investment Decision (+/-). Hvide et al. (2020) examined the impact of broadband Internet use on individual investors' portfolio choices. Instrumental variable estimates show that Internet use leads to a substantial increase in stock market participation, driven primarily by increased fund ownership. Existing investors raise the percentage of their portfolios invested in funds while not increasing their stock trading. Access to the fast Internet seems to induce individual investors to make better financial investment decisions [14]. Liang and Guo (2015) found that Internet access, as an important information channel, attenuates the information

Table 1: The relationship between Big Data and other economic goods

	Exclusive	Non-exclusive
Rival	*Personal goods*: e.g., food, shoes, fish kept in private ponds	*Public resources*: e.g., forests, minerals, fish in publicly owned lakes or seas
Non-rival	*Club products*: e.g., satellite TV, concerts in the city, private parks	*Public goods*: e.g., defense, air, sunlight, news, open-air concerts
	Big Data	

source effect of traditional social interactions and thus the positive effects of social interactions on household stock market participation. However, they did not consider the effects of online social network interactions [15].

Marriage (+) *and Divorce Decision* (+). In terms of marriage behavior. Bellou (2015) highlighted that the Internet can reduce search frictions by allowing people to quickly identify a larger number of possibilities that meet their preferences. The findings demonstrate that the Internet has significantly contributed to increased marriages rates among people aged 21 to 30 years old in the United States. The author also argued that other conventional meeting channels, such as through family and friends, have been squeezed out by the Internet [16]. For divorce behavior, Zheng et al. (2019) evaluated the impact of the Internet on the number of divorces in China using province data from 2002 to 2014. They found that rising broadband internet penetration and usage have substantially impacted the likelihood of divorce. For every one percent increase in broadband subscribers, the number of divorces increased by 0.008%. They also identified three possible explanations for how broadband Internet usage influences divorce rates. The effects of Internet access on divorce are greater in places with lower education levels and higher income growth rates. Those relationships are positively affected by instant messaging services that play an essential role in spreading information related to divorce [17].

4 BIG DATA ON THE INTERNET TO ASSIST DECISION-MAKING

With the iteration of Internet technology and its widespread application, the access, storage, and processing of information are becoming increasingly popular and convenient. The amount of data being produced is becoming increasingly large. According to the statistics and forecasts from Statista, the data volume worldwide is expected to reach 47ZB by the year 2030. Big Data is defined as a large collection of data that cannot be effectively accessed, managed and processed in a reasonable amount of time by current mainstream analytical methods and data analysis software, but which is urgently needed to be organized into information that can help individuals, corporates or government departments to provide effective information for decision-making [18]. Big Data plays an essential role in aiding decision-making in the digital era, where decisions are increasingly made based on data analysis rather than subjective experience and cognition.

4.1 The Economic Characteristics of Big Data

Big Data can aid decision-making inextricably linked to its fundamental economic characteristics. According to established economics literature, Big Data has two attributes that differentiate it from other economic goods (which are rival and excludable, such as oil): non-rivalry [19, 20] and partial excludability [21, 22].

Nonrivalry is the central economic characteristic of Big Data. It refers to the concept that data may be used in an infinite number of ways by several individuals at the same time. Governments and companies, for example, might gather a number of identical personal data sets. Meanwhile, citizens who disclose their data still have access to the same amount of data, with no reduction in the total amount of data. Another economic characteristic of Big Data is partially excludable. Exclusivity is the property of an item that prevents others from using it. Non-exclusivity means that the use of the good by others cannot be excluded or that the cost of excluding others is high. Big Data is partially exclusive because it can be easily and cheaply copied and can be transmitted over long distances, even across a country's borders, which creates a high risk of unauthorized sale, use, or theft of data. If data is completely encrypted, anonymized, or kept offline, it remains excludable. However, encryption, anonymization, and offline isolation involve high costs and can make data less valuable. Without real-time data exchange, many digital goods, such as cloud computing and GPS navigation, can no longer function.

To better understand the economics of the competitive and partially exclusive nature of Big Data, we summarize the relationship between Big Data and other economic goods as shown in Table 1

4.2 Heterogeneous Uses of Big Data

Big Data has many specific uses to assist microeconomic agents in their decision-making, such as targeted advertising, price-discrimination, or product improvement (e.g., better search results, more personalized product recommendations), with the help of machine learning (ML) or deep learning (DL) algorithms.

4.2.1 Targeted Advertising. One of the most widespread uses of Big Data is to facilitate the targeting of advertising. Bergemann and Bonatti (2011) first developed a model with several advertisers and advertising markets. They found that increasing targeting increases consumer-product matches, and therefore advertising's social value. On the other hand, targeting increases the concentration of enterprises advertising in each market. They also found that the equilibrium price of advertisements rises at first, then falls as the targeting capability decreases [23]. Corniere and Nijs (2016)

investigated a business model in which an online platform makes a profit by auctioning an advertising slot that appears whenever a consumer visits its website. They identified a new trade-off; disclosing information leads to better matching between firms and consumers but a higher equilibrium price on the product market. They found that the equilibrium price rises as the number of enterprises increases. As the number of firms becomes large, it is always optimal for the platform to disclose the information, but this need not be efficient, due to the distortion induced by the higher prices [24]. Yu and Shin (2021) developed a micro-model in which many businesses compete for customers through targeted advertising. Consumers infer from targeted advertising about their potential match values for the product category, as well as the advertising firm's unobserved quality. They indicated that when consumers are targeted, they make more positive inferences about the product category and the company's quality. A targeted consumer is more likely to engage in a costly search with such improved beliefs throughout the category. They also found that the increased consumer search causes an advertising spillover beyond the level of the mere awareness effects of advertising. Firms' equilibrium level of targeted advertising can be nonmonotonic in targeting accuracy [25].

4.2.2 Product improvement. Search engine algorithms use data about previous queries to improve the quality of products or services. Schaefer et al. (2020) investigated how data drives the quality of internet search results, finding that the quality of search results improves with more data on previous searches, and that personalized information is valuable [26]. Farboodi et al. (2019) studied a model in which firms accumulate data as a valuable intangible asset. The collection of data affects firms' dynamics. It increases the skewness of the firm size distribution because large firms generate more data and invest more in active experimentation. On the other hand, small data firms can overtake more traditional incumbents, provided they can finance their initial money-losing growth. Big Data helps firms become more productive. Productive firms invest more, grow larger, and produce more data, and this is a "data feedback loop. [27]" Hagiu and Wright (2020) modeled competition between firms that improve their products through learning from customer data. They find that firms can improve their products for each customer based on their individual usage experience and products can improve while customers are still consuming them. They also show when and how network effects arise endogenously from data-enabled learning. Overall, these papers use data (product improvement) as given and focus on how firms' learning process can generate data-driven network effects [28].

4.2.3 Price-discrimination. Fudenberg and Tirole (2000) found that poaching causes socially inefficient switching, and therefore welfare is maximum when this type of price discrimination exists [29]. Taylor (2004) investigated the market for customer information and consumer privacy in electronic selling. The research examines two scenarios: a confidential regime in which selling customer information is impossible and a disclosure regime in which one company may collect and sell a customer list to another firm for price discrimination. The findings reveal that welfare comparisons critically depend on whether consumers expect the list to be sold and demand elasticity [30]. Acquisti and Varian (2005) examined when it is profitable to engage in this form of price discrimination when consumers can adopt strategies to protect their privacy. The results show that although it is feasible to price to distinguish high-value and low-value consumers, the merchant will never find it optimal [31]. Montes et al. (2019) investigated the effects of price discrimination on prices, profits, and consumer surplus. Unlike monopolists, competing duopolists do not always benefit from higher privacy costs. This is because each company's profits decrease, while consumer surpluses increase as that cost increases. Under such competition, the best strategy for the owner of consumer data is to sell to only one company, thereby maximizing the benefits to rival buyers [32]. Ichihashi (2020) studied the welfare and price implications of consumer privacy. Research suggests that while consumers benefit from accurate product recommendations, sellers may use that information to price discriminate. Sellers are more willing to promise not to use consumer information for pricing purposes to encourage disclosure. However, such promises undermine the consumer's interests. Sellers can receive a better bargain by promising to conceal some information in advance. The total surplus may be lower if the sellers can price based on information compared to a single product model [33]. Bonatti and Cisternas (2020) demonstrated the significance of aggregating consumers' purchase histories into scores representing unobserved willingness to pay. Firms prefer to overweight scores on past signals relative to Bayesian laws with disaggregated data to mitigate this ratchet effect [34]. Hidir and Vellodi (2021) studied a bilateral trade scenario in which a buyer had private valuations over a multiproduct seller's inventory. The study speaks directly to consumer privacy and the debate regarding product steering versus price discrimination in online retail [35].

5 CONCLUSION

In this paper, we systematically review the effects of Internet technology on the cognition and decision-making of microeconomic subjects. The subjects of the Crowd Intelligence Network include individuals, enterprises, governments, intelligent robots and intelligent objects, and the core foundation of network connectivity is the Internet; hence it is of great theoretical and practical importance to clarify the impact of Internet technology on the decision-making of economic subjects. We aim at subjects primarily individuals and enterprises and clarify the impact of the Internet on individual and business decision-making. For individuals, the Internet has reshaped their perceptions, with the information impact of the Internet, the Google effect and social networks all having different degrees of positive or negative impact on their perceptions. As individual decisions depend on personal perceptions, we have further examined the effects of the Internet on individual behavior and decisions, including fertility decisions and house purchasing decisions. For enterprises, we mainly consider Internet Big Data-assisted decision-making. By cleaning and mining Big Data and further using artificial intelligence algorithms, enterprises can better realize relevant business decisions such as accurate recommendations, product improvement and price discrimination. Thus, we find that Internet technology can have a direct impact on human intelligence (cognition) and influence individual decisions. Internet

technology such as artificial intelligence algorithms can also assist individual decisions.

It is an ongoing task to investigate how the Internet affects the cognition and decision-making of intelligent subjects, the underlying mechanisms of which are not yet clearly established. This paper only gives a simple framework for theoretical discussion, and we will continue to work on this.

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