Cognitive Processing

In the blink of an eye: behavioural correlates of the confirmation bias effect

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In the blink of an eye: behavioural correlates of the confirmation bias effect*

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The present study aimed to explore the relationship between confirmation bias effect, cognitive load and participants' eye movement activity. To investigate potential behavioural correlates, the laboratory eye-tracking experiment was conducted. Participants (N = 52, 1705 observations) read short social media text messages with different valence (approving and disapproving), which either matched or conflicted with their pre-existing attitudes toward the topic. All stimuli were counterbalanced. Eye blink rate was measured as the dependent variable. The results indicated that the confirmation bias effect was indeed associated with changes in oculomotor activity. Specifically, there was a significant increase in eye blink rate for stimuli that were incongruent with participants' beliefs, and a decrease in blink frequency for congruent stimuli.

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I. Introduction

The decision-making process regarding perceived information is influenced by various factors, with cognitive bias being one of the most significant (Tversky & Kahneman, 1981; Cortes et al., 2023). Among the cognitive biases that profoundly impact decision-making, confirmation bias is particularly prevalent. Confirmation bias (CB) refers to the tendency to selectively seek, interpret, recall, and remember information that aligns with an individual's pre-existing beliefs or expectations (Klayman, 1995; Nickerson, 1998; Koriat et al., 1980; Wickens et al., 2000; Peters, 2022).

While confirmation bias may have evolutionary underpinnings and can sometimes produce positive effects on decision-making and behaviour (Peters, 2022), its negative consequences across various domains are significant and warrant close attention. For example, in the medical field, CB can lead to diagnostic errors, where physicians may either reinforce an earlier diagnosis or overlook symptoms that contradict it (Pines, 2006; Parmeley, 2021). Similarly, in the fields of science and law, positive hypothesis testing driven by CB can result in flawed conclusions (Fugelsang, Stein, Green, & Dunbar, 2004). Although such errors may occur at the individual level, their repercussions can extend to broader societal impacts.

A particularly critical category of negative effects associated with confirmation bias involves its influence on social life. For instance, confirmation bias contributes to the polarization of opinions (Spohr, 2017; Del Vicario et al., 2017) and the spread of misinformation, particularly in online communication (Del Vicario, 2016). This issue is exacerbated by the formation of echo chambers, where individuals primarily share and consume information that reinforces their existing beliefs (Jiang et al., 2021; Del Vicario et al., 2017; Jamieson et al., 2008; Flaxman et al., 2016). As a result, readers on social media are more likely to trust news that aligns with their beliefs, further entrenching these echo chambers. This dynamic has become a crucial factor in shaping social interactions in the modern world, often heightening tensions in socially significant campaigns. A notable example is the campaign for mass COVID-19 vaccination, which encountered considerable resistance. Despite extensive educational efforts, a significant portion of the population continues to refuse vaccination, a stance that can largely be attributed to pre-existing public attitudes towards vaccination (Howell et al., 2022).

In light of this, our main hypothesis that we want to test concerns the replicability of the CB effect on our material.

H1*: There will be a confirmation bias effect, characterized by higher credibility scores for news that aligns with the user's beliefs and lower credibility scores for news that contradicts those beliefs.*

Confirmation bias and cognitive loading

Following the work of some researchers (Jonas et al., 2001; Cao et al., 2014; Marquart et al., 2016; Stone & Wood, 2018; Ling, 2020), we explain the confirmation bias effect by the human brain's predisposition to minimize cognitive effort, linking the avoidance of information irrelevant to beliefs to the mechanism of cognitive dissonance (Festinger, 1957). According to the theory of cognitive dissonance, individuals prefer to avoid information that makes them uncomfortable (Jonas et al., 2001; Knobloch-Westerwick et al., 2014; Moravec et al., 2018). Confirmation of this link can be found in a series of experimental studies. For example, Moravec and colleagues (2018) demonstrated that reading headlines inconsistent with participants' beliefs caused a suppression of the alpha band (8-12 Hz), which is associated with an increase in cognitive load. Additionally, research by Rajsic and colleagues (2015) supports the idea that higher cognitive load contributes to the biased selection of information. Specifically, a series of experiments demonstrated that participants prefer to choose a confirmatory strategy, looking for a target that matches their template, rather than disconfirming it by looking in a non-matching set, even though this strategy is less efficient. The authors suggested that searching for a target in a matching set requires less cognitive effort due to the limited visual working memory capacity. The same mechanism may apply to more complex cognitive tasks. Moreover, the association of cognitive load with the severity of the CB effect has been demonstrated. Also, a recent research by Goette and colleagues (2020) showed the effect of the information environment on confirmation bias. In a guessing task experiment, participants were asked to infer which “computer” (the one that is more likely to produce high or low numbers) had produced a sequence of numbers with varying levels of difficulty in perceiving the sequence. The results suggest that higher information overload increases confirmation bias and has a stronger impact on participants’ belief-updating behaviour.

Thus, we can identify at least two variants of the relationship between confirmation bias and cognitive load. First, stimuli that contradict an individual's pre-existing beliefs can lead to an increase in cognitive load (Rajsic et al., 2015; Moravec et al., 2018). Second, in a state of increased cognitive load (e.g., due to visual stress), individuals are more likely to make decisions based on confirmation bias (Goette et al., 2020).

In this article, we seek to determine whether the confirmation bias effect is associated with an increase in cognitive load, presumably due to cognitive dissonance, and whether it can be operationalized through behavioural oculomotor correlates in online news consumption.

Confirmation bias, cognitive loading and eye movements

Among the oculomotor correlates of cognitive load are gaze aversion (Glenberg et al., 1998; Yang et al., 2018), eye blink rate (Wood & Hassett, 1983; Ueda et al., 2016; Smilek et al., 2010; Benedek et al., 2017; Salvi et al., 2015), Closing time (Veltman & Gaillard, 1998), duration (Benedek et al., 2017; Salvi et al., 2015), amplitude and startle eye blink (A. Mahaffey et al., 2005; Amodio et al., 2003; Mahaffey et al., 2011). For the purposes of this study, we focus only on eye blinks as a behavioural correlate of changes in cognitive load. However, the full list we prepared can be found in Table A in the Supplementary Materials.

The eye blink rate, defined as the mean number of blinks per unit of time, has been associated with various aspects of *cognitive load*. Increased eye blinking is indicative of heightened cognitive activity during task performance, a phenomenon demonstrated in multiple experiments involving both easy and difficult tasks (Benedek et al., 2017; Ueda et al., 2016; Wood & Hassett, 1983). Notably, eye blink frequency correlates positively with task difficulty, suggesting that individuals exhibiting higher blink rates tend to generate more ideas in creative tasks and arrive at solutions more rapidly in analytical tasks (Benedek et al., 2017; Ueda et al., 2016). Furthermore, increased blinking has been observed during creative tasks compared to analytical tasks (Salvi et al., 2015) and during mind wandering compared to focused reading tasks (Smilek et al., 2010). In a complementary study by Veltman and Gaillard (1998), participants engaged in a flight simulation while performing tasks of varying difficulty, enabling an exploration of the intervals between blinks. The findings revealed that the interval between blinks increases when participants process complex visual information. Conversely, as task difficulty escalates, the interval between blinks decreases, suggesting that participants blink more frequently to manage cognitive load. Additionally, closing time—the duration required to complete a blink—decreases under conditions of visual overload, emphasizing the need for rapid visual processing to detect obstacles. Nonetheless, closing time did not show a significant correlation with task difficulty. Similar patterns were observed for blink amplitude and blink duration, with both indicators lacking a significant correlation with task difficulty but exhibiting negative correlations with visual load. Overall, these findings underscore the potential of eye blink metrics as indicators of cognitive processing and load across diverse task contexts.

Numerous studies have established a connection between eye blink frequency and biases. For instance, research conducted by Mahaffey et al. (2005) demonstrated a significant association between negative attitudes toward gay individuals and physiological responses characterized by increased blink amplitude. This study confirmed that eye blinking serves as an effective measure of anti-gay bias, as individuals exhibiting negative attitudes toward gay men displayed a negative affective response when exposed to stimuli such as images of nude men. Although the researchers hypothesized that these responses could be attributed to defensive reactions stemming from uncertainty regarding one's sexual orientation, this hypothesis was not validated in subsequent investigations (Mahaffey et al., 2011). In addition, the interpretation of eye blinks varies based on cognitive processing context and response latency. Amodio et al. (2003) examined confirmation bias in racial perception by categorizing participants into three groups based on their motivations regarding equality. The study investigated the relationship between these attitudes and short- and long-latency startle responses. In short-latency conditions, participants demonstrated limited control over reactions, with blink inhibition indicating affective responses to images of Black faces. In contrast, long-latency conditions revealed that participants with low internal motivation exhibited larger blink amplitudes in reaction to Black faces compared to White faces, suggesting a negative response. These findings indicate that the startle eye blink response effectively detects prejudiced reactions, as increased blink amplitude correlates with underlying biases.

Thus, a change in the eye blink rate may first be associated with a change in the amount of cognitive load (Benedek et al., 2017; Ueda et al., 2016; Wood & Hassett, 1983; Salvi et al., 2015; Smilek et al., 2010) and second, it may be an indicator of the presence of implicit bias (Mahaffey et al., 2005; Mahaffey et al., 2011; Amodio et al., 2003). However, the eye blink rate has never before been applied to assess bias in text comprehension, much less in the context of online communication in SNSs.

Thus, we hypothesize the following relationships: inconsistency of information with the reader's beliefs will lead to an increase in cognitive load, which in turn will lead to an increase in eye blink rate. All this allows us to operationalize our hypothesis H2 as follows:

H2. Matching (mismatching) the stimulus valence to the user's beliefs will result in a decrease (increase) in eye blink rate during reading process.

To test the hypotheses, we conducted a laboratory experiment with eye movement recordings.

I. Method

Participants

Participants were native Russian speakers (N=52, 17 males, Mage = 26.86 *(7.09)*). The sample was balanced in terms of age, gender, and key demographic attributes: 42% of participants were studying and 46% were employed, also 12% of participants were unemployed or retired. Data from 4 individuals were excluded from the analyses due to a recording error.

Environment and quipment

We used the Pupil Core mobile eye movement tracking system (Pupil Labs, Pupil Labs GmbH, Germany). Recordings were performed in serial mode. Participants worked on a laptop computer with a 15.6-inch monitor (1900 x 1200) and a sampling rate of 120 Hz. The Pupil Core mobile eye-tracking system was connected to the laptop using Pupil Labs open source Softwear v.3.4 software. Recordings were made in a quiet room with balanced artificial light, with all participants working at a separate computer. The experimenter could not see the participant's computer screen to avoid biased responses.

Stimuli

A separate web interface in *python* (for the server side) and in *html* (for the client side) was developed specifically for the purposes of the experiment. The interface imitated a message in a social network. In total 36 social media news messages were used as material (1 additional training text was given, which was not included in the analysis afterwards). Texts may or may not be accompanied by comments in a similar way to social media. All texts were taken from news networks or written by a professional journalist. All texts were professionally evaluated by experts, including journalists, sociologists and psychologists. All texts were written on one of three socially important topics (death penalty, abortion, LGBTQ+ rights).

Each news text was accompanied by a positive comment (“pro-topic”), a negative (“contra-topic”) comment, or presented without a comment (x3). For real news, comments were selected from among the comments on those news items. For fake news, comments were taken from comments to messages in SNS on a similar topic. Since a social media message is a combination of text and commentary, it is not possible to reliably separate the effects of message and commentary on the perceptual process. For this reason, we used the combination of text and commentary as the stimulus unit. Thus, a total of 6 types of stimuli can be distinguished (see Table 1).

Table 1. Combination of comment and message valence across stimulus types.

Condition	Message valence	Comment valence
1	negative/contra	negative/contra
2	negative/contra	positive/pro
3	negative/contra	without comment
4	positive/pro	negative/contra
5	positive/pro	positive/pro
6	positive/pro	without comment

Each text was approximately 334 (73) words in length. We pre-tested the difference between groups of texts on the length factor using a non-parametric Mann-Whitney U-test for *veracity* (false and true messages) ($p = 0.365$); for *text valence* (between groups with positive and negative valence) ($p = 0.959$); and Kruskal-Wallis ANOVA by Ranks for *comment valence* (between groups with positive, negative and no comment texts) ($p = 0.991$); for *topic* (between texts of different topics) ($p = 0.365$).

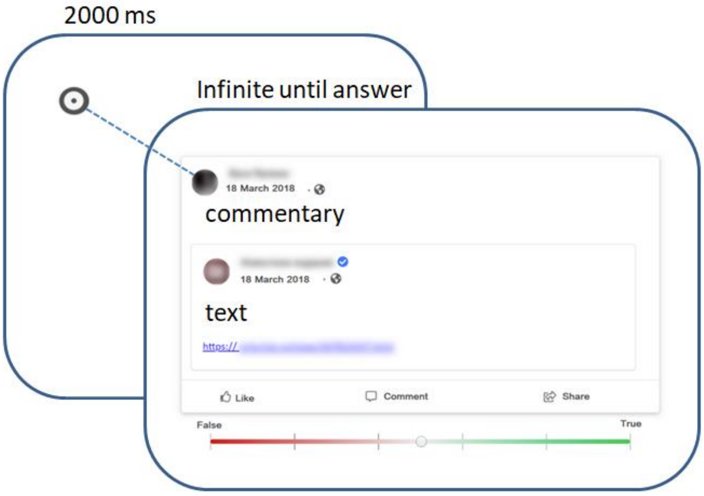
Design & Procedure

The procedure for the experimental study was approved by the Commission for Ethical Assessment of Empirical Research Projects at the NAME of the University (deleted for the blind version). All participants completed an informed consent form before starting the experiment.

Participants' sociodemographic status (in the form of a pre-designed survey), including age, gender, level and field of education, and attitude, was recorded prior to the eye-tracking session. During the eye-tracking session, participants were asked to read news posts presented in an interface that mimicked a social network feed and to make a judgment about the trustworthiness of these messages by selecting a response option on a Likert scale (1 - “definitely false”, 7 - “definitely true”) using the mouse. All other messages were presented in random order.

The experiment began with a 5-point calibration. We considered accuracy < 0.3 and precision < 0.1 to be acceptable for recording.

The experimental trial started with a reference point followed by a text. Switching between texts was performed after pressing the "next" button (see Pic. 1). The eye tracker was recalibrated every 6 texts (~3-4 min) (see (Ehinger et al., 2019) for an explanation). The training session contained one text that was the same for all participants, the results of which were excluded from further analyses.



Picture 1. The experimental trial example.

The figure (picture 1) shows the change of screens of the experimental trial. The first screen includes a reference point whose coordinates correspond exactly to the commentator's avatar on the stimulus screen. On the first screen, the participant is required to look at the reference point for 2000 ms, after which the screen will change. On the second screen, the participant has to read the text and rate its credibility on a 6-point Likert scale.

Independent variables

Attitude. We asked respondents to evaluate their attitudes toward topics using a 7-point Likert scale (1 is "definitely not supporting" and 7 is "definitely supporting"). The survey was added before the experiment to avoid a priming effect. The values 1,2,3 on Likert scale were further used as indicators of negative attitude towards the topic, values 5,6,7 were used as indicators of positive attitude towards the topic.

Message valence. All news articles had a positive ("pro-topic", e.g., support LGBTQ+ rights) or negative ("contra-topic", favour the infringement of LGBTQ+ rights) valence towards the topic addressed (see Knobloch-Westerwick et al., 2014).

The interaction between attitude and text valence created a *message consistency* variable divided into two levels: yes/congruent/match (for texts whose valence matched participants' beliefs) and no/incongruent/mismatch (for texts whose valence did not match participants' beliefs).

Commentary valence. The valence of comments was determined in the same way as for texts.

The interaction between attitude and commentary valence created a *commentary consistency* variable divided into three levels: yes/congruent/match (indicating comments whose valence aligned with participants' beliefs), no/incongruent/mismatch (indicating comments whose valence was inconsistent with participants' beliefs), and no commentary (referring to stimuli that lacked accompanying commentary). These variables formed the basis of the construct variable *Stimulus type*, which contained 6 stimulus combination options. Figure 2 shows all stimulus types presented to the participant. Thus, a participant could see text that matched (Type 5) or did not match their beliefs (Type 2) without any commentary; the text and accompanying commentary could match the user's beliefs (Type 6) or not (Type 1) or could contradict each other (Type 4, Type 3).

	TEXT/MESSAGE CONSISTENCY	COMMENTARY CONSISTENCY
TYPE 1	NO	NO
TYPE 2	NO	NO COMMENTARY
TYPE 3	NO	YES
TYPE 4	YES	NO
TYPE 5	YES	NO COMMENTARY
TYPE 6	YES	YES

Picture 2. Levels of the stimulus type dependent variable.

Type 1 *- text valence and comment valence do not match the participant's beliefs;* ***Type 2*** *- text valence does not match the participant's beliefs, no comment;* ***Type 3*** *- text valence does not match the participant's beliefs, comment valence supports them;* ***Type 4*** *- text valence matches the participant's beliefs, comment valence contradicts them;* ***Type 5*** *- text valence matches the participant's beliefs, no comment;* ***Type 6*** *- text valence and comment valence match the participant's beliefs.*

Dependent variable

The eye blinks rate was chosen as dependent variables. *The eye blinks rate* is a measurement of the number of blinks in a second. This measurement is obtained by dividing the AOI number of blinks by reading duration. Reading duration is the duration of one trial from when the screen appears until the respondent presses the button “next” (in seconds). This is necessary in order to reliably compare texts of different lengths as well as texts presented without commentary.

II. Analysis & Result

A total of 1705 observations were obtained. We removed missing values for variables. We also removed texts with attitude scores of 4 from the final dataset because they were less than 1.5 percent. The final dataset contained 1529 observations. Descriptive statistics for blink rate and fixation duration are presented in Table 2.

Table 2. Mean and SD for blinks depending on the confirmation bias both to text and commentary

Stimulus type		***Credibility***	***Eye blink rate***
Type 1	no - no	3,624 *(1,527)*	0.147 *(0.302)*
Type 2	no - no commentary	3,498 *(1,534)*	0.126 *(0.187)*
Type 3	no - yes	3,568 *(1,557)*	0.125 *(0.142)*
Type 4	yes - no	4,101 *(1,443)*	0.136 *(0.200)*
Type 5	yes - no commentary	3,880 *(1,559)*	0.117 *(0.140)*
Type 6	yes - yes	4,029 *(1,530)*	0.119 *(0.155)*

Notes: 1. Standard deviation values for mean values are presented in parentheses. 2. In the expansion of stimulus types, consistency to message is always listed first, consistency to commentary second.

Confirmation bias effect

To test the effect of confirmation bias on the perception of news reports in our experiment, as outlined in hypothesis H1, we constructed linear mixed-effects model. The selection of the final model was based on information criteria. The values of the information criteria can be seen in the commented code output.

In the final model, *credibility* was the dependent variable, while news consistency and comment consistency were treated as independent variables. The *news topic issue* (abortion, LGBTQ+, death penalty) variable was added to the model as a control variable. Additionally, we controlled for gender and age in the final model. Random effects based on the intraclass correlation coefficient (ICC) controlled for were included in the models. The models did not fit the normality test assumption but in LMEM (linear mixed effect model), lack of normality does not significantly reduce model quality (Schielzeth et al., 2020). Table 3 lists the fixed-effect terms of the Mixed-Effect linear model for eye blinks rate.

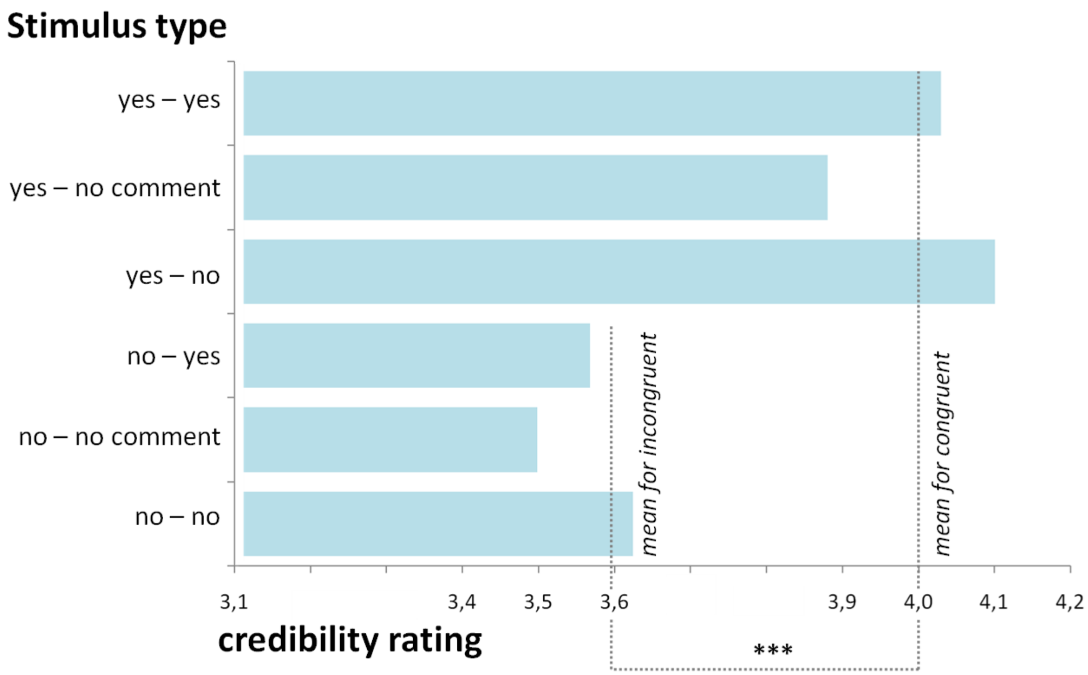
Table 3. Fixed-effect estimates with p-values of Linear Mixed-Effect Models for the credibility rating

	Credibility rating		
Predictors	*Estimates*	*CI*	*p*
(Intercept)	3.86	3.58 – 4.15	**<0.001**
Age	0.13	0.05 – 0.21	**0.001**
Gender (male)	-0.14	-0.31 – 0.03	0.113
News consistency (yes)	0.32	0.15 – 0.49	**<0.001**
Commentary consistency (no commentary)	-0.16	-0.41 – 0.09	0.209
Commentary consistency (yes)	-0.07	-0.27 – 0.13	0.495
News issue (lgbt)	-0.24	-0.57 – 0.09	0.149
News issue (death penalty)	-0.11	-0.45 – 0.22	0.502

Notes: 1. Bold font for significant effects

As the results of the analysis indicate, if the valence of a news item is consistent with the reader's beliefs, the reader gives it higher trust scores ($F = 14.297$, $b = 0.322$, $t = 3.778$, $p < 0.001$). In contrast, there was no significant effect of comment valence on the decision on stimulus credibility ($b = 0.020$, $t = 0.350$, $p = 0.457$; $b = 0.16$, $t = 1.26$, $p = 0.209$). This was also confirmed by comparing contrasts for the levels of this variable using the *emmeans* package (Lenth, 2017), which facilitates obtaining and comparing means for various linear, generalized linear, and mixed models. The level of significance did not exceed the significance threshold ($p > 0.4$-0.7 in all pairwise comparisons). We also examined the effects of the *news topic issue* variable by including it in the model as a control variable and comparing the results for each topic using the emmeans package (Lenth, 2017). No significant effects of message topic were found ($p > 0.3$-0.7 in all pairwise comparisons).

Figure 1 shows the mean values for each stimulus type and for the congruent and incongruent valence groups. The differences for each item obtained from the post-hoc analyses are summarised in Supplementary material.



Picture 3. Dependence of credibility ranging on stimulus type.
*Note: the symbol *** is for the p<0.001 level of significance.*

Thus, it can be concluded that texts aligned with the user's beliefs indeed receive higher ratings on the credibility scale, which confirms hypothesis H1 and suggests the presence of a confirmation bias effect in our data. The validation of hypothesis H1 allows us to proceed to testing hypothesis H2, examining whether the effect of confirmation bias is associated with an increase in blink frequency as an oculomotor correlate resulting from cognitive load induced by this cognitive distortion.

Eye blink rate in confirmation bias effect

To test the hypotheses H2, linear mixed-effects models were constructed. Age and gender of participants were accounted for. In the final model, *eye blink rate* was the dependent variable, while Type of stimuli was treated as independent variables. The *news topic issue* (abortion, LGBTQ+, death penalty) variable was added to the model as a control variable. Additionally, we controlled for gender and age in the final model. Random effects based on the intraclass correlation coefficient (ICC) controlled for were included in the models. The models did not fit the normality test assumption but in LMEM (linear mixed effect model), lack of normality does not significantly reduce model quality (Schielzeth et al., 2020). The commented analysis code and data can be found in an open repository on GitHub (deleted for the blind version). For the variable Type stimulus ‘Type 1' is the reference stimulus.

Table 4 lists the fixed-effect terms of the Mixed-Effect linear model for eye blink rate.

Table 4. Fixed-effect estimates with p-values of Linear Mixed-Effect Models for the eye blink rate

	Eye blink rate		
Predictors	*Estimates*	*CI*	*p*
(Intercept)	0.15	0.10 – 0.20	**<0.001**
Age	-0.03	-0.07 – 0.01	0.122
Gender (male)	-0.04	-0.13 – 0.05	0.383
Type 2 (no – no commentary)	-0.02	-0.04 – 0.01	0.164
Type 3 (no – yes)	-0.02	-0.05 – 0.00	0.065
Type 4 (yes – no)	-0.01	-0.03 – 0.02	0.452
Type 5 (yes – no commentary)	-0.03	-0.06 – -0.01	**0.013**
Type 6 (yes – yes)	-0.03	-0.05 – -0.00	**0.044**
News issue (lgbt)	0.01	-0.01 – 0.03	0.239
News issue (death penalty)	0.02	-0.00 – 0.04	0.061

Notes: 1. Bold font for significant effects. 2. In the expansion of stimulus types, consistency to message is always listed first, consistency to commentary second. 3. For the variable Type stimulus 'Type 1' is the reference stimulus.

Table 4 indicates that for stimuli with congruent valence, the relative number of blinks is significantly reduced. Specifically, for stimulus Type 6 (yes – yes), the blink count decreases compared to stimulus 1 (no – no) (b = 0.037, t = 2.019, p = 0.044). Similarly, for stimulus type 5 (yes – no commentary), the number of blinks is reduced compared to stimulus 1 (no – no) (b = 0.032, t = 2.499, p = 0.013). No other significant differences between stimulus types were identified.

We also accounted for the potential influence of the variable news issue by including it in the model as a control variable and comparing results for each topic using the *emmeans* package (Lenth, 2017). The topic of the message had no significant effect (p > 0.06-0.7 in all pairwise comparisons).

Interestingly, for stimulus type 3 (yes – no), no statistical significance was found in the relative number of blinks compared to stimulus type 1 (no – no), suggesting that combining different valences within a single stimulus may also lead to increased cognitive load.

The results are more clearly illustrated in Figure 3. Interestingly, for stimulus type 3 (yes – no), no statistical significance was found in the relative number of blinks compared to stimulus type 1 (no – no), suggesting that combining different valences within a single stimulus may also lead to increased cognitive load.

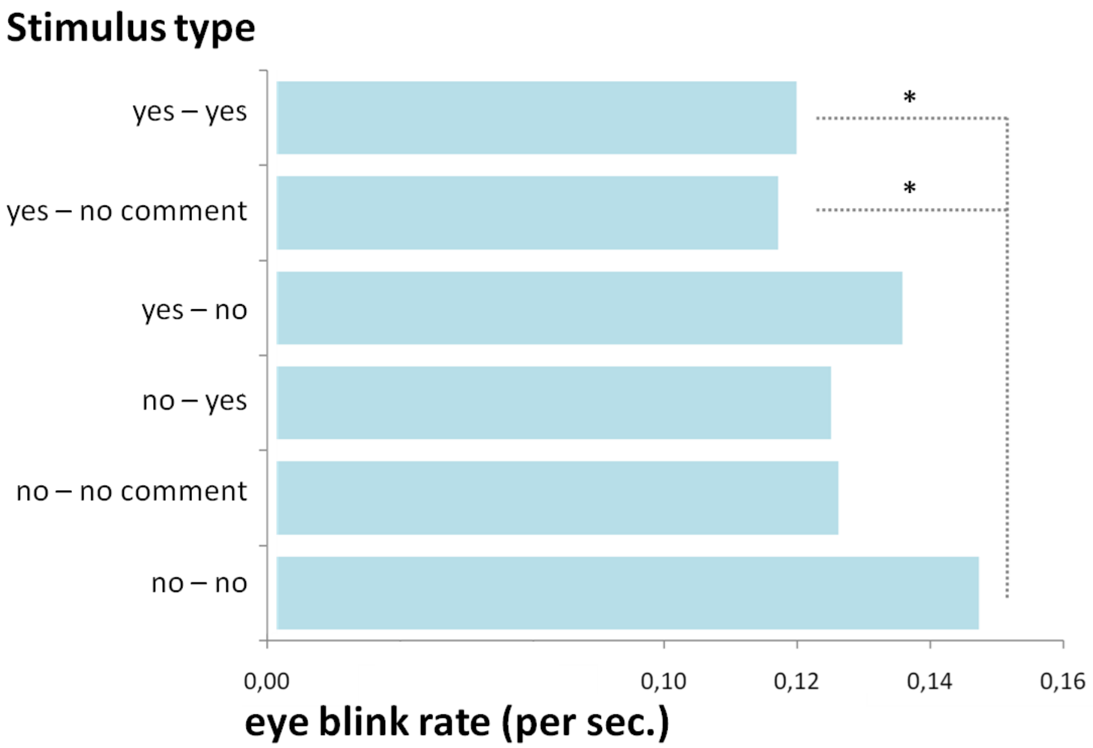


Figure 3. Dependence of eye blink rate on stimulus type.
*Note: the symbol * is for the p<0.05 level of significance.*

Thus, our results support hypothesis 2 that the effect of confirmation bias (CB) causes a change in eye blink rate, possibly related to an increase in cognitive load. Matching the valence of the text to the user's beliefs leads to a decrease in eye blink rate.

III. Discussion and Conclusion

This study employed a laboratory experiment with eye movement recording to investigate the behavioural correlates of the confirmation bias effect during the reading process in the social networking services (SNS) environment.

Our results first demonstrate the confirmation bias effect in text perception: participants rated texts that aligned with their pre-existing beliefs as more credible, while assigning lower credibility ratings to texts that contradicted those beliefs. This effect was amplified by the valence of the accompanying comments.

Second, our findings revealed that confirmation bias is accompanied by changes in oculomotor activity. Reading texts whose valence was inconsistent with participants' beliefs led to an increase in the relative number of eye blinks (eye blink rate variable). This effect was further intensified depending on the valence of the accompanying comments. These results suggest that increased eye blink frequency may serve as a behavioral correlate of the cognitive distortions associated with confirmation bias and may act as a predictor of confirmation bias in text comprehension.

This latter finding allows us to propose a potential mechanism underlying the increased number of blinks resulting from the perception of incongruent information. Our work is based on two main theses. The first thesis posits that the confirmation bias effect may be associated with an increase in cognitive load, as demonstrated in various studies (Moravec et al., 2018; Rajsic et al., 2015; Goette et al., 2020). The second thesis relates to the notion that increased cognitive load is connected to changes in human oculomotor behaviour, particularly an increase in the relative number of eye blinks, which is also supported by several studies (Benedek et al., 2017; Ueda et al., 2016; Wood & Hassett, 1983; Veltman and Gaillard, 1998; Salvi et al., 2015; Smilek et al., 2010), including cognitive load triggered by implicit bias (Mahaffey et al., 2005; Mahaffey et al., 2011; Amodio et al., 2003). These two theses led us to formulate our main hypothesis: the presence of the confirmation bias effect in the experiment would causally influence changes in oculomotor activity, presumably due to the effects of increased cognitive load.

Although we cannot directly describe unobserved processes, we can document that the confirmation bias effect is indeed accompanied by a change in oculomotor load, as demonstrated by the results of our study. Accordingly, we propose a mechanism of the following nature: information inconsistency with readers' beliefs leads to an increase in cognitive load.

We believe that the results of our study can form the basis of predictive models aimed at combating perceptual and dissemination bias in social media, as oculomotor behavioral correlates (in particular, eye blink frequency) have not been previously applied to assess confirmation bias in text perception. Furthermore, we expect our results to elucidate the cognitive mechanisms underlying the confirmation bias effect.

Conflict of interest

The authors declare no potential conflict of interests.

Ethical statement

The present research was approved by the local ethics committee. Participants were informed about its aim and confidentiality of the data collection, and gave their consent to participate. Participants could withdraw at any time during the study.

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The authors thank [deleted from the blind version] for partially translating and English proofreading of the first draft of the manuscript.

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Dear colleagues, we thank you sincerely for your time! Your valuable comments helped us to make our article significantly better.

All our changes in the text are highlighted in blue ink.

Reviewer #1:

This manuscript aims to explore the relationship between confirmation bias and eye-movement activities, a relatively under-researched area in the field. While the potential for contributions to understanding the physiological correlates of confirmation biases is evident, the manuscript currently reads more like an early draft than a submission-ready document.

First Concern: One primary issue is the disconnection between the theoretical framework and the empirical investigation. The main bulks of the abstract, introduction, and discussion/conclusion discuss the significance of cognitive loading in the context of confirmation bias and eye movements. However, the method and results sections (pp. 6-12) do not operationalize cognitive loading nor measure it directly, focusing instead only on the relationship between confirmation bias and eye blinking. While cognitive loading is a crucial aspect of the study's theoretical importance, its absence in the empirical examination crucially weakens the manuscript's coherence and relevance. The study's claims about cognitive loading are speculative rather than evidence-based, as acknowledged on pp. 4 and 13, where even the authors only "suggest" rather than demonstrate a link.

Authors:
Dear Colleague, Thank you for your comments that allowed us to make the article significantly better. We have completely restructured the theoretical part and completely rewritten the discussion section in order to correct this deficiency.

Second Concern: The presentation of the statistical analysis and results is another critical area that needs substantial improvement. The manuscript often mentions significant effects without detailed explanation or clear reporting of significance levels, which are sometimes only indicated in figures and not discussed in the text. A more thorough and systematic exposition of the analysis, including explicit reporting of p-values and effect sizes in the evaluation, is essential to assess the study's validity and to substantiate the claims made.

Authors:
We added p-value and F-statistics everywhere where possible.

Writing Quality: The overall quality of writing requires significant attention. The hypothesis is introduced abruptly at the end of the introduction and lacks assertiveness. The discussion and conclusion are merged in a manner that does not allow for clear differentiation or adequate depth. The manuscript suffers from a lack of detailed explanation in several sections, including lack of references in some parts of the writing (only one citation appears from lines 4 to 24 on p. 3), lack of details for the evaluation of texts used in the experiment (mentioned only in one sentence in line 28, p. 6), lack of appropriate captions for figures, and incomplete explanations of some important cited studies (e.g., line 34, p.6; line 49, p.7).

Authors:
The text has been corrected in accordance with these comments.

Moreover, the manuscript includes numerous one or two-sentence paragraphs that are either too short to be meaningful or disrupt the flow of reading, alongside several minor typographical and grammatical errors.

Authors:
The text has been corrected in accordance with these comments.

Reviewer #2:

Authors:
Dear Colleague, Thank you for your comments that allowed us to make the article significantly better.

This is an interesting study where it is observed that higher blink rate is associated with text stimuli that are contrary to participants political beliefs, which the authors interpret as increased cognitive load associated with a confirmation bias effect.

Comments:
Abstract (Page 1, line 25): Be specific about what stimulus condition is associated with higher and lower eye blink rate

Authors:
The text of the abstract has been corrected.

Methods:
Captions for Figure 1 should be more descriptive. Please briefly describe what the participant will do in each trial of the task.

Authors:
We have added much more descriptive captions to the figures

Analysis & Results:

Tables 3 and 5 should specify that in the models, the 'Type 1' stimulus is the reference stimulus.

Authors:
Thank you. We've done it now

Regarding assessment of attitudes (page 7, line 28), it would be nice to have a breakdown of participant attitudes towards the three social topics.

Authors:

We added this variable as a control variable to the overall effect estimation model for reanalysis

For stimuli related to each topic, how many trials in total were "pro-topic" and how many were "contra-topic"?

Authors:
Explanation added in the text that there is an equal number of pro-topic and contra-topic stimuli.

What happens when a participant is neutral towards a topic, ie. their attitude towards the topic = 4? Do they still view stimuli related to that topic? If so, it would be nice to know mean eye-blink rate and fixation length for neutral messages.

Authors:
An explanation is added to the text that such observations are less than 3 percent, and they are removed from the analysis.

The Design and Procedure (page 7, line 36-41) mentions that participants made judgments as to whether messages were trustworthy or not. Would there be a pattern of judgment (ie. pro-topic messages are rated as more trustworthy and contra-topic messages are rated less trustworthy) that would demonstrate confirmation bias, and was such a pattern observed?

Authors:
Added an entire section to the article "Confirmation bias effect" in the Methods mexicon to demonstrate this effect. Additional analysis and description has been done. The introduction has also been restructured accordingly.

Section IV (discussion and conclusion) is written as if it is a given that increased blink rate and fixation duration are evidence of increased cognitive load, and that the paradigm has successfully induced confirmation bias among participants. However, cognitive load is not the only psychological phenomena that is associated with blink rate, and alternative interpretations should be addressed, especially with consideration to whether or not participants task responses can be interpreted as a demonstration of confirmation bias.

Authors:
We have adjusted the discussion and conclusion section in accordance with your comments.