A Hierarchical Model for Misinformation Detection Based on Signal Detection Theory

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Abstract

In the field of misinformation detection research, System 2 motivated reasoning theory and classical reasoning theory respectively examine the factors influencing individual misinformation detection from different perspectives, yet they exhibit disagreement regarding the explanatory role of cognitive ability. Building upon existing research, this study incorporates factors such as emotion, information characteristics, individual stance, and their underlying motivations to further refine the hierarchical model of misinformation detection based on signal detection theory, aiming to deepen the understanding of how different factors influence misinformation detection. By distinguishing the effects of different factors on discriminative sensitivity and decision criteria in information detection, this model not only effectively reconciles the disagreement between System 2 motivated reasoning theory and classical reasoning theory concerning the role of cognitive ability, but also provides a more nuanced and structured analytical framework for understanding the complex mechanisms of misinformation detection.

Full Text

A Hierarchical Model of Misinformation Identification Based on Signal Detection Theory

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Abstract: In the field of misinformation identification research, the motivated System 2 reasoning account and classical reasoning account have explored factors influencing individual misinformation identification from different perspec-

tives, yet they diverge in their interpretations of cognitive ability's role. Building upon existing research, this study incorporates factors such as emotion, information characteristics, individual stance, and underlying motivations to further refine a hierarchical model of misinformation identification based on signal detection theory. This aims to deepen understanding of how different factors influence misinformation identification. By distinguishing how various factors affect discrimination sensitivity and judgment criteria in the identification process, the model not only effectively reconciles the disagreement between motivated System 2 reasoning and classical reasoning accounts regarding cognitive ability' s role but also provides a more nuanced and structured analytical framework for understanding the complex mechanisms of misinformation identification.

Keywords: misinformation, signal detection theory, influencing factors, motivated System 2 reasoning account, classical reasoning account

1. Introduction

While the development of network communication technology has brought numerous conveniences, it has also spawned certain hazards, with misinformation being one of them (彭知辉, 2022; 吴诗苑等, 2022; Wang et al., 2019; Wardle & Derakhshan, 2017). Compared to true information, misinformation spreads faster, deeper, farther, and more widely (Vosoughi et al., 2018). It not only affects individuals' ability to make optimal decisions about events but may also trigger numerous negative social consequences (Lewandowsky et al., 2017). Consequently, researchers have explored from various perspectives why individuals believe misinformation (Brashier & Marsh, 2020; Pennycook & Rand, 2021) and proposed recommendations for identifying and correcting it (Lewandowsky et al., 2012; Swire et al., 2017).

Information identification is a complex process (Brashier & Marsh, 2020) influenced by multiple factors including cognition, emotion, and motivation. The complex interactions among these factors lead to different theoretical interpretations of influencing factors. For example, the motivated System 2 reasoning account and classical reasoning account hold different views on how individual cognitive ability affects misinformation identification (Baron, 2017; Gawronski et al., 2023; Kahan & Corbin, 2016; Pennycook & Rand, 2019). This theoretical divergence stems from failing to adequately distinguish and understand the roles of different factors in misinformation identification. As an analytical framework widely adopted in psychological research, signal detection theory provides an effective method for distinguishing and deeply understanding various factors that influence individual judgment (Green & Swets, 1966; Lynn & Barrett, 2014). Based on this, the present study attempts to supplement and refine a hierarchical model of misinformation identification grounded in signal detection theory, further elaborating how factors such as cognition, emotion, motivation, and information characteristics influence misinformation identifica-

tion. This aims to reconcile existing theoretical disagreements, provide a more detailed analytical framework for future research, and offer theoretical support for practical information identification and governance applications.

When reviewing relevant literature, we noticed that terms such as "false information," "misinformation," "harmful information," "fake news," and "rumors" are often used interchangeably, causing conceptual ambiguity and confusion in research content. Some researchers point out that the term "misinformation" can be interpreted in both narrow and broad senses. In the narrow sense, "misinformation" refers to false or inaccurate information disseminated unintentionally (彭知辉, 2022; Wardle & Derakhshan, 2017). In the broad sense, "misinformation" serves as an umbrella term encompassing all forms of false information that may lead to serious consequences, including disinformation, rumors, fake news, and conspiracy theories (吴诗苑等, 2022; Wang et al., 2019). In view of this, this paper adopts the broad definition of "misinformation" to more comprehensively cover and discuss relevant research.

2. Theoretical Background

2.1 Motivated System 2 Reasoning Account

Individuals are not blank slates when identifying information. Motivated reasoning theory posits that factors such as prior beliefs, expectations, and goals all influence judgment and decision-making (Kunda, 1990). Through a series of studies, Kahan and colleagues further proposed the motivated System 2 reasoning account (MS2R). This theory argues that individuals with higher cognitive ability are more inclined to trust and support viewpoints consistent with their own interests when identifying information (Kahan, 2013; Kahan & Corbin, 2016; Kahan et al., 2012; Kahan et al., 2017).

Kahan et al. (2012) investigated the effects of scientific literacy and numeracy on climate change risk perception. The results showed that individuals' scientific literacy and numeracy were negatively correlated with climate change risk perception. However, as scientific literacy and numeracy increased, individuals' perceptions of climate change risk became more polarized, leaning more toward trusting and defending their own group' s viewpoints. This indicates that the higher individuals' scientific literacy and numeracy, the more they tend to trust and defend their group' s viewpoints when identifying information. Additionally, Kahan (2013) found that individuals with high analytic thinking similarly tend to trust and support their group' s viewpoints when identifying information.

Kahan et al. (2017) further explored the relationship between cognitive ability and partisan bias through two different information identification tasks. One task evaluated the effectiveness of skin cream in treating rashes, which was unrelated to partisan bias. The other task assessed the effectiveness of gun control in reducing urban crime rates, which was related to partisan bias. The results showed that individuals with high numeracy demonstrated higher accuracy in the skin cream task. However, in the gun control task, high-numeracy individ-

uals showed greater partisan bias, providing further support for the motivated System 2 reasoning account.

2.2 Classical Reasoning Account

Decision researchers often divide thinking into two algorithmic systems or processing pathways (Evans & Stanovich, 2013; Thompson & Johnson, 2014; Tversky & Kahneman, 1983). System 1 relies on intuition for heuristic fast processing, while System 2 relies on rational analytic slow processing. The classical reasoning account posits that when individuals use System 1 for information identification, they ignore information details and make rough estimates and judgments, thereby reducing identification accuracy (Pennycook & Rand, 2019, 2020). Conversely, employing System 2 for analytic reasoning can improve individuals' information identification accuracy. Related research at both the individual difference level (Pennycook & Rand, 2019, 2020) and the within-individual experimental manipulation level demonstrates that employing System 2 analytic reasoning helps improve information identification accuracy.

Pennycook and Rand (2019) investigated the effect of analytic reasoning on misinformation identification. Their findings refuted the motivated System 2 reasoning account and supported the classical reasoning account, showing that regardless of individuals' political stance, analytic reasoning helps improve misinformation identification accuracy. Subsequently, their research again found that the relationship between analytic reasoning and misinformation identification is relatively stable and unaffected by information source and familiarity (Pennycook & Rand, 2020). Similarly, Pehlivanoglu et al. (2022) showed that individuals with higher analytic reasoning ability were more accurate in identifying misinformation unrelated to COVID-19, and this relationship was not affected by age. These individual difference-level studies consistently indicate that individuals with higher analytic reasoning tendencies are more accurate in information identification (Pennycook & Rand, 2019, 2020).

Furthermore, some studies have explored the effect of within-individual cognitive processing depth on misinformation identification. Qiu et al. (2017) found that both low-quality information overload and insufficient individual attention reduce information identification accuracy. Pennycook et al. (2020) prompted individuals to invest more analytic reasoning in identifying information by adding warning labels to information. The results showed that this approach not only improved individuals' information identification accuracy but also effectively reduced trust in partisan information. These results similarly support the classical reasoning account and refute the motivated System 2 reasoning account. Bago et al. (2020) used a two-response paradigm to explore the effect of analytic thinking on information identification. They found that when individuals had more time for analytic thinking (Bago & De Neys, 2017, 2019), their trust in information errors decreased. Additionally, their research again confirmed that individuals with higher analytic thinking were more accurate in information identification. These within-individual experimental manipulation

studies indicate that both providing sufficient time to prompt analytic reasoning (Bago et al., 2020) and adding warning labels to stimulate analytic reasoning (Pennycook et al., 2020) can improve individuals' information identification accuracy.

2.3 Opposition or Misunderstanding?

In existing research, the motivated System 2 reasoning account and classical reasoning account are often viewed as opposing viewpoints (Bago et al., 2020; Gawronski et al., 2023; Pehlivanoglu et al., 2022; Pennycook & Rand, 2019, 2020). The core controversy between the two theories lies in: the motivated System 2 reasoning account argues that individuals with high cognitive ability are more inclined to trust information consistent with their partisan stance when identifying information; whereas the classical reasoning account holds that regardless of whether information aligns with individuals' partisan stance, the higher their analytic thinking, the higher their information identification accuracy (李艳红, 刘佳诺, 2022). Although some studies treat these two theories as mutually opposed, this perspective requires careful scrutiny.

On the one hand, the measurement tools used in relevant theoretical research do not correspond clearly enough to what the theories refer to, which may be one of the important reasons for contradictory conclusions. Increasingly, theories and models subdivide intelligence factors into cognitive ability and thinking disposition aspects (冯雪, 彭凯平, 2015; Stanovich, 2016), yet existing studies related to the two theories seem to have failed to fully distinguish these two aspects. In particular, some studies equate measurement tools closely related to numeracy (Thomson & Oppenheimer, 2016) with analytic reasoning (Bago et al., 2020; Kahan, 2013; Kahan, 2017; Kahan & Corbin, 2016; Kahan et al., 2012; Kahan et al., 2017; Pennycook & Rand, 2019, 2020), or generally categorize these factors as cognitive ability (Kahan & Corbin, 2016), leading to misunderstanding these factors' roles and causing theoretical contradictions.

More importantly, the two theories focus on different aspects. The motivated System 2 reasoning account focuses on the influence of individuals' social motivations on misinformation identification, while the classical reasoning account emphasizes the influence of individuals' cognitive abilities on misinformation identification. Treating social motivation and cognitive ability as competing factors seems inappropriate because they play different roles in misinformation identification. Cognitive ability represents individuals' basic capacity to complete tasks and does not have clear goal directionality, whereas motivation, as a psychological tendency or internal drive that stimulates individual behavior, has clear goal directionality. Therefore, a more appropriate approach is to compare different types of motivations or different cognitive abilities to more accurately understand these factors' influences on misinformation identification. For example, Rathje et al. (2023) explored the competitive relationship between social motivation and accuracy motivation in information identification. Their study found that manipulating accuracy motivation through monetary incen-

tives could reduce partisan bias in information identification. Conversely, manipulating social motivation by having participants identify information their group might endorse reduced misinformation identification accuracy. This indicates that accuracy motivation and social motivation have a certain competitive relationship. Additionally, their study found that analytic thinking and accuracy motivation had different effects on different variables. Specifically, accuracy motivation had greater weight than analytic thinking in influencing partisan bias-related factors, while analytic thinking had greater weight than accuracy motivation in influencing misinformation identification. This not only reveals differences in the roles of accuracy motivation and analytic thinking but also again validates some competitive relationship between social motivation and accuracy motivation. Therefore, the factors emphasized by the two theories are not mutually opposed but belong to different categories.

In summary, viewing the motivated System 2 reasoning account and classical reasoning account as mutually opposed perspectives appears to be a misunderstanding. The fundamental reason for this misunderstanding lies in failing to adequately distinguish the roles of different factors in misinformation identification. As a widely used analytical framework in psychology, signal detection theory enables researchers to more clearly understand how different factors influence judgment, thus promising to resolve the misunderstanding of treating the two theories as opposed (Batailler et al., 2022; Gawronski et al., 2023).

3. Signal Detection Theory and Misinformation Identification

3.1 Introduction to Signal Detection Theory

Signal detection theory (SDT) is an important analytical framework in perception, cognition, and decision-making research (Green & Swets, 1966) that can also be used to understand how different factors influence information identification (Gawronski et al., 2023). By analyzing different outcomes of information identification (hits, misses, false alarms, and correct rejections), researchers can deeply understand various factors influencing misinformation identification.

In signal detection theory (Green & Swets, 1966; Lynn & Barrett, 2014), there are two core metrics for measuring response performance: hit rate (H) and false alarm rate (FA). In information identification, hit rate is the proportion of times true information is correctly identified as true out of the total times true information appears. Correspondingly, false alarm rate is the proportion of times misinformation is incorrectly identified as true out of the total times misinformation appears. These two response indicators provide a foundation for further understanding key factors influencing individual judgment.

Signal detection theory distinguishes two key factors influencing individual judgment (Green & Swets, 1966; Lynn & Barrett, 2014): discrimination sensitivity (d') and judgment criterion (c). Discrimination sensitivity reflects individuals'

ability to distinguish between true and false information. Judgment criterion reflects individuals' tendency to identify information as true or false. After converting hit rate and false alarm rate to z-scores of the standard distribution, discrimination sensitivity can be calculated through formulas and judgment criterion can be calculated through formulas = − (꽹.

In signal detection theory, post-judgment payoff, base rate of event occurrence, and stimulus similarity are also important indicators influencing individual judgment (Lynn & Barrett, 2014). Post-judgment payoff refers to the potential benefits or losses individuals may gain after making specific judgments, and expectations of such benefits or losses affect individuals' judgment criteria. Base rate of event occurrence involves the prior probability of specific events occurring, which also influences individuals' judgment criteria. Stimulus similarity refers to the degree of similarity between signal and noise, which affects individuals' discrimination sensitivity. The higher the similarity between stimuli, the more difficult it is for individuals to distinguish them, thereby reducing discrimination sensitivity. Conversely, the lower the similarity between stimuli, the easier it is for individuals to distinguish them, thereby increasing discrimination sensitivity.

3.2 Existing Research Based on Signal Detection Theory

Batailler et al. (2022) pointed out that previous research on why people believe misinformation conflated the ability to accurately identify information with response bias in identification, potentially leading to erroneous conclusions. Therefore, they applied signal detection theory to misinformation identification research to better understand why individuals believe misinformation. Batailler et al. (2022) used signal detection theory methods to reanalyze data from two previously published studies by Pennycook et al. (Pennycook et al., 2018; Pennycook & Rand, 2019). The results aligned with Batailler et al.' s (2022) initial hypothesis that partisan bias influences information identification by affecting judgment criteria. Specifically, individuals tend to view information inconsistent with their partisan stance as misinformation. Although they initially hypothesized that analytic thinking would influence information identification by affecting discrimination sensitivity, the results showed that analytic thinking could influence information identification not only by improving discrimination sensitivity but also by increasing the tendency to identify information as false. Furthermore, their study further explored the relationship between analytic thinking and partisan bias. The results indicated that although both factors jointly influence misinformation identification, increased analytic thinking did not reduce partisan bias. This further supports this paper' s viewpoint that the opposition between motivated System 2 reasoning and classical reasoning accounts is actually a misunderstanding.

Similarly, Gawronski et al. (2023) also revealed that motivated System 2 reasoning and classical reasoning accounts are not mutually opposed. Through signal detection theory analysis, they found that giving participants more analytic

thinking time during misinformation identification improved their discrimination sensitivity and also increased their tendency to identify information as false, but did not reduce their partisan bias. This finding is consistent with Batailler et al. (2022) and again proves that partisan bias and analytic thinking do not influence each other. Meanwhile, the study also found that partisan bias influences information identification by changing individuals' judgment criteria. Specifically, individuals are more inclined to trust information consistent with their partisan stance when identifying information. Their comprehensive analysis found that partisan bias plays a central role in misinformation susceptibility. Although the study did not confirm that manipulations of self-affirmation or self-threat affect partisan bias, it suggests that future research needs to further explore deeper factors influencing partisan bias.

4. Hierarchical Model of Misinformation Identification Based on Signal Detection Theory

The aforementioned signal detection theory-based research collectively points out that motivated System 2 reasoning and classical reasoning accounts are not mutually opposed (Batailler et al., 2022; Gawronski et al., 2023). Part of the reason for mistakenly viewing them as opposed lies in previous research' s failure to adequately distinguish the roles of different factors in misinformation identification. Based on signal detection theory analysis results, Gawronski et al. (2023) proposed a brief hierarchical model for understanding why individuals trust misinformation, aiming to more clearly understand how different factors influence misinformation identification. In the first layer of this model, factors influencing misinformation identification are divided into information discrimination sensitivity and partisan bias. The second layer further explores the psychological foundations influencing the first-layer factors. For example, lack of analytic thinking and insufficient attention to truth lead to reduced discrimination sensitivity in misinformation identification, while individuals' subjective judgment confidence exacerbates partisan bias.

Although the work of Batailler et al. (2022) and Gawronski et al. (2023) initially outlined a signal detection theory-based hierarchical model of misinformation identification, the model has room for improvement in several aspects. First, when considering factors influencing misinformation identification, the model has not yet incorporated important factors such as emotion and information characteristics. As Batailler et al. (2022) noted in their study, future research should consider the influence of other factors such as information sources on misinformation identification through signal detection theory analysis methods. Second, the model's analysis of the deep reasons why partisan bias influences misinformation identification is insufficient (Gawronski et al., 2023). Additionally, the model is primarily based on the special political context of the U.S. two-party system, where partisan bias is regarded as a key research object. However, misinformation identification is not limited to the political domain and may occur in various other social and cultural contexts. Therefore, partisan bias is

somewhat just a special case influencing judgment criteria. In view of this, this paper will supplement and refine the signal detection theory-based model of misinformation identification to make it applicable to broader application scenarios.

4.1 Influence of Emotion on Misinformation Identification

Emotion is one of the important factors influencing judgment (Lerner et al., 2015), and some studies have explored the influence of emotion on misinformation identification (Bago et al., 2022; Martel et al., 2020; Weeks, 2015).

First, emotion can influence individuals' judgment criteria when identifying misinformation. Weeks (2015) investigated the influence of emotional states on misinformation identification. The study manipulated participants' anger or anxiety by having them write essays about immigration reform and the death penalty. Subsequently, participants were asked to identify partisan misinformation. The results found that anger enhanced individuals' tendency to support partisan information, while anxiety reduced this tendency. This may be because anxiety prompts individuals to consider information from multiple perspectives, thereby reducing partisan bias in information identification. Conversely, anger triggers individuals' defensive psychology, reduces thinking about opposing information, and thereby increases partisan bias in information identification. Therefore, emotion can influence judgment criteria by strengthening or weakening individuals' tendency to trust information aligned with their partisan stance.

Second, emotion can also serve as a cue and basis for information identification, thereby influencing individuals' discrimination sensitivity when identifying information. The feelings-as-information theory posits that people use their emotional feelings (whether conscious or unconscious) as an information source that influences cognitive style and judgment (Schwarz & Clore, 2003). Similarly, the affect heuristic theory emphasizes that subjective emotional experiences generated when individuals face judgment tasks can serve as judgment basis, and this emotion-dependent judgment is an important component of System 1 processing (Slovic et al., 2007). From the dual-system theory perspective, emotion-dependent judgment and rationality-dependent judgment have a certain oppositional relationship. Martel et al. (2020) used an induction cue paradigm to divide participants into affective induction, rational induction, and control groups to explore the different roles of emotion-dependence and rationality-dependence in misinformation identification. The results found that rationality-dependent methods were more accurate than emotion-dependent methods when identifying information. Related research also indicates that emotional involvement in misinformation identification usually predicts reduced accuracy in misinformation identification (Bago et al., 2022; Martel et al., 2020). These studies show that emotion, as a cue and basis for information identification, can lead to reduced discrimination sensitivity in misinformation identification by inhibiting or hindering individuals' rational cognition.

The above evidence indicates that emotion' s influence on misinformation identification is dual-pathway: on the one hand, emotion influences misinformation identification by affecting individuals' judgment criteria; on the other hand, emotion also influences misinformation identification by affecting individuals' discrimination sensitivity. Bago et al. (2022) also validated this view in their supplementary analysis.

4.2 Influence of Information Characteristics on Misinformation Identification

There are obvious characteristic differences between misinformation and true information, and these differences can serve as cues and basis for individual misinformation identification. According to Vosoughi et al.' s (2018) big data research, misinformation typically spreads faster, deeper, farther, and more widely, has more novel content, and more easily triggers individuals' disgust emotions. 刘雅辉 et al. (2018) showed that misinformation content tends to include more negative emotional words, verbs, first-person pronouns, profanity, non-standard grammar, symbolic aids, and intensified tone. Li et al. (2022) revealed several key characteristics of misinformation content, including exaggerated and absolute expressions, seductive wording, overly strong tone, claims of uniqueness and secrecy, and problematic punctuation usage. Additionally, the study pointed out that misinformation' s layout and presentation methods also have certain irrationalities. Zheng et al. (2021) found that misinformation headlines tend to use definitive expressions while also containing more emotional appeals. 吴诗苑 et al. (2022) reviewed misinformation characteristics from multiple perspectives including content, users, and dissemination, pointing out that misinformation identification can be divided into entity feature recognition (e.g., graphics, text) and non-entity feature recognition (e.g., information attitude, emotion, and stance).

Information source attribute characteristics can also serve as cues and basis for individual misinformation identification. According to Hovland' s source credibility model, individuals' perceived credibility of information sources positively correlates with perceived information credibility (Ismagilova et al., 2020), and further divides information source credibility into authenticity and professionalism dimensions. Pilditch et al. (2020) used a probabilistic learning paradigm to explore the influence of individuals' direct experience and information source credibility on information identification. In their study, the number of times an information source participated in tasks was used to manipulate professionalism, linking the information source' s interests to participants' judgment performance as authenticity manipulation, while using feedback on drug effectiveness after individual choices as direct experience manipulation. The results found that individuals' perceived credibility of information sources had a greater influence on judgment than direct experience. Additionally, Trivedi et al. (2020) also validated the positive correlation between perceived information source credibility and individual information trust. Furthermore, their study using eye-tracking

indicators (Trivedi et al., 2022) found that individuals with lower misinformation identification ability pay more attention to information sources when identifying information, possibly because they are more inclined to use information source heuristics to identify information. These studies show that individuals tend to view information from high-credibility sources as true information and information from low-credibility sources as misinformation.

When individuals use the above information characteristics as cues and basis for misinformation identification, the magnitude of characteristic differences between misinformation and true information affects misinformation identification. Similarly, in signal detection theory, stimulus similarity is also a key indicator affecting judgment, directly influencing individuals' discrimination sensitivity (Green & Swets, 1966; Lynn & Barrett, 2014). Therefore, the above characteristic differences between misinformation and true information can be viewed as physical characteristic differences between signal and noise within the signal detection theory framework. When characteristic differences between misinformation and true information are smaller, individuals' discrimination sensitivity is lower, making it more difficult to distinguish misinformation from true information. For example, some misinformation disseminators disguise themselves as high-credibility information sources to spread misinformation (Trivedi et al., 2020), which reduces participants' accuracy in identifying misinformation. Conversely, when characteristic differences between misinformation and true information are larger, individuals' discrimination sensitivity is higher, making it easier to distinguish misinformation from true information. For instance, overly exaggerated misinformation headlines improve individuals' information identification accuracy.

4.3 Influence of Individual Stance and Underlying Motivations on Misinformation Identification

The partisan bias individuals exhibit when identifying information is actually just a surface phenomenon based on motivated reasoning, and it is necessary to further explore the deeper motivations behind partisan bias. Moreover, partisan bias is just a special case affecting judgment criteria, and other similar factors should be explored to more comprehensively understand the influencing factors of misinformation identification and effectively expand and apply existing research findings.

Lewandowsky and Oberauer (2016) argue that the emergence of misinformation and its negative impacts are closely related to specific historical backgrounds, including reduced social capital, shifting values, increased polarization in American society, declining trust in science, differences in susceptibility to misinformation across political parties, and changes in the media landscape. They emphasize that individuals' rejection of scientific information and trust in misinformation are deeply influenced by their core beliefs and worldviews. Similarly, Hornsey and Fielding (2017) metaphorically compare individuals' specific motivations and attitudes toward information identification to leaves and branches,

while underlying motivations such as latent fears, social identity needs, interests, identity, conspiracy theories, ideology, and worldview are compared to roots. They believe that the key to improving misinformation identification accuracy lies in understanding and utilizing these deep-seated motivations for effective persuasion and guidance. Additionally, Van Bavel and Pereira (2018) proposed an identity-based model to explain why individuals' beliefs tend toward partisanship rather than truth. The model posits that partisan groups satisfy individuals' needs for belonging, distinctiveness, cognitive closure, access to rights and resources, and identification with moral values. Therefore, individuals may perceive the benefits of supporting truth as smaller than the benefits of supporting partisan stance, leading them to tend to use partisan stance to identify information. This view also aligns with our above hypothesis that partisan stance motivation and accuracy motivation are opposed in misinformation identification. These theories indicate that partisan stance is merely a surface phenomenon influencing individual misinformation identification, while actual interests and psychological needs hidden behind partisan stance are the core elements influencing individuals' judgment criteria. From the signal detection theory perspective (Green & Swets, 1966; Lynn & Barrett, 2014), these deep-seated motivations can be viewed as post-judgment payoffs that influence misinformation identification by affecting individuals' judgment criteria.

Moreover, partisan stance as the focus of existing research primarily stems from the special political background of the U.S. two-party system. Treating partisan stance as a core factor of the model may limit its broad applicability. Therefore, partisan bias should be regarded as a special case affecting judgment criteria, and other similar stances (such as gender, economic status, social role, etc.) should be considered to expand and apply existing research findings. The above exploration of deep-seated motivations behind partisan stance also provides theoretical support for understanding and explaining different stances that affect judgment criteria. For example, misinformation may also involve different stances such as gender or economic status, and individuals' tendency to trust or reject information of a certain stance when identifying information may similarly stem from considerations of actual interests and psychological needs.

4.4 Hierarchical Model Diagram of Misinformation Identification Based on Signal Detection Theory

From the signal detection theory analysis perspective, existing research provides the basic framework for the model (Batailler et al., 2022; Gawronski et al., 2023). Within this framework, influencing factors of misinformation identification can operate through two main pathways: one affecting discrimination sensitivity, and the other affecting judgment criteria. Specifically, lack of analytic thinking and insufficient attention to truth weaken individuals' discrimination sensitivity in misinformation identification, while partisan bias operates by changing judgment criteria, making individuals more inclined to view information inconsistent with their stance as misinformation.

Furthermore, this paper deeply explores the deep-seated reasons why partisan bias influences misinformation identification. In misinformation identification, partisan bias is only a surface phenomenon and special case affecting individuals' judgment criteria, while actual interests and psychological needs behind it are the core factors influencing individuals' judgment criteria. Simultaneously, this paper expands the concept of partisan bias to a broader stance, enabling the model to effectively apply to different situations and cultural contexts.

Additionally, factors such as emotion and information characteristics are incorporated into the model. Emotion, as a key factor influencing misinformation identification, can not only influence individuals' judgment criteria by strengthening or inhibiting their stance tendencies (Weeks, 2015) but also reduce individuals' discrimination sensitivity by competing with rational thinking (Bago et al., 2022; Slovic et al., 2007). Meanwhile, individuals' stance and its underlying deep-seated motivations can also trigger emotional responses (汪新建等, 2017; Kahan et al., 2010).

Similarly, characteristic differences between misinformation and true information also influence individuals' discrimination sensitivity, thereby affecting misinformation identification. When the characteristic gap between misinformation and true information is smaller, meaning misinformation is highly disguised, individuals' discrimination sensitivity is lower, and it becomes more difficult to accurately identify information. When the characteristic gap between misinformation and true information is larger, meaning misinformation is less disguised, individuals' discrimination sensitivity is higher, and they can more effectively identify misinformation.

In summary, this model divides factors influencing misinformation identification into two categories: those operating by influencing judgment criteria, and those operating by influencing discrimination sensitivity. Regarding judgment criteria, individuals' deep-seated motivations play a key role, making individuals more likely to trust information consistent with their own stance. Additionally, emotion can also strengthen or weaken this stance tendency, thereby influencing judgment criteria. Meanwhile, individuals' stance and underlying deep-seated motivations can also trigger emotional responses. Regarding discrimination sensitivity, characteristic differences between misinformation and true information and rational thinking play key roles. Emotion can also influence discrimination sensitivity through interaction with rational thinking (see Figure 1 [Figure 1: see original paper]).

Figure 1 Hierarchical Model of Misinformation Identification Based on Signal Detection Theory

The establishment of this model helps deeply understand the roles different factors play in misinformation identification and can reconcile the disagreement between motivated System 2 reasoning and classical reasoning accounts. According to the hierarchical model of misinformation identification based on signal detection theory, the core factors emphasized by motivated System 2 reasoning

and classical reasoning accounts influence misinformation identification through different pathways. The partisan bias emphasized by motivated System 2 reasoning primarily operates by influencing judgment criteria, while the analytic thinking emphasized by classical reasoning primarily operates by influencing discrimination sensitivity. For example, Kahan et al. (2017) found that individuals with high numeracy showed higher accuracy in evaluating skin cream effectiveness (unrelated to partisan stance) but were more inclined to trust information consistent with their partisan stance in evaluating gun control effectiveness (related to partisan stance), thereby reducing judgment accuracy. According to the model, when judgment tasks do not involve partisan stance, high-numeracy individuals have higher discrimination sensitivity and thus more accurate information judgment. When judgment tasks involve stance, individuals' deep-seated motivations cause judgment criteria to favor information beneficial to their own stance, thereby reducing accuracy.

This further illustrates that the main factors emphasized by the two theories can be divided into two different pathways: influencing discrimination sensitivity or influencing judgment criteria. It is worth noting that although such division helps clearly understand the roles different factors play in misinformation identification, it does not mean that a factor can only operate through one pathway. In fact, some factors' effects on other pathways may be relatively small and unstable, thus not being fully reflected in the current model. For instance, Batailler et al. (2022) and Gawronski et al. (2023) found that analytic thinking can also influence information identification by increasing individuals' tendency to identify information as false, but this effect is small and unstable. Additionally, their studies found that the interaction between analytic thinking and partisan stance on judgment criteria was not significant (Batailler et al., 2022; Gawronski et al., 2023), which not only weakens analytic thinking' s influence on judgment criteria but also partly refutes the hypothesis that analytic thinking strengthens partisan stance. Overall, motivated System 2 reasoning and classical reasoning accounts are not opposed to each other but focus on different aspects; the factors they emphasize both play important roles in misinformation identification.

Furthermore, by distinguishing two pathways influencing misinformation identification, this model not only helps understand why individuals trust misinformation but also provides strategic implications for information governance. Specifically, different governance strategies can be adopted for different types of misinformation. For example, for misinformation that is easily believed due to lack of vigilance, strategies such as adding warning labels to information (Pennycook et al., 2020) or strengthening individuals' preventive awareness (Swire et al., 2017) can be used to improve discrimination sensitivity, thereby reducing trust in misinformation. For misinformation containing different stances that is difficult to directly correct, in addition to timely emotional soothing triggered by the information, it is necessary to deeply analyze the underlying interests and psychological needs behind the information (Hornsey & Fielding, 2017) and guide individuals to establish correct judgment criteria, thereby effectively re-

ducing the impact of misinformation on individuals and society.

5. Summary and Outlook

This paper introduced two important theories influencing misinformation identification: the motivated System 2 reasoning account (Kahan, 2013; Kahan & Corbin, 2016; Kahan et al., 2012; Kahan et al., 2017) and the classical reasoning account (Pennycook & Rand, 2019, 2020). Although some studies view these two theories as opposing viewpoints (Bago et al., 2020; Gawronski et al., 2023; Pehlivanoglu et al., 2022; Pennycook & Rand, 2019, 2020), this view may be a misunderstanding resulting from insufficient understanding of the different roles motivation and cognitive ability play in misinformation identification. In response, the hierarchical model of misinformation identification based on signal detection theory divides factors influencing misinformation identification into two pathways—by influencing judgment criteria or discrimination sensitivity—enabling researchers to more clearly and deeply understand the roles different factors play in misinformation identification (Batailler et al., 2022; Gawronski et al., 2023) and reconciling contradictions among existing theories. Additionally, based on relevant research and theories, this paper deeply explores the deep-seated reasons for partisan bias and expands this special case to broader stances to apply to different situations and cultural contexts. Moreover, this paper incorporates factors of emotion and information characteristics into the model, supplementing and refining the hierarchical model of misinformation identification based on signal detection theory, providing researchers with a more comprehensive theoretical framework for understanding how individuals identify misinformation and offering theoretical support for practical information identification and governance applications.

Although the signal detection theory-based model provides a new perspective for researching and understanding misinformation identification, it still has some limitations. Overall, using basic signal detection theory analysis inevitably has certain limitations. First, this model uses basic signal detection theory based on binary judgments (“true” or “false”), but some studies use multi-point scales to assess trust in misinformation, which prevents the model from fully utilizing information. Although signal detection theory based on multi-point scales exists, these models are usually more complex (e.g., involving multiple judgment criteria) and require deeper exploration of relevant factors to adapt to complex models. Second, signal detection theory’ s calculation process is relatively complex, which may lead to poor model fit with actual research data. Third, signal detection theory assumes that the statistical characteristics of signal and noise are known and stable, but in reality, the forms and characteristics of misinformation are constantly changing.

Although this paper discusses the influence of emotion on misinformation identification, many aspects require further research. First, although this paper points out that emotion can influence misinformation identification by affecting discrimination sensitivity or judgment criteria, the specific roles and mechanisms

of different emotions are not yet clear. The appraisal-tendency framework theory posits that different emotions lead individuals to adopt different cognitive patterns when processing information (Lerner et al., 2015), but current research is insufficient. For example, positive emotions seem to have complex effects on human reasoning (Pham, 2006), but research exploring the influence of positive emotions on misinformation identification is relatively scarce. Additionally, the role of anger in misinformation identification shows inconsistent results in existing research. Weeks (2015) found that anger states strengthened individuals' tendency to trust information consistent with their partisan stance. However, Bago et al. (2022) found that when people felt angry facing information headlines inconsistent with their stance, their misinformation identification performance was actually more accurate. Future research needs to further explore the reasons behind this. Second, existing research exploring the relationship between emotion and misinformation identification does not clearly distinguish between integral and incidental emotions (朱月龙等, 2017). Integral emotions are subjective emotional experiences caused by current information, while incidental emotions are background emotions less related to the information itself. For example, Weeks (2015) and Bago et al. (2022) measured integral emotions related to misinformation, while Martel et al. (2020) measured incidental emotions less related to misinformation. Therefore, future research can further explore the influences of integral and incidental emotions on misinformation identification.

Furthermore, research can further refine cognitive factors influencing misinformation identification. Rational thinking is an important factor influencing misinformation identification, and its measurement can be divided into cognitive ability measurement and cognitive disposition measurement (冯雪, 彭凯平, 2015). Similarly, in Stanovich' s (2016) triarchic intelligence theory, System 2 rational cognition can be further divided into cognition related to computational ability and cognition related to rational thinking disposition. As mentioned in this paper, another reason for mistakenly viewing motivated System 2 reasoning and classical reasoning accounts as opposed may be that the measurement tools used in relevant research do not correspond clearly enough to what the theories refer to. Although the Cognitive Reflection Test (CRT) can measure the ability to inhibit intuitive reactions in System 2, it is closely related to individuals' arithmetic ability and has ceiling and floor effects in some groups (Thomson & Oppenheimer, 2016). This suggests that researchers need to use other tools to measure rational thinking when exploring its relationship with misinformation identification. Existing research has found that using the Actively Open-Minded Thinking scale as a measure of rational thinking disposition can not only effectively predict misinformation identification accuracy (Mirhoseini et al., 2023; Saltor et al., 2023) but also explain why individuals with delusional tendencies are more likely to trust misinformation (Bronstein et al., 2019). Notably, although Kahan (2017) found that individuals with high actively open-minded thinking are more inclined to trust information consistent with their own stance when identifying information (Kahan & Corbin, 2016), this result has been questioned by other researchers (Baron, 2017). Addition-

ally, Baron (2017) pointed out that the Actively Open-Minded Thinking scale and Cognitive Reflection Test measure different cognitive styles, which may be reflected in the quantity and direction of thinking. Therefore, further exploration is needed on how rational thinking measured by different tools influences misinformation identification.

Additionally, future researchers can manipulate misinformation characteristics through experiments to more clearly reveal how these characteristics influence misinformation identification. Currently, misinformation characteristics are mainly extracted through big data technology and computer algorithms, which, although having high ecological validity, are not rigorous enough in proving causal relationships. Moreover, some researchers suggest manipulating post-judgment payoff, base rate of event occurrence, and stimulus similarity through experimental design to further improve signal detection theory (Green & Swets, 1966; Lynn & Barrett, 2014). Therefore, subsequent researchers can manipulate characteristic differences between misinformation and true information through experimental methods to further refine and validate the existing model.

Although this model emphasizes the need to consider diverse stances including gender, economic status, and social role influences on judgment criteria, existing research mostly focuses on partisan stance in the U.S. two-party political context, with relatively insufficient research on other stances. In view of this, future research can deeply explore diverse stances in misinformation identification across different situations and cultural contexts to enhance the model' s applicability.

In conclusion, the hierarchical model of misinformation identification based on signal detection theory provides researchers with a clear theoretical framework that helps deeply understand and analyze multiple factors influencing misinformation identification and provides theoretical basis for information identification and governance practices in real life.

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Note: Figure translations are in progress. See original paper for figures.