

Tian, Mei

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Research on the dimension of algorithmic consciousness composition and construction of evaluation framework in the age of digital intelligence

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Research and Evaluation Framework for Algorithm Awareness in the Era of Digital Intelligence

Tian Mei, Shanghai University

Keywords: Algorithm awareness; Algorithm literacy; Algorithm critique; Evaluation framework

I. Media literacy and algorithm awareness

British cultural researchers Leavis and Thompson proposed the concept of "media literacy" for the first time and defined it as people's ability to interpret and critique various media information, as well as their ability to use media information for personal life and social development [1]. Similarly, American scholar James Potter also emphasized this point and said that "when we use media to understand the information we encounter, we actively employ a strategy and method. This is our media literacy." [2] According to British researcher David Buckingham, media education and the knowledge, skills, and abilities in the learning process constitute our media literacy [3]. In 1992, the American Media Literacy Research Institute provided a clear definition of media literacy: It consists of four aspects, namely the ability to choose, understand, question, evaluate, create and produce various kinds of information in the media, as well as the ability to think critically and respond.

With the advent of the digital age, discussions about algorithm literacy have emerged. As pointed out by Daniel L. Hocutt, a network administrator at the University of Richmond in the United States, the purpose of citizens having algorithmic literacy is to be able to critically examine and understand the comprehensive impact brought by algorithms. American programmer Matthew Oldridge also mentioned that the public should understand that algorithms have played an increasingly important role in their lives, whether that role is good or bad. According to him, the algorithm literacy mentioned here does not require individuals to be proficient in programming languages or have the ability to write code, but rather, with the continuous advancement of technology, it becomes increasingly crucial for everyone to understand algorithms in

the era of digital intelligence. [4]. As algorithms are building digital lifestyle patterns, it has become a new media literacy to correctly recognize and understand algorithms. Norwegian scholar Gran defined algorithmic awareness as a fundamental skill that is a prerequisite for acquiring other skills. In his view, algorithmic awareness is a higher-level algorithmic literacy built upon algorithmic knowledge. [5]

Lots of scholars have defined algorithm awareness based on subjective views and applications of algorithm knowledge, in which the foundation of this cognitive feedback is a basic understanding of whether algorithms are existent or not. Eslami et al. proposed several key questions such as "Can algorithms be presented to users as part of an open system organization?" and "How can users be educated to better understand algorithms?", coincidentally proving the need to conceptualize algorithm awareness as part of algorithmic operations and practices [6]. From the perspective of researchers, Gran regarded algorithm awareness as an individual's cognitive ability to understand how algorithms function in platforms, services, and search engine features, and can be interacted with in an active and critical manner [7]. Brahim et al. further elaborated on algorithmic awareness: It refers to an individual's keen perception of the algorithms within their media environment, primarily how algorithms affect the display of content and user experience on media platforms [8]. With a similar understanding of algorithm cognition, domestic scholar Fang Zheng and Daniel L. Hocutt believed that algorithm cognition does not emphasize the need for individuals to have the ability to interpret the source code or related program technology that make up the algorithm, but rather whether individuals can basically master the basic operation process and logic of the algorithm [9]. As claimed by Deng Shengli et al, algorithm awareness should include whether the subject can recognize the existence of the algorithm and become aware of its actual application status. They advocated that relevant users can distinguish the reliability of various algorithms, make independent choices and decisions, gain a clear insight into the dual nature of algorithms, and deeply understand the benefits and challenges they bring [10]. Similarly, Hong Jiewen defined algorithm awareness as the understanding and cognition that users have of the algorithm technology displayed during the use of new media tools, including issues such as the existence of algorithms,

their operation methods, and potential risks and threats [11]. In conclusion, this study considers that algorithm awareness refers to the user's cognitive understanding and judgment evaluation of the algorithm, including the perception of the algorithm's existence, insight into its operating mechanism, and judgment evaluation of the ethical risks that the algorithm may cause.

II. Research and Evaluation Framework for Algorithmic Awareness Dimensions

(1) Research on the dimensions and evaluation indicators of algorithmic consciousness

There are few empirical studies on algorithm awareness both at home and abroad. Although scholars from countries such as Norway, the United States, and Germany have conducted large-scale surveys on algorithm awareness, there are no relevant research results in China yet. In the research on algorithm awareness measurement dimensions, most of domestic studies use expert evaluation and in-depth interviews to construct dimensions and frameworks related to algorithm awareness measurement, or specifically analyze the important role of algorithm awareness on user behavioral intentions based on the "cognition-emotion-behavior" theory.

According to the ACRL standards in the U.S., China has established a complete and systematic evaluation system for information literacy abilities for the first time, namely the *Information Literacy Ability Index System for Higher Education Institutions in Beijing*. This system includes twelve refined levels, such as information sensitivity, information application level, information evaluation ability, and information values [12]. When constructing their algorithm literacy evaluation index system, Deng Shengli et al. referred to the *Information Literacy Ability Index System for Higher Education Institutions in Beijing*, and identified algorithm awareness and critical thinking (corresponding to the subject and self levels) as the core components of algorithm literacy. Apart from that, dimensions such as algorithm awareness evaluation, algorithm sensitivity, algorithm credibility, algorithm value awareness, algorithm risk awareness, algorithm sensitivity, algorithm credibility, and algorithm risk awareness were included [13]. Zarouali defined algorithmic awareness as people's accurate perception of the

behavior of algorithms in specific media environments, as well as the impact of algorithms on user consumption and experience of media content. Zarouali categorized users' algorithmic awareness into awareness of content filtering, awareness of automated decision-making, awareness of human-computer interaction, and awareness of ethical considerations [14]. Through qualitative in-depth interviews, Guo Quanzhong, Li Li, et al summarized the three categories of algorithm awareness based on a user perspective cognitive framework: algorithm filtering awareness, algorithm regulation awareness, and algorithm critique awareness [15]. Based on social cognitive theory, Yan Qihong proposed two layers of algorithm perception: (1) recognizing the existence of algorithms through practical application; (2) the subjective understanding of algorithm operation principles by users. He further pointed out that the younger generation's understanding of algorithms consists of a technological perspective and a social perspective. The technological perspective is characterized by pragmatism and pluralism, while the social perspective mainly includes the perception of individual privacy, the relationship between technological progress and personal growth, self-awareness and collective consciousness, as well as the manifestation of the objectivity of algorithms and the values behind them [16].

(2) Dimensions of algorithmic awareness and setting of evaluation questions

Based on the content of five *Domestic Internet Information Service Algorithm Filing Lists* released by the Cyberspace Administration of China in August and October 2022, and January, April, and December 2023, this study summarizes the measurement of algorithm awareness based on related research. The measurement of algorithm awareness is divided into two levels, from basic to advanced, based on two dimensions [17]. To be specific, the first-level indicators include: algorithm basic recognition awareness, which is the awareness of users about the basic functions and uses of algorithms, and is equivalent to the scholars' discussion of whether they are aware of the existence and operation of algorithms; algorithm critical awareness, which is the judgment and evaluation of users towards algorithms. Furthermore, nine secondary dimension indicators are divided, involving personalized recommendations, curated

sorting, scheduling decisions, synthesis generation, retrieval filtering, algorithm black box and transparency, algorithm manipulation and subjectivity, algorithm privacy infringement, algorithm discrimination and fairness.

In the definition of algorithm awareness, many relevant scholars such as Hamilton [18] and Swar [19] regarded the awareness of the existence of algorithms and understanding the role played by algorithms as the most basic connotation of algorithm awareness. Therefore, its consciousness is summarized as algorithmic foundational recognition consciousness in this study. The National Internet Information Office has released a public announcement regarding the filing information of internet information service algorithms. The document contains a total of 233 types of application algorithms, which are classified according to their types and functions. Apart from that, it comprehensively summarizes the basic functions and application types of algorithms in China, including many mainstream domestic large enterprises and their related products such as NetEase and 360. From the perspective of algorithm types, there are five major types, including personalized recommendation, search and filtering, sorting and selection, scheduling and decision-making, and generation and synthesis. This article includes it in the criteria for measuring algorithmic awareness, namely determining whether users can be aware of the above algorithmic basic functions in their daily use process. Based on this document's introduction to algorithmic functions, a list of test questions related to algorithmic basic recognition awareness has been provided.

At the same time, Norwegian scholar Gran considered engagement in critical interaction in algorithmic consciousness as the highest algorithmic literacy. [20]. Based on the entropy weight method, Deng Shengli et al. established an algorithm literacy evaluation model. Through calculation, the weights of critical thinking in algorithm literacy are as follows: critical thinking (0.407) > algorithm knowledge and skills (0.332) > algorithm awareness (0.186) > algorithm social norms (0.075). This reflects the central role of critical thinking in algorithm literacy. Among them, algorithm selection, algorithm data evaluation, algorithm model evaluation, and algorithm result evaluation are crucial indicators for measuring algorithm critical thinking [21]. Through

semi-structured interviews, Guo Quanzhong et al determined the criteria for critiquing algorithms as criticism of algorithmic privacy invasion, criticism of algorithmic black boxes and transparency, and criticism of algorithmic bias and discrimination [22]. This study is aimed to incorporate algorithmic critical consciousness as an important assessment of quality into the measurement framework of algorithmic consciousness. It is believed that algorithmic criticism is a relevant critique of the ethical issues caused by algorithms. Based on a comprehensive summary of previous scholars' research on algorithmic ethics issues, this study refers to the *Regulations on the Management of Algorithmic Recommendation for Internet Information Services* [23] and Hu Xiaomeng's [24] summary of algorithmic ethics issues. Algorithmic critical consciousness is mainly divided into critiques of algorithmic black boxes and algorithmic transparency, critiques of algorithmic manipulation and subjectivity imbalance, critiques of algorithmic privacy infringement and data security, and critiques of algorithmic discrimination and fairness. At the same time, test questions related to algorithmic criticism are listed based on relevant literature. In conclusion, this study will summarize how to evaluate citizens' awareness of algorithmic fundamentals and critical algorithmic awareness as the following evaluation questions:

Algorithm Basic Recognition Awareness

1) Personalized push

Question 1: I am aware of that the information platform I use recommends news content that may be of interest to me based on users' data such as basic information, browsing history, saved articles, viewing duration, and user matching tags.

Question 2: I am aware of that the information platform I use can deliver advertisements based on users' network and device information.

Question 3: I am aware of that the recruitment platform I use can recommend high matching positions to users through homepage job recommendations, user-posted job information, resume information (user attribute information), and selected relevant conditions.

Question 4: I am aware of that the social platforms I use can recommend social content

that users may be interested in based on users' profile information, browsing history (clicks, duration, likes, comments, shares, dislikes, etc.), recent interests, long-term interests, and current popularity.

Question 5: I am aware of that the video platform I use can recommend news and video content that may be of interest to users based on their behavioral log data.

Question 6: I am aware of that the shopping platform I use can recommend products or services that may be of interest to me based on users' browsing history, historical search data, user behavior patterns, and merchant descriptions.

Question 7: I am aware of that the shopping platform I use can recommend content to users based on their location information, device information, authorization information, and objective factors such as time, geography, and weather, which may be of interest to the users.

Question 8: I am aware of that the video platform I use can recommend audio and video content that I may be interested in based on user interest and activity data.

Question 9: I can become aware of that the travel platform I use can recommend information that users may be interested in based on their historical behavior characteristics, service package attribute characteristics, user historical service package preference characteristics, and basic transportation vehicle attribute characteristics.

2) Featured Sorting

Question 1: I am aware of that the social media platforms I use have trending lists that rank popular content based on users' searches, discussions, and sharing data.

Question 2: I am aware of that the search platform I use can rank hot events based on event-related statistics and user behavior data.

Question 3: I am aware of that the shopping platform I use can objectively sort products based on users' clicks, additions to cart, sales volume, and other data, according to different categories and attributes.

Question 4: I am aware of that the consultation platform I use can sort consultation content by intervention strategy.

Question 5: I am aware of that the consultation platform I use can sort content based on users' favorites, likes, and replies.

Question 6: I am aware of that the video platform I use can form related featured rankings through users' browsing and searching for video content.

Question 7: I am aware of that the delivery platform I use can rank businesses and dishes based on monthly sales, customer ratings, and repeat purchase rates, and select the best restaurants and dishes for delivery.

3) Scheduling Decision

Question 1: I am aware of that the food delivery platform can calculate the estimated delivery time of user orders and match me with the appropriate delivery rider.

Question 2: I am aware of that the express platform can coordinate regional orders and riders, predict the delivery time of packages, and assign orders to riders with ample time and on the way.

Question 3: I am aware of that travel platforms can calculate the estimated arrival and delivery time of drivers, and match suitable order drivers for users.

4) Generate synthesis

Question 1: I am aware of that video platforms can use generative models to edit and regenerate user-uploaded images and videos in the short video production scene, achieve attribute editing, style transformation, etc.

Question 2: I am aware of that the shopping platform has image creation functionality, which can recognize facial expressions and actions in photos, and generate image pictures such as Taobao's Life.

Question 3: I am aware of the voice-to-text feature in instant messaging scenarios.

Question 4: I am aware of that on delivery/logistics platforms, phone-based intelligent customer service can recognize text/voice issues in intelligent customer service and provide solutions to simple user problems.

5) Retrieval Filtering

Question 1: I am aware of that through the platform, I can search for information meeting my needs by using query terms inputted by the user.

Question 2: I am aware of that the platform can identify and handle content safety risks in published texts, images, audio, video, etc, and to detect and deal with illegal and non-

compliant content.

Question 3: I am aware of that the ticketing platform can search for content that meets the user's needs by combining the total time, price, and availability of tickets for transfer options with the user's input of departure and arrival cities.

Algorithmic Criticism

1) Algorithm Black Box and Transparency

Issue 1: I am aware of that I have the right to be informed about algorithms in accordance with the law.

Question 2: I am aware of the hiddenness of power operations in algorithms.

Question 3: I am aware of that the high professionalism and complexity of algorithms make it difficult for us to understand.

Question 4: I am aware of the issue of difficult attribution of responsibility in algorithms.

2) Algorithm manipulation and subjectivity

Question 1: I am aware of that algorithm developers may quantitatively evaluate users for some commercial purposes.

Question 2: I am aware of that algorithms are used to censor information, control trending lists, and public opinion.

Question 3: I am aware of algorithms inducing user addiction.

Question 4: I am aware that algorithms can be used for fake registration accounts, illegal transaction accounts, and manipulating user accounts.

Question 5: I am aware of that I have the right to choose options that do not target my personal characteristics or convenient options to disable algorithmic recommendation services.

3) Algorithmic privacy infringement

Question 1: I am aware of that algorithms collect user data and monitor user behavior on the internet to provide personalized media content, which infringes on users' privacy.

Question 2: I am aware of that algorithms can accurately target users and deliver internet ads based on their precise profiles and consumption habits, which I consider a violation of privacy.

Question 3: I am aware of that the algorithm has not excessively collected and stored personal sensitive data about users, which violates their privacy.

Question 4: I am aware of that algorithms may sell users' personal data to the third parties without permission, which violates their privacy.

4) Algorithmic Discrimination and Algorithmic Fairness

Question 1: I am aware of the gender discrimination algorithms impose on users.

Question 2: I am aware of the age discrimination that algorithms impose on users.

Question 3: I am aware of the algorithm's discrimination against users based on race and country of birth.

Question 4: I am aware of discriminatory practices such as "personalized pricing" and "big data discrimination" carried out by algorithms against users.

Question 5: I am aware of the occurrence of discriminatory remarks and other phenomena in the process of human-computer dialogue with artificial intelligence.

III. Algorithmic Awareness Assessment Dimension Identity Survey

(1) Identity Verification

To validate the rationality and acceptance of the evaluation framework for citizen algorithm awareness in this study, a "Citizen Algorithm Awareness Identification Survey" was developed. The questionnaire uses the rating method of the Richter five-level scale to assess the importance of algorithm awareness and the first and second-level dimensions. In addition, a survey of the degree of agreement was conducted using the options "completely disagree, somewhat disagree, uncertain, somewhat agree, completely agree". As claimed by Zhao Longxuan et al., individuals with higher education have a higher algorithmic awareness [25]. Therefore, the survey participants selected for this study need to have a master's degree or higher. The data was collected through the Windchime system (<https://www.powercx.com>). With the paid "sample service" feature of this platform, the platform organizes the random filling out of the population in its own sample library. The target number of participants for this data collection is 488 people, with 450 valid questionnaires and a valid questionnaire rate of 92%.

As shown by the survey results, there is a high level of agreement with the two primary evaluation dimensions of algorithm awareness. The combined agreement level for algorithm basic identification awareness and algorithm critical awareness is 77.11% and 77.33% respectively for "comparatively agree" and "fully agree". The sum of the degrees of agreement for the "comparative agreement" and "complete agreement" for the nine second-level indicators of personalized push, sorting selection, scheduling decision-making, synthesis generation, retrieval filtering, algorithm black box and transparency, algorithm manipulation and subjectivity, algorithm privacy infringement, algorithm discrimination and fairness are 73.33%, 74%, 65.78%, 68%, 74.44%, 68.44%, 71.11%, 76%, and 71.56% respectively.

(2) Test of reliability and validity.

As revealed by the calculation of the survey results, the KMO value of the questionnaire is 0.856, and the p-value of the Bartlett sphericity test is less than 0.001. The cumulative variance contribution of the two factors is 73.672%, in which the clone Bach α coefficients of algorithm basic recognition awareness and algorithm criticism are 0.772 and 0.734 respectively. As indicated by the above results, the scale has good reliability and validity, further validating the research-constructed framework for measuring algorithmic awareness of citizens.

IV. Conclusion

In the era of digital intelligence, algorithm awareness is a meta-skill as well as the fundamental connotation and important component of algorithm literacy. This study not only explores the definition, evaluation dimensions, and framework of algorithmic awareness, but also preliminarily sets corresponding questions for the dimensions. With the further development of artificial intelligence algorithms, it is hard to become aware of that AIGC is an algorithm model of constant iterative updating that can even be manipulated by algorithms to trigger the risk of group polarization and cause cognitive dilemmas, especially for users with low algorithm literacy. Therefore, evaluation of the algorithm awareness of Chinese citizens is conducive to providing practical evidence for strengthening their algorithm perception and dependence, conducting more targeted

popularization of algorithm knowledge and application education for the public with weak algorithm awareness, better addressing social issues such as the difficulties faced by vulnerable groups in adapting to the digital society, and bridging the new digital divide generated in the era of intelligent algorithms. It is hoped that further related research can provide more practical standards for improving the algorithm awareness and literacy popularization education of Chinese citizens.

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