Mouse Chase: Detecting Careless and Unmotivated Responders Using Cursor Movements in

Web-Based Surveys

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Abstract

Web surveys offer new research possibilities, but they also have specific problems. One of them is a higher risk of careless, inattentive, or otherwise invalid responses. Using paradata, which are data collected apart from reactionary data, is one of the potential tools that can help to screen for problematic responses in web-based surveys. One of the most promising forms of paradata is the movement, or trajectory, of the cursor in making a response. This study constructed indicators of such data, presented correlations between them and provided an interpretation and validation of these components by correlating them with previously known indices of careless responding. Finally it tested cursor movement indices during different motivational states induced by experimental instructions. Cursor movement indices proved to be moderately related to classical careless responding indices but some of them (horizontal distance traveled as well speed and acceleration on vertical dimension) were as responsive to manipulation conditions as classical indices. Potential role of cursor movement indices in survey practice and future studies in this area are discussed.

Keywords: paradata, web survey, survey methodology, cursor movement, careless/insufficient effort responding (C/IER).

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in Web-Based Surveys

The introduction of web-based surveys has been a major development in social sciences

methodology, and it has facilitated and enriched data collection in many respects. Web-based

surveys are not without their problems, though; in this article, we will address one of them:

careless or insufficient effort responding (C/IER; Johnson, 2005).

The absence of interviewers during a survey is likely to lower participant motivation and

interest making web-based environments especially vulnerable to C/IER (Johnson, 2005; Meade

& Craig, 2012), and other forms of distraction such as background noise, technical problems, or

multitasking activities (Zwarun & Hall, 2014). Data provided by unmotivated, careless, or

inattentive respondents can lead to serious distortions in measurement (Johnson, 2005; Meade &

Craig, 2012). Recent C/IER detection approaches rely on (1) special items designed to detect

careless responses (Huang et al., 2012; Meade & Craig, 2012), (2) response consistency indices

formed from responses to typical survey items (Huang et al., 2012), (3) multivariate outlier

analysis (Meade & Craig, 2012), (4) response time analysis (Ulitzsch et al., 2022), and (5) self-

reported scales of diligence (Meade & Craig, 2012). None of these methods guarantee a flawless

identification of careless responses. The main recommendation is to use a combination of these

methods to better predict C/IER (Curran, 2016; Meade & Craig, 2012).

The aim of this article is to provide and examine an additional set of indicators that could

predict C/IER, that is, cursor movement indices (CMIs). Cursor tracking is a relatively recently

developed behavioral methodology that offers potentially promising indicators of the cognitive

processes underlying survey responses. There is strong theoretical and empirical evidence that

people's cognitive, attitudinal, and affective states are expressed in their bodily actions

(Yamauchi & Xiao, 2018). On those grounds, data on cursor movements have been extensively used in web design studies (Huang et al., 2011; Rodden et al., 2008) and controlled laboratory experiments to test social cognition models (Kieslich & Henninger, 2017; Stillman et al., 2018), but were relatively less explored in the context of web-based surveys. In the latter, mouse movements were successfully used to predict respondent confusion and difficulty in answering questions (Fernández-Fontelo et al., 2022; Horwitz et al., 2017, 2020; Steiger & Reips, 2010).

In a web-based study Steiger and Reips (2010) have manually coded movement data and looked for indicators of lower criterion-related validity, pointing towards long idleness periods and excessive mouse movements as indicators of confusion and lower data quality. Horwitz et al. (2020) and Fernadez-Fontelo et al. (2022) used another web survey experiment to verify whether cursor moves have potential to capture participants' difficulties due to experimentally induced item difficulty (e.g. unordered response categories). They have found that some of the moves (e.g. regressions between important areas of survey page or holding cursor above key page areas) are predictive of respondent difficulties over and above response times.

To the best of our knowledge, however, cursor-based indices have not been investigated for the detection of C/IER. We have thus decided to link CMIs usage with rich C/IER literature and explore their utility in measuring careless responding. Unlike some of the previous studies (Horwitz et al., 2017; Steiger & Reips, 2010) our study employs a fully automated collection and processing of process data, also analyzing different indicators that were studied by our predecessors (Horwitz et al., 2020; Steiger & Reips, 2010). We also test CMIs under different motivational conditions that were experimentally manipulated. Moreover, our data come from the largest to date sample in CMIs studies (> 2000) and employs questions and scales most frequently used in (psycho)educational assessment and public opinion research, in contrast to

previous studies that have mostly used factual questions and yes/no items, i.e. items more seldom used in practice (Horwitz et al., 2017; Steiger & Reips, 2010). In this way, we want to broaden the arsenal of researchers against C/IER by exploring possibilities that CMIs offer in this regard.

To this end we developed a set of CMIs that combined timing and trajectory data and collated and compared them with five C/IER detection indices (Meade & Craig, 2012). First, we analyzed correlations between different CMIs. Second, we predicted that CMIs were significantly correlated with classic C/IER indicators. Third, we hypothesized that CMIs would significantly differ between experimental conditions that targeted participants' motivation, as had previously been shown for some of the classic C/IER indices (Burns et al., 2015; Huang et al., 2012). In this way, we aimed to establish process indicators for C/IER based on both survey responses and paradata. Paradata are understood here as by-products – data collected additionally to actual survey responses (*substantive data*) of which process data (and indicators derived from it) are a special case conveying extra information specifically about survey responding and navigating (Kroehne & Goldhamer, 2018).

Data and Methods

Participants

Data were collected between 23rd November and 6th December 2021 in web-based mode, using opt-in Internet panel Ariadna. Respondents participated in the study using their own computers (either desktop or laptop) and we had no control over the environment in which they completed the questionnaire. Respondents were remunerated for the completed interview with points that could be exchanged into small gifts. The experiment was begun by 3407 respondents, but, mostly for technical reasons, only 2023 were retained in the analysis (see Supplementary Online Materials for details). Characteristics of the final sample are presented in Table 1.

Table 1 Participant Characteristics

Characteristic	Value	N	Percentage
Gender	Male	941	46.5%
	Female	1082	53.5%
Age	18–29	481	23.8%
	30–39	693	34.3%
	40–50	849	42.0%
Education	Secondary	1067	52.7%
	Tertiary	956	47.3%
	Total	2023	100.0%

Procedure

At the beginning of the survey, respondents were randomly assigned to one of three sets of test instructions (provided in the form of a short video): (1) standard, containing an invitation to the survey and brief information on its contents, (2) warning, containing a caution against responding carelessly to the survey and a reminder that participants responding carelessly could be excluded from the survey, thus losing their remuneration, and (3) appeal, containing a detailed description of the questionnaire, as well as a request to participants to respond diligently due to the social importance of the survey. The types of instruction were modeled after the literature (Adair, 2014; Burns et al., 2015; Huang et al., 2012). Respondents were also randomly assigned to one of several experimental conditions in which the number and format of response categories was manipulated (from a 4-point to an 11-point scale). This was independent of the assignment to the set of test instructions. The approval of the institutional ethical committee was sought and obtained.

The study included several parts, starting with a Polish adaptation of cognitive abilities test *Pathfinder* (Malanchini et al., 2021), followed by several survey scales, manipulation check and self-reported survey diligence scale. In the main analysis we focused on one scale and the second

scale is used for cross-validation (Tables S12-17). The order of measurement and manipulations used in the study is displayed in Table S1. All participants responded to the measures in the same order.

Materials

The analysis covered survey responses and paradata collected from a reading attitudes scale of 11 items, including 5 reversed, that was originally used to construct a unidimensional scale in PISA 2000, 2009, and 2018. In this experiment, the version from PISA 2009 was used as it was the longest (OECD, 2010). The whole scale was displayed on one screen - it was the 8th screen in the survey part.

C/IER Indices

We decided to use five of the classic C/IER indices: (1) control questions (QC) failure, (2) longstring index, (3) Mahalanobis distance, (4) page time, and (5) self-reported diligence. In this way, we covered the main approaches to C/IER indices, that is, the response pattern, response inconsistency, and response time analysis (Huang et al., 2012; Meade & Craig, 2012).

Control questions were taken from Pathfinder: they were just four very easy items, correct solving of which should be evident for all participants. Number of incorrect responses to these questions served as an indicator (Malanchini et al., 2021). The Mahalanobis distance returns a value indicating the distance from the data center in a multivariate normal distribution. This measure serves for finding outlier, aberrant participants in the dataset. The longstring measure is the number of identical responses in a row (i.e., longest uninterrupted string of identical responses). The page time is used on the basis of an assumption that very short responses indicate insufficient cognitive processing. According to common practice, we used the natural logarithm of page time to account for skewness of this measure. Self-reported measures of

survey effort tend to converge with other C/IER indices and can also be used as a self-standing C/IER indicator. The items used in this experiment were adapted from the scale presented by Meade and Craig (2012; see Table S5).

Cursor Movement Indicators

We constructed four sets of indicators based on cursor movement: (1) total distance traveled, (2) average speed, (3) average absolute acceleration of cursor move, and (4) number of flips, that is, changes of direction of movement (cf. Horwitz et al., 2017; Steiger & Reips, 2010).

Because the layout of the page could vary between respondents due to the size of their windows, browser type, or other factors, we constructed relative indicators of the traveled distance in the horizontal (dX_rel) and vertical (dY_rel) dimensions. They were computed by dividing total horizontal or vertical distance (in pixels) traveled by the response table size (distance between the position of the first answer to the first item and position of the last answer to the last item).

Prior research showed that the position of the cursor was relatively close to the position of the eye gaze on the screen (Clark & Stephane, 2018; Kirsh & Joy, 2020) therefore, we stipulated that the distance traveled reflected the survey response–related behaviors. A short distance traveled should therefore indicate less reading, less hesitation, and a smaller number of opinion changes or adjustments to the response categories, and, therefore, it could be related to more C/IER. The shortest possible distance traveled indicated a straight line, and, therefore, it seemed natural that the horizontal distance traveled should be a good measure of straightlining. The vertical dimension should also be of some importance, because a long distance traveled in it may indicate going back to items and changing the responses, or thinking of changing them, thus indicating more careful responding (Horwitz et al., 2017; 2020). There was also evidence that an

excessive distance traveled could indicate confusion and difficulty in making a response (Stieger & Reips, 2010).

Another two indices reported the average speed of the cursor moves in horizontal (vX) and vertical (vY) directions (in pixels per second [px/s]). Following the theory that the cursor is relatively close to the position of the eye gaze on the screen, a high speed in both dimensions should indicate inattentiveness or speeding. The vertical speed could be a good indicator of straightlining, as we expected that it was related to rapid response patterns that follow a straight line.

The third set of indices reported the average absolute acceleration of cursor moves in the horizontal direction ($aX)$ and vertical direction (aY) (in pixels per squared second [px/s^2]). According to previous data, high average absolute acceleration could indicate distractions (Brenner & Smeets, 2003).

Finally, we counted the number of flips, that is, changes in direction of movements, again separately for horizontal (flipsX) and vertical (flipsY) directions. We assumed that respondents used direction changes to reach thought-over responses and that straightlining should be indicated by a small number of flips. A very large number of flips could also indicate hesitancy or indecisiveness (Horwitz et al., 2020; Steiger & Reips, 2010).

Analysis

Pearson correlation coefficients were used to explore relations between cursor moves and C/IER indicators. Analysis of variance (ANOVA) was conducted in the 3 (experimental instructions: standard, warning, appeal) x 8 (scale length: 4, 5, 6, 7, 10, or 11 all-labeled response categories plus 10 or 11 end-labeled response categories) between-participants design to compare the cursor moves and C/IER indices between the experimental conditions. We reported

post-hoc differences only for the main effects for instruction conditions, treating the length of the

scale as a controlled confounding factor. Also, we checked for statistical significance of the

interaction effects to assess homogeneity of effect of instruction type across different response

scale lengths and formats.

We have transformed CMIs using either square root (flips) or natural logarithm (other

indices) to account for non-normal distributions of the variables.

Results

Relationships between cursor movement and C/IER indices, depicted in Table 3, are

at best moderate and as such comparable to the strength of the relationships between different

C/IER indices (cf. Tables S8 and S9 and see Huang et al., 2012; Meade & Craig, 201210). Clearly,

the two CMIs most strongly correlated with the C/IER indices are the horizontal distance traveled

and the number of vertical flips. On the other hand, the C/IER measures correlated most strongly

with at least some CMIs are the page time, longstring index, and self-reported diligence.

Table 2 Pearson correlations between cursor moves and CIE/R indices

Measure	Longstring	Mahalanobis	Pathfinder QC Failures	Self-Reported Diligence	log(Page Time)
log(dX_rel)	-0.70***	0.12***	-0.26***	0.47***	0.59***
log(dY_rel)	-0.18***	0.07**	-0.04	0.13***	0.40***
sqrt(flipsX)	-0.32***	0.07**	-0.14***	0.20***	0.49***
sqrt(flipsY)	-0.44***	0.08***	-0.15***	0.28***	0.55***
log(vX)	-0.39***	0.07**	-0.14***	0.25***	-0.22***
log(vY)	0.38***	-0.09***	0.17***	-0.27***	-0.75***
log(aX)	-0.28***	-0.02	-0.12***	0.19***	-0.18***
log(aY)	0.23***	-0.14***	0.09***	-0.17***	-0.54***

N = 2007 for correlation involving self-reported diligence.
N = 2023 for all the other correlations.
*** $p < .001$; ** $p < .01$, * $p < .05$.

The horizontal distance traveled was strongly negatively correlated with the longstring

index. It also correlated moderately negatively with QC failures, and positively with the self-reported diligence and page time. In contrast, the vertical distance was moderately correlated with the page time and correlated to a much lesser degree with the longstring index and self-reported diligence. Flips in both dimensions correlated mostly with the longstring index (negatively) and page time (positively). Their correlations with self-reported diligence and QC failures were considerably weaker. The speed and acceleration of cursor moves had a similar pattern of relationships with all the CIE/R indexes except for page time. They correlated moderately with the longstring index and slightly weaker with self-reported diligence and QC failures – in each case negatively with regards to horizontal measures and positively with regards to vertical ones. On the other hand, correlations with page time were all negative and while they were strong for vertical measures, for horizontal ones they were much weaker.

Regarding the experimental manipulations, in both the warning and appeal conditions, participants traveled a longer horizontal distance and did it with lower speed in comparison with the standard instruction condition. Similarly, participants yielded higher scores of self-reported involvement, lower scores of the longstring index, and longer page time in the warning and appeal conditions in comparison with the standard condition. Also, they made more vertical flips and had lower absolute acceleration, but the first of these effects was statistically significant only for the appeal condition, and the latter only for the warning condition. The size of the effects was rather small and did not differ considerably between the warning and appeal conditions. The remaining indices did not differ significantly between the experimental conditions (cf. Figure 1 and Tables S10 and S11).

Most measures showed no interaction between instruction type and response scale length with the exception of vertical distance and QC failures (Table S11).

Table 4 Results of ANOVAs

Measure	Instruction main effect			Response scale main effect			Interaction: instruction X response scale		
	F	p	partial η^2	F	p	partial η^2	F	p	partial η^2
log(dX_rel)	5.71	0.003	0.006	1.85	0.074	0.006	1.38	0.153	0.010
log(dY_rel)	1.95	0.142	0.002	8.24	0.000	0.028	1.80	0.033	0.012
sqrt(flipsX)	1.68	0.186	0.002	2.06	0.045	0.007	1.22	0.251	0.008
sqrt(flipsY)	3.12	0.045	0.003	2.23	0.029	0.008	1.39	0.150	0.010
log(aX)	0.93	0.397	0.001	1.47	0.172	0.005	0.93	0.530	0.006
log(aY)	6.19	0.002	0.006	2.04	0.047	0.007	0.43	0.966	0.003
log(vX)	0.06	0.941	0.000	1.72	0.100	0.006	1.19	0.276	0.008
log(vY)	9.47	0.000	0.009	1.04	0.398	0.004	0.92	0.538	0.006
Self-reported diligence	32.40	0.000	0.031	1.43	0.188	0.005	1.40	0.144	0.010
Longstring	5.20	0.006	0.005	1.07	0.381	0.004	1.53	0.094	0.011
log(Page time)	8.67	0.000	0.009	3.61	0.001	0.012	1.24	0.238	0.009
Pathfinder QC failures	0.97	0.378	0.001	1.12	0.350	0.004	2.28	0.004	0.016
Mahalanobis	0.60	0.546	0.001	174.42	0.000	0.378	1.66	0.057	0.012

N = 2007 for analysis involving self-reported diligence as a dependent variable.
N = 2023 for all the other analyses.
Note: Test statistics and partial η^2 for main effects computed in the absence of the interaction effect (type II test).
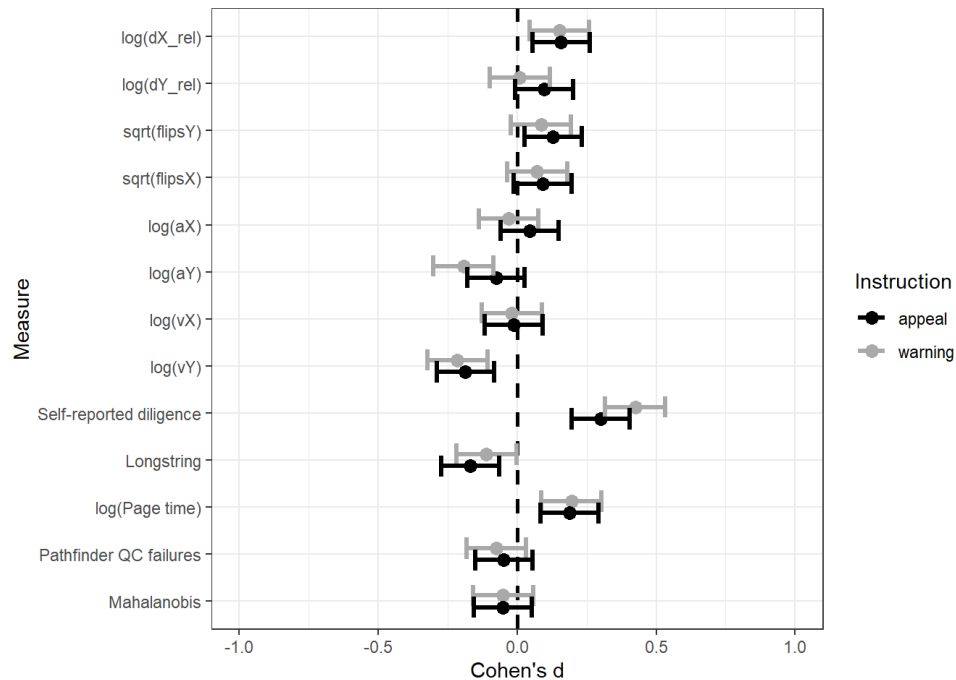
Figure 1. *Effect size of warning and appeal instructions (compared with the standard instruction) for different measures, along with the 95% confidence intervals.*

Discussion

The emerging literature suggests that cursor movements could be used to predict the cognitive states of survey respondents (Fernández-Fontelo et al., 2022; Horwitz et al., 2020; Yamauchi & Xiao, 2018). This paper was devoted to exploring the possibilities of using cursor movements to construct indicators that would help to identify careless or insufficient effort responding (C/IER). This is a crucial issue in an era dominated by web-based research where the physical disconnection of the researcher and respondent is likely to lower motivation and participant interest in the survey significantly, reducing the quality of the measurement (Johnson, 2005).

Conclusions

The general conclusion is that CMIs are a promising source of information about

respondents' involvement in a survey and might be used as additional information for existing C/IER indicators. First, the results of our analyses indicated that CMIs are significantly correlated with classic C/IER indicators and that the direction of correlations meets both the theoretical and common-sense patterns. Measures of distance traveled and the number of flips were negatively related to the longstring index, positively to the self-reported diligence and page time, and very weakly to the Mahalanobis distance. Indicators of speed and acceleration showed positive relations with C/IER in case of vertical indices and negative in case of horizontal ones.

Second, we hypothesized that the CMIs would significantly differ between experimental conditions. Here we found only weak effects. Consistently significant effects occurred for the horizontal distance traveled, which was larger in conditions inducing higher motivation and for the vertical speed, which was smaller in such conditions. Also, the number of vertical flips and absolute acceleration differed, but only in either *appeal* or *warning* conditions. The effects for the C/IER indices were also small, except for the longstring index, page time, and self-reported diligence. The effect size (Cohen's *d*) of the longstring index (0.15 for warning, 0.16 for appeal instruction) and page time (0.20 and 0.19, respectively) was similar to that of the cursor distance traveled (0.15 and 0.16) and speed on vertical dimension (-0.21, -0.19). Only the self-reported diligence showed substantially higher effects (0.41 and 0.30).

The results suggest that CMIs provide us with additional tools to identify careless responding in survey data, potentially over and above classical C/IER indices and response times (Horwitz et al., 2017; 2020). Moreover, collecting CMIs has virtually no cost, is highly automated and noninvasive. It does not increase the duration of the interview nor does it bring problems related to reversed, attention check or bogus items (Huang et al., 2012; Meade & Craig, 2012).

Limitations

The study was not initially designed for mouse movement analysis. We did not record the information on different types of cursor devices used by our participants (e.g., touchpad vs. an actual mouse). However, we estimate that a vast majority (~81%) of users of the Ariadna panel use a mouse[1]. Different types of devices might lead to noise in the constructed indicators. There is no detailed research on these issues, but some of the studies are suggesting that including or excluding touchpad users does not change the results significantly (Gatti et al., 2021). Moreover, we did not perform any advanced outlier analysis; however, in this state of knowledge it is very difficult to say how such an analysis should look like (cf. Horwitz et al., 2020). Moreover, our study was conducted in ecologically valid, but methodologically imperfect web mode. In this way, our results come from a setting typical for most modern-day surveys, but it also means that our process data come from an uncontrolled environment with a number of insufficiently researched factors that could lower the quality of the process data collected.

Another limitation of our study is that we present results from only one scale. To make up for that we have presented the same analyses on a different scale as a cross-validation of the above results (Tables S12-S17). The additional results point to virtually the same conclusions, giving a proof for robustness of our findings.

Directions for Future Studies

Future studies should strive to identify further links between CMIs and classic C/IER indices, providing mutual validation and enhancing knowledge about C/IER in web surveys in general. Further research should also compare cursor trajectories in participants flagged as careless with those yielding engaged responses. Validity studies, showing increase of survey data construct or criterion-related validity after accounting for C/IER flagged by CMIs are also needed.

It also seems promising to compare cursor moves under different experimental manipulations, for example, under a cognitive load or fatigue, thus broadening our understanding and interpretation of this type of paradata. Cursor trajectories and related indices can also be used in faking and socially desirable responding research, for instance, as potential additional indices of faked or tailored response profiles.

Knowledge about sociodemographic, personality, and cognitive correlates of CMIs is still lacking. Future studies should offer insight in these areas, possibly in combination with mixture models, providing information on typical profiles of cursor moves. Importance of scale and item characteristics for CMIs, such as content and presence of negatively worded items, should also be systematically studied in future research.

Further still, not much is known on how CMIs differ on different devices (e.g., touchpad vs. mouse), with touch screens being *terra incognita* almost completely. The latter is especially important because completing web surveys on touch-screen devices (e.g., smartphones) is on the rise (Horwitz et al., 2017).

As CMIs research in survey context is still in its infancy there is a paramount need of methodological studies that would enable to set methodological standards, including hardware and software details, important for creating theoretically meaningful response processes indicators (Kroehne & Goldhammer, 2018). To this end more empirical studies on CMIs are needed, including those relating process data with other information, e.g. eye-tracking, cognitive interviews or think-aloud protocols.

Web survey paradata is a rapidly developing field, and the mouse chase continues in hopes of correlating cursor moves with specific cognitive, affective, and motivational states of participants.

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Endnotes

[1] The number of 81% of respondents using mice as opposed to other devices (touchscreen, touchpad, etc.) was obtained in an additional survey conducted on a sample of more than 1000 participants of the panel used to recruit our sample using the same recruitment procedures and quotas. This number is in accord with other web-based studies (Fernandez-Fontelo et al., 2022).

Mouse Chase: Detecting Careless and Unmotivated Responders Using Cursor Movements in Web-Based Surveys

(Supplementary Online Materials)

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Contents

Experimental procedure

Table S1 Schematic outlook of experimental procedure

Ordinal number	Measurement	Screens	Response scale length/format manipulation	Median Time
1.	Movies with instruction manipulation	1	No	2 minutes
2.	Cognitive abilities test Pathfinder	Many	No	15 minutes
3.	Survey: vaccinations	2	Yes	15 minutes
4.	Survey: general trust (source: ESS)	3	Yes	
5.	Survey: institutional trust (adapted from ESS)	2	Yes	
6.	Survey: reading attitudes (source: PISA)	1	Yes	
7.	Survey: reading materials (source: PISA)	2	Yes	
8.	Manipulation check	1	No	
9.	Self-reported survey diligence and comments	4	No	
10.	Debriefing	1	No	

Note: ESS: European Social Survey; PISA: Programme for International Student Assessment

Consequences of sample exclusions

The experiment was begun by 3407 respondents. However, many of them had to be excluded from the analysis because they did not reach the analyzed scale while answering the survey (540 respondents), encountered technical difficulties while watching the video on the test instructions (202 respondents), spent more than 2 minutes answering the scale, a span that exceeded the maximum time for log-data collection[1] (118 respondents), had an Internet browser window that was too small for filling in the survey[2] (30 respondents), left the survey browser window while answering the scale (25 respondents), or had broken records in their log-data regarding answering the scale (274 respondents), or did not pass a manipulation check (195 respondents; see section below). Eventually, 2023 respondents were included in the analysis.

[1] The amount of cursor moves data grows very fast with time and at some point it may become so large that its sheer size (in MBs) causes difficulties to process it and to send it over the Internet. These technical difficulties may cause lags in the survey interface and slow down respondent's web browser and computer. To diminish the probability of encountering such problems, on the basis of our previous experience, we decided to limit the period of process data collection to 2 minutes. Please also mind that exceeding this limit for a screen with only 11 survey

items means that probably respondents are engaged in off-screen multitasking or have made a pause in the survey anyway.

[2] Survey questions in our questionnaire were presented in a tabular form with response categories put in columns and the items in rows. However, the survey platform we used had a so-called responsive layout – if the table did not fit in a browser window layout has changed with items being offered in a form of list instead of table.

Table S2 Number of respondents included into the final sample for each combination of experimental conditions

Response scale	Instruction			Total
	Standard	*Warning*	*Appeal*	
4 cat. (all labelled)	97	90	85	272
5 cat. (all labelled)	97	81	102	280
6 cat. (all labelled)	100	71	96	267
7 cat. (all labelled)	94	87	77	258
10 cat. all labelled	103	70	89	262
10 cat. end labelled	86	75	78	239
11 cat. all labelled	87	59	79	225
11 cat. end labelled	90	59	71	220
Total	754	592	677	2023

Manipulation check

Procedure: close to the end of the survey respondents were asked a set of 5 questions about whether the video they watched at the beginning of the survey contained specific information:

1. Warning that researchers are capable of detecting careless and dishonest respondents (true for *warning* instruction),
2. Warning that careless and dishonest respondents may lose their pay for the survey (true for *warning* instruction),
3. Summary of the survey content (see below),
4. Call for respondents' commitment, carefulness and honesty (true for both *warning* and *appeal* instructions),
5. Emphasis on the role of honesty and respondents' involvement in the development of science (true for *appeal* instruction).

The third item was supposed to be considered true for the *appeal* instruction because it was the only one including some more detailed information regarding survey content. However, respondents tended to choose this item irrespective of the instruction they were given. Because of this we decided to exclude this item from use in the manipulation check procedure.

Respondents were assumed to pass the manipulation check (MC) if:
- Were given the *standard* instruction – irrespective of responses to the aforementioned items.

- *Agreed* or *strongly agreed* to all the items relevant to the instruction he/she was given (i.e., items 1, 2 and 4 in the case of *warning* instruction or items 4 and 5 in the case of *appeal* instruction).

Number and percentage of respondents who passed the manipulation check for each instruction is presented in a table below (including only respondents that were not excluded from the analysis because of the technical reasons that were described in the paper).

Table S3 Number of respondents passing manipulation check

Instruction	N		Pct.
	Passed MC	Failed MC	Passed MC
Standard	754	0	100.0%
Warning	592	141	80.8%
Appeal	677	54	92.6%
Overall	2023	195	90.4%

Wording of scale items and response categories

Table S4 Wording and ascription to dimensions of the PISA reading attitudes scale items

No.	Item	Wording
1	I read only if I have to	-
2	Reading is one of my favourite hobbies	+
3	I like talking about books with other people	+
4	I find it hard to finish books	-
5	I feel happy if I receive a book as a present	+
6	For me, reading is a waste of time	-
7	I enjoy going to a bookstore or a library	+
8	I read only to get information that I need	-
9	I cannot sit still and read for more than a few minutes	-
10	I like to express my opinions about books I have read	+
11	I like to exchange books with my friends	+

Note: In the survey Polish translation as in PISA 2009 was used.

Table S5 Wording of the self-reported diligence scale. English (EN) and Polish (PL) versions

No.	Item
1EN	I carefully read every survey item.
2EN	I probably should have been more careful during this survey.
3EN	I worked to the best of my abilities in this study.
4EN	I put forth my best effort in responding to this survey.
5EN	I didn't give this survey the time it deserved.

No.	Item
6ENI	was dishonest on some items.
7ENI	was actively involved in this study.
8ENI	rushed through this survey.
9ENI	was easily distracted when answering the questions.
1PL	Uważnie przeczytałem/przeczytałam każde pytanie w tej ankiecie.
2PL	Prawdopodobnie powinienem/powinnam w tej ankiecie odpowiadać uważniej.
3PL	Odpowiadałem/odpowiadałam najlepiej, jak umiałem.
4PL	Starałem/starałam się odpowiadając na pytania w tej ankiecie.
5PL	Nie poświęciłem/poświęciłam tej ankiecie tyle czasu, ile powinienem.
6PL	Byłem/byłam nieszczery w niektórych odpowiedziach.
7PL	Byłem/byłam aktywnie zaangażowany uczestnicząc w tej ankiecie.
8PL	Zrobiłem/zrobiłam tę ankietę w pośpiechu.
9PL	Łatwo się rozpraszałem/rozpraszałam odpowiadając na pytania w tej ankiecie.

Note: In the survey Polish translation was used (items 1PL-9PL from the table above).

Table S6 Wording of response scale categories for different response scale lengths and formats used in the experiment (English translation in parenthesis)

4 cat. (all labelled)	5 cat. (all labelled)	6 cat. (all labelled)	7 cat. (all labelled)
Zdecydowanie się NIE zgadzam (*Strongly disagree*)	Zdecydowanie się NIE zgadzam (*Strongly disagree*)	Zdecydowanie się NIE zgadzam (*Strongly disagree*)	Zdecydowanie się NIE zgadzam (*Strongly disagree*)
NIE zgadzam się (*Disagree*)	NIE zgadzam się (*Disagree*)	NIE zgadzam się (*Disagree*)	NIE zgadzam się (*Disagree*)
Zgadzam się (*Agree*)	Ani się nie zgadzam, ani się zgadzam (*Neither disagree nor agree*)	Raczej się NIE zgadzam (*Rather disagree*)	Raczej się NIE zgadzam (*Rather disagree*)
Zdecydowanie się zgadzam (*Strongly agree*)	Zgadzam się (*Agree*)	Raczej się zgadzam (*Rather agree*)	Ani się nie zgadzam, ani się zgadzam (*Neither disagree nor agree*)
	Zdecydowanie się zgadzam (*Strongly agree*)	Zgadzam się (*Agree*)	Raczej się zgadzam (*Rather agree*)
		Zdecydowanie się zgadzam (*Strongly agree*)	Zgadzam się (*Agree*)
			Zdecydowanie się zgadzam

			(*Strongly agree*)
10 cat. all labelled	**10 cat. end labelled**	**11 cat. all labelled**	**11 cat. end labelled**
Całkowicie się NIE zgadzam (*Entirely disagree*)	Całkowicie się NIE zgadzam (*Entirely disagree*)	Całkowicie się NIE zgadzam (*Entirely disagree*)	Całkowicie się NIE zgadzam (*Entirely disagree*)
Zdecydowanie się NIE zgadzam (*Strongly disagree*)	1	Zdecydowanie się NIE zgadzam (*Strongly disagree*)	1
NIE zgadzam się (*Disagree*)	2	NIE zgadzam się (*Disagree*)	2
W większości się NIE zgadzam (*Mostly disagree*)	3	W większości się NIE zgadzam (*Mostly disagree*)	3
Raczej się NIE zgadzam (*Rather disagree*)	4	Raczej się NIE zgadzam (*Rather disagree*)	4
Raczej się zgadzam (*Rather agree*)	5	Ani się nie zgadzam, ani się zgadzam (*Neither disagree nor agree*)	5
W większości się zgadzam (*Mostly agree*)	6	Raczej się zgadzam (*Rather agree*)	6
Zgadzam się (*Agree*)	7	W większości się zgadzam (*Mostly agree*)	7
Zdecydowanie się zgadzam (*Strongly agree*)	8	Zgadzam się (*Agree*)	8
Całkowicie się zgadzam (*Entirely agree*)	Całkowicie się zgadzam (*Entirely agree*)	Zdecydowanie się zgadzam (*Strongly agree*)	9
		Całkowicie się zgadzam (*Entirely agree*)	Całkowicie się zgadzam (*Entirely agree*)

Note: In the survey Polish wording was used.

Supplementary results

Table S7 Pearson correlations between CMIs.

	log(dX_rel)	log(dY_rel)	sqrt(flipX)	sqrt(flipY)	log(aX)	log(aY)	log(vX)
log(dY_rel)	0.51***						
sqrt(flipX)	0.55***	0.54***					
sqrt(flipY)	0.68***	0.62***	0.82***				
log(aX)	0.53***	0.32***	0.19***	0.34***			
log(aY)	-0.07**	0.31***	-0.00	0.06*	0.72***		
log(vX)	0.60***	0.21***	0.15***	0.26***	0.84***	0.47***	
log(vY)	-0.28***	0.22***	-0.20***	-0.21***	0.41***	0.77***	0.45***

N = 2023
*** p < 0.001; ** p < 0.01; * p < 0.05

Table S8 Pearson correlations between C/IER indices.

	Longstring	Mahalanobis	Pathfinder QC failures	Self-reported diligence
Mahalanobis	-0.13***			
Pathfinder QC failures	0.24***	0.02		
Self-reported diligence	-0.41***	0.09***	-0.29***	
log(Page time)	-0.42***	0.13***	-0.18***	0.34***

N = 2007 for correlations involving self-reported diligence
N = 2023 for all the other correlation
*** p < 0.001; ** p < 0.01; * p < 0.05

Table S9 Ranges (min; max) of Pearson correlations between cursor moves and CIE/R indices across different response scales and formats

Measure	Longstring	Mahalanobis	Pathfinder QC Failures	Self-Reported Diligence	log(Page Time)
log(dX_rel)	(-0.728; -0.572)	(0.091; 0.279)	(-0.467; -0.130)	(0.386; 0.575)	(0.464; 0.662)
log(dY_rel)	(-0.296; -0.094)	(0.014; 0.157)	(-0.118; 0.042)	(0.061; 0.285)	(0.343; 0.451)
sqrt(flipsX)	(-0.440; -0.140)	(0.018; 0.208)	(-0.282; 0.016)	(0.139; 0.279)	(0.455; 0.534)
sqrt(flipsY)	(-0.608; -0.353)	(0.032; 0.172)	(-0.311; -0.020)	(0.237; 0.358)	(0.473; 0.557)
log(vX)	(-0.498; -0.245)	(-0.038; 0.226)	(-0.255; -0.033)	(0.062; 0.314)	(-0.406; -0.083)
log(vY)	(0.321; 0.451)	(-0.248; 0.047)	(0.001; 0.340)	(-0.385; -0.140)	(-0.798; -0.708)

log(aX)	(-0.379; -0.157)	(-0.024; 0.157)	(-0.172; -0.070)	(0.070; 0.258)	(-0.353; -0.083)
log(aY)	(0.120; 0.321)	(-0.185; 0.052)	(-0.002; 0.207)	(-0.249; -0.109)	(-0.635; -0.486)

N for different response scale lengths and formats ranges from 220 to 280

Table S10 Effect size of instruction type in models predicting values of specific CMIs and CIE/R indices using type of test instructions and response scale length and format

	Warning instruction effect		*Appeal* instruction effect	
Measure	Cohen's d	p (Wald's test)	Cohen's d	p (Wald's test)
log(dX_rel)	0.15	0.006	0.16	0.003
log(dY_rel)	0.01	0.866	0.10	0.068
sqrt(flipsX)	0.07	0.188	0.09	0.082
sqrt(flipsY)	0.09	0.119	0.13	0.015
log(aX)	-0.03	0.577	0.05	0.395
log(aY)	-0.19	0.000	-0.08	0.152
log(vX)	-0.02	0.733	-0.01	0.824
log(vY)	-0.21	0.000	-0.19	0.000
Self-reported diligence	0.42	0.000	0.30	0.000
Longstring	-0.11	0.045	-0.17	0.002
log(Page time)	0.20	0.000	0.19	0.000
Pathfinder QC failures	-0.07	0.174	-0.05	0.372
Mahalanobis	-0.05	0.360	-0.05	0.337

N = 2007 for analysis involving self-reported diligence as a dependent variable; N = 2023 for all the other analysis

Table S11 Effect size of instruction type in models predicting values of specific CMIs and CIE/R indices using type of test instructions for specific response scale length and format - CMIs and CIER/R indices for which interaction effect of instruction type and response scale length and format was statistically significant

						Warning instruction effect		*Appeal* instruction effect	
Measure	Response scale	N	η^2	F	p	Cohen's d	p (Wald's test)	Cohen's d	p (Wald's test)
dY_rel	4 cat. (all labelled)	272	0.017	2.26	0.106	0.15	0.294	0.32	0.035
	5 cat. (all labelled)	280	0.008	1.07	0.344	0.21	0.172	0.16	0.267

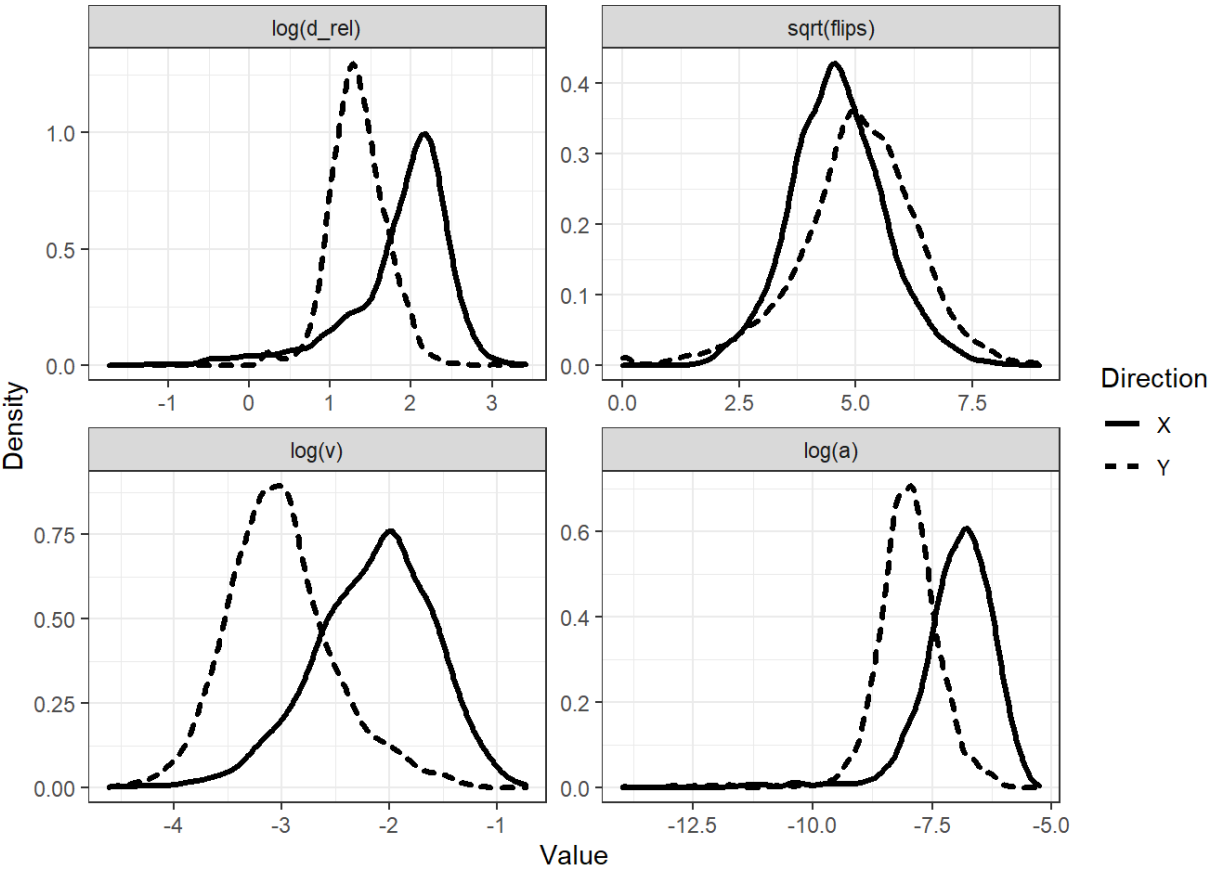|								
	6 cat. (all labelled)	267	0.052	7.31	0.001	-0.53	0.001	0.01	0.973
	7 cat. (all labelled)	258	0.014	1.83	0.163	0.29	0.057	0.14	0.352
	10 cat. all labelled	262	0.003	0.42	0.656	-0.13	0.391	-0.01	0.938
	10 cat. end labelled	239	0.007	0.83	0.437	0.05	0.739	0.20	0.211
	11 cat. all labelled	225	0.004	0.47	0.627	-0.13	0.454	0.03	0.826
	11 cat. end labelled	220	0.005	0.51	0.600	0.11	0.512	-0.07	0.670
Pathfinder QC failures	4 cat. (all labelled)	272	0.029	4.06	0.018	-0.40	0.007	-0.08	0.574
	5 cat. (all labelled)	280	0.011	1.56	0.211	0.03	0.830	-0.20	0.153
	6 cat. (all labelled)	267	0.033	4.45	0.013	0.36	0.021	-0.09	0.532
	7 cat. (all labelled)	258	0.003	0.37	0.691	0.01	0.962	0.12	0.434
	10 cat. all labelled	262	0.004	0.50	0.609	-0.00	0.979	-0.13	0.364
	10 cat. end labelled	239	0.008	0.93	0.394	-0.13	0.415	-0.21	0.178
	11 cat. all labelled	225	0.017	1.87	0.157	-0.12	0.463	0.20	0.201
	11 cat. end labelled	220	0.037	4.19	0.016	-0.36	0.032	0.14	0.391

Additional figures

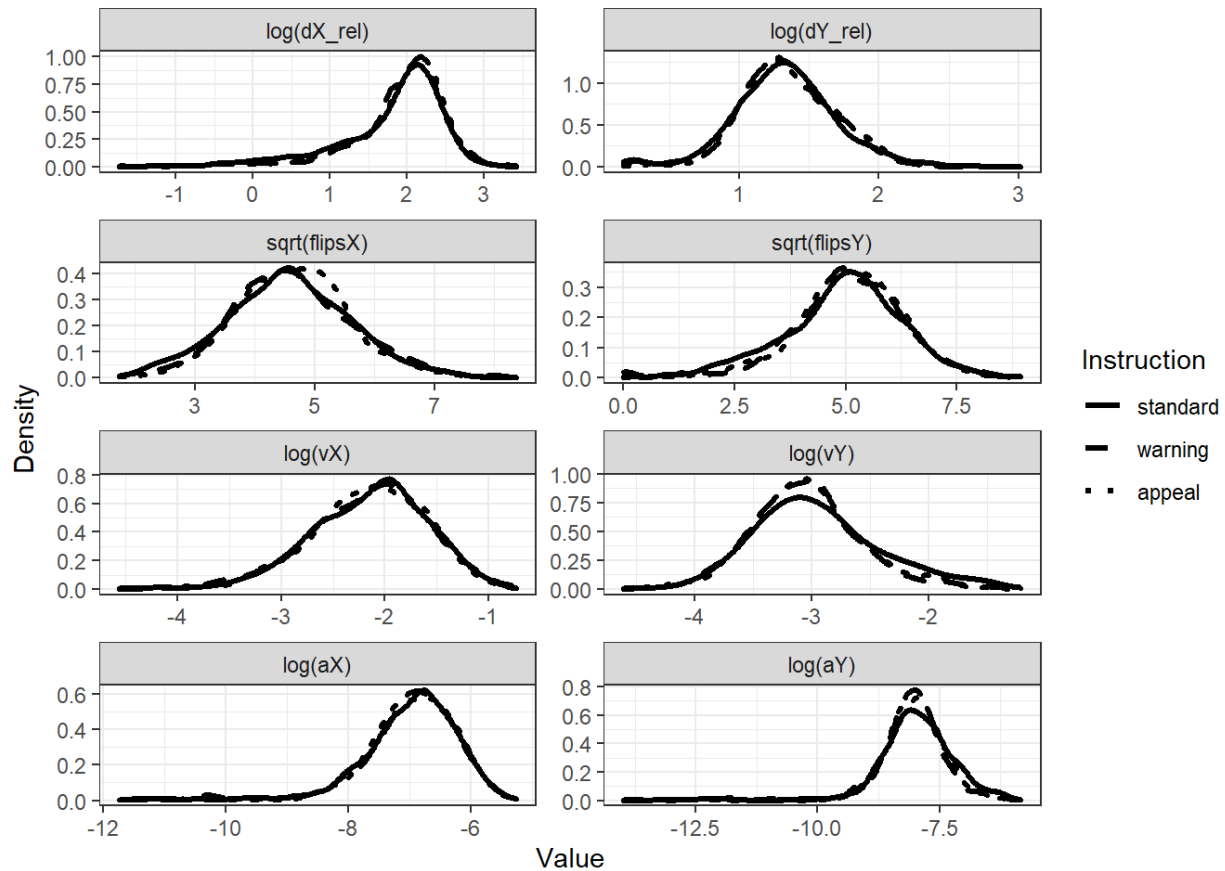*Figure S1 Distributions of mouse moves indices in the full sample.*

Figure S2 Distributions of mouse moves indices among respondents with a specific type of instruction. Only respondents who passed the manipulation check were included.

Reanalysis using views on vaccines scale

Table S12 Wording of the views on vaccines scale (English translations in parenthesis).

No.	Item	Wording
1	Ważne jest, aby każdy miał podstawowe szczepienia. (*It is important that everyone has basic vaccinations.*)	+
2	Szczepienia są ważne, ponieważ chronią nie tylko Pana/Panią, ale także inne osoby. (*Vaccinations are important because they protect not only you but others as well.*)	+
3	Niewykonanie szczepień może prowadzić do poważnych problemów zdrowotnych. (*Not getting vaccinations can lead to serious health problems.*)	+
4	Szczepienia są ważne tylko dla dzieci. (*Vaccinations are only important for children.*)	-
5	Szczepionki są poddawane rygorystycznym badaniom, zanim zostaną dopuszczone do stosowania. (*Vaccines are rigorously tested before they are approved for use.*)	+
6	Szczepionki mogą wywoływać poważne choroby (np. bezpłodność, autyzm itp.). (*Vaccines can cause serious diseases (e.g. infertility, autism, etc.).*)	-

No.	Item	Wording
7	Wszyscy pełnoletni, zdrowi Polacy powinni zaszczepić się przeciwko SARS-COV-2. (*All adult, healthy Poles should be vaccinated against SARS-COV-2.*)	+
8	Dzięki szczepieniom ochronnym dzieci wiele groźnych chorób obecnie praktycznie nie występuje. (*Thanks to immunization of children, many serious diseases are now practically non-existent.*)	+
9	Szczepienia są najskuteczniejszym sposobem ochrony dzieci przed poważnymi chorobami. (*Vaccinations are the most effective way to protect children from serious diseases.*)	+
10	Szczepienia są promowane nie dlatego, że są rzeczywiście potrzebne, lecz dlatego, że leży to w interesie koncernów farmaceutycznych. (*Vaccinations are promoted not because they are really needed, but because it is in the interests of pharmaceutical companies.*)	-

Note: In the survey Polish wording was used.

Table S13 Pearson correlations between CMIs.

	log(dX_rel)	log(dY_rel)	sqrt(flipX)	sqrt(flipY)	log(aX)	log(aY)	log(vX)
log(dY_rel)	0.50***						
sqrt(flipX)	0.55***	0.56***					
sqrt(flipY)	0.65***	0.61***	0.84***				
log(aX)	0.48***	0.29***	0.17***	0.27***			
log(aY)	-0.02	0.35***	0.04	0.08**	0.76***		
log(vX)	0.56***	0.23***	0.17***	0.22***	0.84***	0.57***	
log(vY)	-0.24***	0.31***	-0.10***	-0.14***	0.42***	0.79***	0.50***

N = 1825
*** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$

Table S14 Pearson correlations between C/IER indices.

	Longstring	Mahalanobis	Pathfinder QC failures	Self-reported diligence
Mahalanobis	-0.18***			
Pathfinder QC failures	0.21***	-0.01		
Self-reported diligence	-0.37***	0.09***	-0.28***	
log(Page time)	-0.49***	0.15***	-0.21***	0.34***

N = 1809 for correlation involving self-reported diligence
N = 1825 for all the other correlations
*** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$

Table S15 Pearson correlations between cursor moves and CIE/R indices across the whole dataset

Measure	Longstring	Mahalanobis	Pathfinder QC Failures	Self-Reported Diligence	log(Page Time)
log(dX_rel)	-0.58***	0.12***	-0.19***	0.34***	0.56***
log(dY_rel)	-0.09***	0.14***	-0.01	0.05*	0.33***
sqrt(flipsX)	-0.25***	0.09***	-0.06*	0.12***	0.44***
sqrt(flipsY)	-0.34***	0.08***	-0.10***	0.19***	0.49***
log(vX)	-0.11***	0.01	-0.05*	0.08***	-0.37***
log(vY)	0.46***	-0.07**	0.16***	-0.27***	-0.74***
log(aX)	-0.02	-0.08***	-0.07**	0.04	-0.34***
log(aY)	0.35***	-0.14***	0.06**	-0.19***	-0.62***

N = 1809 for correlation involving self-reported diligence.
N = 1825 for all the other correlations.
*** $p < .001$; ** $p < .01$, * $p < .05$.

Table S16 Results of ANOVAs (type II tests) predicting a given measure using type of survey instruction, response scale length and format, and interaction of the two

Measure	Instruction main effect			Response scale main effec			Interaction: instruction X response scale		
	F	p	partial η^2	F	p	partial η^2	F	p	partial η^2
log(dX_rel)	6.03	0.002	0.007	3.37	0.001	0.013	1.51	0.101	0.012
log(dY_rel)	2.44	0.087	0.003	11.63	0.000	0.043	1.57	0.079	0.012
sqrt(flipsX)	0.93	0.396	0.001	2.00	0.052	0.008	1.31	0.195	0.010
sqrt(flipsY)	0.53	0.591	0.001	1.93	0.061	0.007	1.12	0.338	0.009
log(aX)	2.90	0.055	0.003	1.97	0.056	0.008	0.87	0.595	0.007
log(aY)	4.62	0.010	0.005	1.65	0.116	0.006	1.32	0.186	0.010
log(vX)	1.70	0.183	0.002	1.72	0.101	0.007	0.90	0.559	0.007
log(vY)	5.30	0.005	0.006	1.65	0.116	0.006	1.25	0.231	0.010
Self-reported diligence	24.02	0.000	0.026	1.37	0.216	0.005	1.19	0.280	0.009
Longstring	1.68	0.186	0.002	1.33	0.233	0.005	1.54	0.088	0.012
log(Page time)	5.93	0.003	0.006	3.15	0.003	0.012	1.49	0.106	0.011
Pathfinder QC failures	0.88	0.413	0.001	0.57	0.783	0.002	2.12	0.009	0.016
Mahalanobis	1.01	0.366	0.001	120.09	0.000	0.317	0.93	0.522	0.007

N = 1809 for analysis involving self-reported diligence as a dependent variable
N = 1825 for all the other analysis
Note: Test statistics and partial η^2 for main effects computed in the absence of the interaction effect (type II test).

Table S17 Effect size of instruction type in models predicting values of specific CMIs and CIE/R indices using type of test instructions and response scale length and format

Measure	*Warning* instruction effect		*Appeal* instruction effect	
	Cohen's *d*	*p* (Wald's test)	Cohen's *d*	*p* (Wald's test)
log(dX_rel)	0.08	0.159	0.19	0.001
log(dY_rel)	-0.03	0.622	0.09	0.089
sqrt(flipsX)	0.03	0.623	0.08	0.176
sqrt(flipsY)	0.02	0.740	0.06	0.310
log(aX)	-0.07	0.233	0.07	0.183
log(aY)	-0.18	0.002	-0.07	0.233
log(vX)	-0.06	0.320	0.05	0.348
log(vY)	-0.18	0.002	-0.13	0.017
Self-reported diligence	0.38	0.000	0.28	0.000
Longstring	-0.06	0.328	-0.10	0.068
log(Page time)	0.15	0.009	0.18	0.001
Pathfinder QC failures	-0.07	0.256	-0.06	0.259
Mahalanobis	-0.05	0.379	0.03	0.549

N = 1809 for analysis involving self-reported diligence as a dependent variable
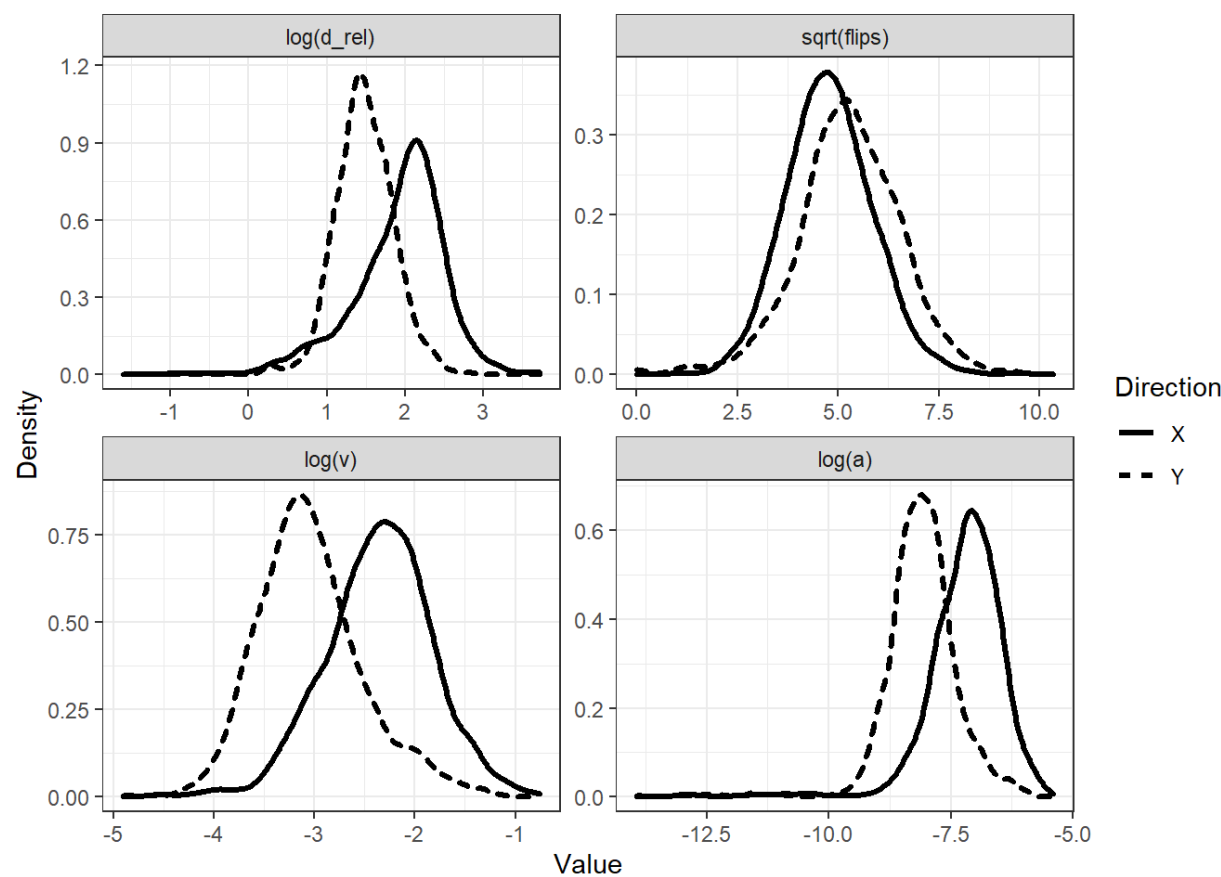N = 1825 for all the other analysis

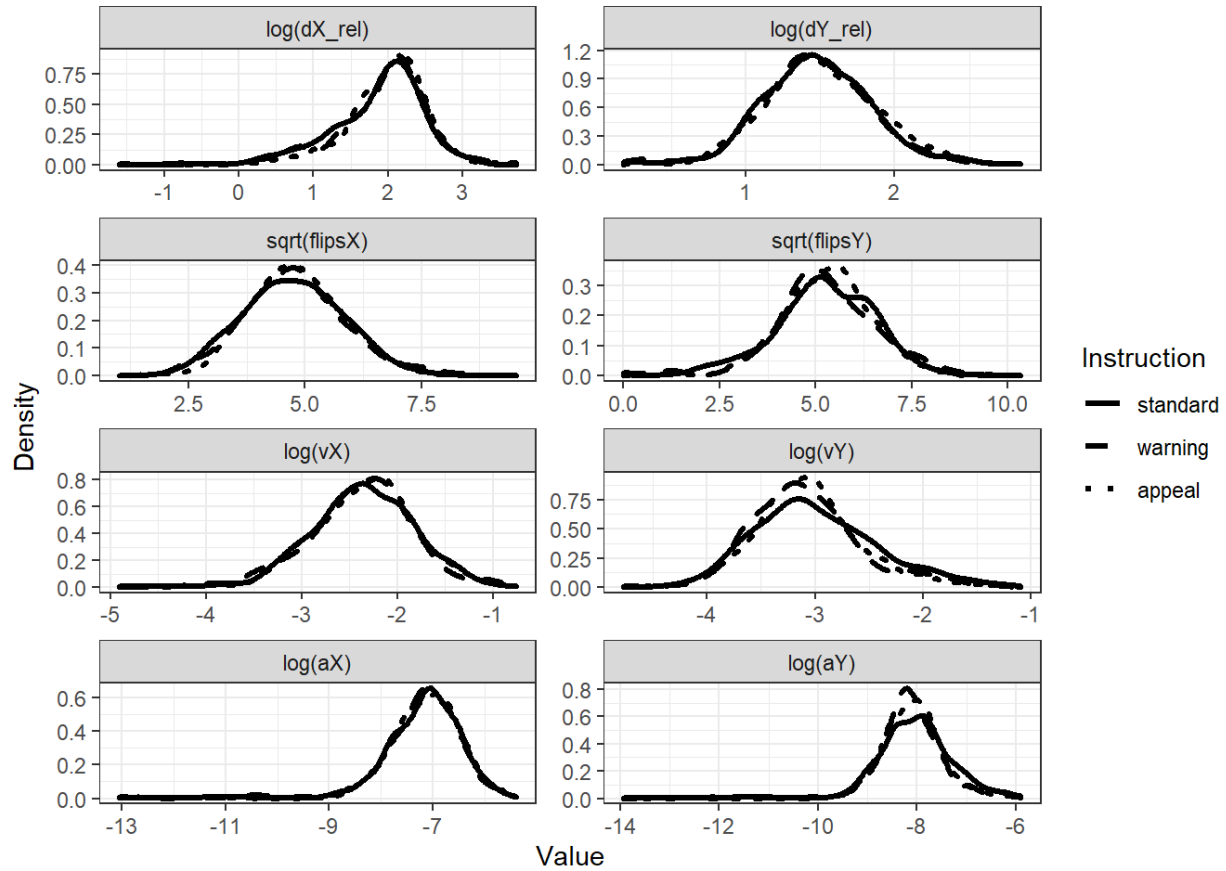*Figure S3 Distributions of mouse moves indices in the full sample - views on vaccines scale.*

Figure S4 Distributions of mouse moves indices among respondents with a specific type of instruction. Only respondents who passed the manipulation check were included - views on vaccines scale.