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New techniques to measure lie detection using COVID-19 fake news and the Multivariable Multiaxial Suggestibility Inventory-2 (MMSI-2)

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ABSTRACT

The pandemic caused by COVID-19 led to the distribution of excessive pseudoscientific information and fake news that has confused the general population. In the field of forensic psychiatry, lie detection is essential to determine if the witness is telling the truth with the purpose of making fair and effective decisions. In this research, we present a new approach that uses the pseudoscientific beliefs related to COVID-19 and 4 psychometric scales of the *Multivariable Multiaxial Suggestibility Inventory-2* (MMSI-2) to detect and predict lies. A total of 268 participants were classified into two groups: the control group (n = 132) and the quasi-experimental group (n = 136). The quasi-experimental group participants received instructions to lie as they wished in response to a number of questions on a content exam (called exam 1) based on a short children's film. The participants had to indicate which and how many questions they had lied on. The quasi-experimental group was only required to lie in exam 1. A second exam (called exam 2) was also administered to assess whether the participants could recognize which news items about COVID-19 were false or true. The control group was not required to lie on any exam. Several multiple regression models were applied. The 4 scales of the MMSI-2 predicted 71.2% of the lies for exam 1 and 41.5% of the lies for exam 2. The control group participants obtained lower average scores on exam 1 than the quasi-experimental group in the "F" and "Si" scales. The *theory of signal detection* is proposed as a possible explanation of the effectiveness of the MMSI-2 scales in lie detection.

1. Introduction

How to know whether someone is deliberately or automatically lying is a complex task in the field of forensic science (e.g., Hershkowitz & Lamb, 2020; Petersen & Morentin, 2019). Techniques that assess and detect lying often distinguish between *automatic lying* (which occurs when the witness is unknowingly deceptive) and *deliberate lying* (which occurs when the witness intends to cause a deception) (e.g., O'Sullivan, 2003; Vrij & Nahari, 2019). In both types of lying, the deception is expressed in the form of *omission errors* (the witness omits true information about the facts) and *commission errors* (the witness adds or invents false information about the facts) (e.g., Nahari et al., 2014; Pittarello et al., 2016; Spranca et al., 1991).

Techniques that assess lying are based on three sources of information focused on witness behaviors (see Chiu & Oh, 2020; Vrij et al., 2010): (1) Sources based on the individual's physiological activity; (2) sources related to the nonverbal behavior of the declarant; and (3) sources based on the verbal language or explicit verbal content of the testimony. The information obtained from these sources cannot always be compared with empirical evidence from forensic investigations, and only the sources of information directly associated with the witness's behavior are available to the courts (e.g., Bycroft et al., 2020; Otgaar et al., 2016; Vrij et al., 2019). The most commonly used source of information in the forensic field is the verbal behavior of the witness (e.g., Neuschatz et al., 2012; Vrij & Turgeon, 2018). In this research, we will focus on the verbal behavior and self-reported speech of the witness.

1.1. How to assess verbal witness credibility

The *Criteria-Based Content Analysis* (CBCA) protocol is a psychological and forensic method consisting of 19 criteria that identify characteristics of true content in witness declarations (see Maier et al., 2018; Oberlader et al., 2016). The CBCA method only examines the credibility of the testimony and does not enable the detection of lying (e.g., Dukala et al., 2018). Although CBCA is very popular in the field of forensic psychology, several studies question the validity and generalizability of results obtained with this method (e.g., Hauch et al., 2017; Schemmel et al., 2019; Uziel, 2010; Welle et al., 2016). For this reason, some forensic professionals recommend the application of the CBCA in conjunction with other verbal techniques and information sources (e.g., Bogaard et al.,

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2019; Nahari, 2016; Schemmel et al., 2020).

Psychometric techniques that focus on verbal behavior, perceptions, and facts experienced by the witness are *self-report tests or questionnaires* (see Iacono & Patrick, 2018; Littrell et al., 2020). Self-report questionnaires collect structured statements (hereafter items); the participant must analyze and specify how true the items are or how strongly he/she has experienced them in his or her past (e.g., Lee et al., 2019; Simms et al., 2019). The verbal statement or declaration that a witness makes in a forensic investigation has the same main characteristics as self-report data from psychometric questionnaires: the participant states what he or she perceived and his or her subjective interpretation of what he or she experienced but does not have to explain how the events actually occurred (e.g., Campbell et al., 2019; Pfeuffer et al., 2019). Forensic declarations differ from psychometric data in that (1) the witness makes their own statements or declarations, and (2) the witness's discourse is not objectively structured (see Hauch et al., 2017).

There are multiple self-report questionnaires that examine *social desirability* or *dissociation* as forms of lying but they do not have much applicability in forensic sciences (see Hart et al., 2019; Littrell et al., 2020; Moral & Sirvent, 2014; Sirvent et al., 2019). However, Escolà-Gascón (2020a) developed and validated the *Multivariable Multiaxial Suggestibility Inventory-2* (MMSI-2). This questionnaire aims to detect and measure the subclinical psychological variables and cognitive biases present in subjects who claim to have "psychic" abilities or those who have experienced pseudoscientific phenomena (e.g., paranormal phenomena) (Escolà-Gascón, 2020b). The MMSI-2 was created with the purpose of understanding outside the psychopathological framework, that is, why some people believe they have had paranormal experiences and others do not. In fact, it should be considered that paranormal experiences have no ontological validity in science and are a scientifically impossible phenomena (e.g., Reber & Alcock, 2020). The MMSI-2 includes 4 scales that examine the *inconsistencies* (hereafter K scale), *frauds* (hereafter F scale) *lies* (hereafter L scale) and *simulation* behaviors (hereafter Si scale) in the interviewee's speech. These scales are contextualized in the context of pseudoscience and anomalous experiences (see French & Stone, 2014; Maraldi & Krippner, 2019).

1.2. Lies and pseudoscientific hoaxes about COVID-19

The coronavirus pandemic has revolutionized the health, economic, political and social sectors of many eastern and western countries (e.g., Armitage & Nellums, 2020; Bavel et al., 2020). One of the most widely used containment measures has been the implementation of widespread *social quarantine* of the entire population (e.g., Huang et al., 2020). Actually, in no other historical period of democracy has a health measure as restrictive as this one been applied (e.g., Wilder-Smith et al., 2020). The coronavirus crisis has generated a monopoly of social media and disseminated official news (e.g., Innerarity & Colomina, 2020b). Statistical evidence indicates that social panic, irrational behavior, and pseudoscientific beliefs have increased during the crisis period (e.g., Boyraz & Legros, 2020; Horesh & Brown, 2020; Liang et al., 2020). Likewise, several studies have warned of the growth of numerous pseudoscientific lies and fake news related to COVID-19 (e.g., Escolà-Gascón et al., 2020). The problem is that some people do not clearly distinguish between information based on scientific evidence versus pseudoscientific information (e.g., Pulido, Villarejo-Carballido, et al., 2020). Moreover, accepting false information as truth can lead to serious problems for people's health (e.g., Pulido, Ruiz-Eugenio, et al., 2020).

In this research, we consider whether it is possible to use COVID-19-related fake news to detect perceptual biases in the witness's verbal discourse. In fact, we believe that deceptions and scams carried out by those who have claimed to experience paranormal activities can be useful in assessing and detecting lies in the legal-forensic field. Thus, a question arises as to whether paranormal fraud can be used to detect lies in the clinical and forensic field.

1.3. Definition of the main variables of the study

As initially specified, lies can be understood as errors of omission or commission in the witness's verbal speech (e.g., O'Sullivan, 2003). When a subject accepts fake news or pseudoscientific information as truth, he or she is making a mistake of commission (or type I error). People who detect these errors question the subject's credibility as the number of errors increases. Along this line, the tendency to lie is understood as the number of errors made by omitting truthful data or adding false information in a verbal statement (e.g., Semrad et al., 2019; Vrij et al., 2010). The more mistakes the participant makes, the greater his or her tendency to lie (see O'Reilly & Doerr, 2020).

"Perceptual bias" and "cognitive bias" are psychological expressions to classify automatic errors observed in verbal statements (e.g., Nahari et al., 2014; Pittarello et al., 2016). The word "bias" is used in this research as a synonym for automatic error and should not be understood otherwise. In parallel, the concept of pseudoscientific lies about COVID-19 refers to information that contradicts the current scientific evidence regarding the coronavirus. The expression pseudoscientific beliefs have a more generic meaning (e.g., Escolà-Gascón et al., 2020). In this case, pseudoscientific beliefs consist of accepting the existence of phenomena that are scientifically impossible because they lack ontological validity (e.g., Reber & Alcock, 2020).

The basis of this research is as follows: according to the previous logic, the credibility of the witness will decrease as a person accepts the veracity of pseudoscientific phenomena (errors of commission) and rejects scientifically proven phenomena (errors of omission).

1.4. Research objectives and hypotheses

This research has three main objectives: (1) To examine and detect the tendency to lie in verbal statements; (2) to use pseudoscientific lies related to COVID-19 and the perceptive biases present in those who practice pseudoscience as psychological indicators that enable the detection of lying; and (3) to analyze the effectiveness of the K, F, L and Si scales of the MMSI-2 to detect *liars* (quasi-experimental group) and *honest* subjects (control group). These scales could be a complementary tool for forensic investigators to improve their decisions regarding the credibility of a statement or the detection of lies. The main hypothesis is the following: *MMSI-2 scales detect the number of lies and pseudoscientific beliefs related to COVID-19. The pseudoscientific beliefs are correlated with the lies.*

2. Methods

2.1. Sample

There were 268 participants (45.1% were men and 54.9% women). All of them were adults ($mean_{age} = 22.09$; $standard\ deviation_{age} = 2.489$) and self-reported that they had no psychiatric antecedents. In terms of academic training, 39.9% said they had completed *university studies,* 30.2% said they had received *vocational training,* and 29.9% had completed *high school.* The participants authorized their collaboration in this study by signing the informed consent form. All personal data were anonymized.

2.2. Materials and instruments

2.2.1. Multivariable Multiaxial Suggestibility Inventory-2 (MMSI-2)

The MMSI-2 is a 174-item questionnaire developed and validated by Escolà-Gascón (2020a). The MMSI-2 is composed of 20–21 scales that examine different psychological variables and biases related to pseudoscientific beliefs. However, in this research, only 4 scales were used: *Inconsistencies* (K), *Frauds* (F) *Lies* (L) and *Simulation* behaviors (Si). In total, these scales have 61 items. The participant must indicate the degree of agreement for all items. The answers are coded following the *Likert* model with 5 answer options that range from 1 (which means completely

Table 1
Contents and behaviors assessed in K, L, F and Si scales and corresponding reliability coefficients.

S	Content assessed		Ordinal *Cronbach's Alpha*
K	Random answers	Item understanding	0.973
	Psychopathological risks	Degree of collaboration with the interview	
L	Presence of lies	Credulity	0.994
	Defensive behavior	Unmotivated decisions	
	Moralistic behaviors		
F	Psychological games	Machiavellianism	0.993
	Deliberate lies	Bad thought	
	Manipulations	Be a whistle	
	Frivolous behaviors		
Si	Ambiguous responses	Lack of responsibility	0.976
	Confusing answers	Barnum effect	

Note: S = scales; *K= Inconsistencies; L= Lies; F= Fraud; Si= Simulation.*

disagree) to 5 (which means completely agree). Table 1 shows the behavioral contents that each scale assesses and the corresponding reliability coefficients. All this information, including the validity of the MMSI-2, can be found in the work by Escolà-Gascón (2020b).

2.2.2. List of pseudoscientific lies about COVID-19

In this research work, an optimal performance test was created to evaluate the population's knowledge and judgments about the scientific evidence of coronavirus. The participant indicated whether the information provided in each item was possible or not. The test has 18 questions with three answer options: "Yes", which must be chosen when the contents are true or can occur scientifically; "No", which must be chosen when the contents are impossible or false according to the scientific research; and "inconclusive information" (represented as "?"). This alternative answer must be chosen when the item contents show inconclusive results (i.e., there is no official scientific consensus). To avoid guessing behaviors, errors and lies, a fourth response alternative was added: "I do not know the correct answer". This option had to be chosen only when the participant (1) did not know the correct answer, (2) was uncertain about how to interpret the content of the items, or (3) did not have enough knowledge to choose the right option. With this answer option, the participant had no reason to guess, lie, or risk making mistakes in answering the items. In this test, all items had to be answered. Table 2 shows all the items in this test and the correct answer for each (column R).

According to Tables 2 and 6 items contain true information, 6 contain false information and the other 6 contain inconclusive information. The false contents were extracted from the publications of the *World Health Organization* (see World Health Organization, 2020) and from the information that Escolà-Gascón et al. (2020) published in Globalization and Health. Errors were not penalized.

2.2.3. Contents list of the children's short film entitled: "Clara or the girl who wouldn't grow up"

This optimal performance test was developed to have an equivalent or complementary measure to the COVID-19 lie-list exam. Although COVID-19 is an international phenomenon, asking about COVID-19 may be biased (see Escolà-Gascón et al., 2020). Therefore, a new performance test with the same characteristics as the COVID-19 test was developed. This test used the contents of a short children's film, which has an open access license and is subtitled in English (See Tamayo, 2020). Table 3 shows the items and correct answers for this test.

The coding of the answers is the same as that used in the COVID-19 test. The contents were also designed in such a way that they were balanced: 8 items had true contents, 8 presented false contents and another 8 presented inconclusive contents. Errors were not penalized.

Table 2
Experimental questions about COVID-19.

N°	Questions	R
1	The coronavirus can be transmitted through mosquito bites.	?
2	Coronaviruses can be deadly at any age.	Y
3	Coronaviruses can be cured with antibiotics.	N
4	Coronaviruses can cause diarrhea.	?
5	Coronavirus can be prevented through vaccination.	Y
6	Coronavirus can be a chronic disease.	?
7	Coronaviruses can cause flu-like symptoms.	Y
8	Coronaviruses can spread through the air over long distances.	N
9	Coronaviruses can be spread through physical contact.	Y
10	Coronaviruses can spread more quickly through electromagnetic fields.	N
11	Coronavirus can be transmitted through dogs and cats.	?
12	Coronavirus can make your nails grow faster.	N
13	Coronavirus can cause pneumonia.	Y
14	Coronavirus can cause a loss of smell.	?
15	Coronavirus can be a mutation of the AIDS virus.	N
16	Coronavirus can cause coughing.	Y
17	Coronavirus can be prevented by taking stimulant substances.	N
18	The coronavirus may mutate in the future and be more lethal.	?

Note: R = correct answer; Y = yes; N = no; ? = content not verifiable.

Table 3
Experimental questions about the short-movie titled "Clara or the girl who wouldn't grow up".

N°	T	Questions	R
1	T2	Did Clara and Zoe make a toast while drinking some smoothies?	Y
2	T3	Is Clara in a scene in "a kitchen"?	?
3	T2	Does Clara make up Zoe?	N
4	T2	Does Zoe fall in love with a boy?	?
5	T3	At some point does Clara meet a clown?	Y
6	T2	Does Zoe get a kiss on the cheek from a boy?	N
7	T1	Are any smoothies in the video chocolate?	?
8	T1	Does Clara wear a mask?	Y
9	T3	Can you see the audience applauding when Clara finishes her performance?	N
10	T2	Is Clara disappointed when she sees Zoe making out with a boy?	?
11	T1	Does Zoe wear a head scarf with pictures of skulls?	Y
12	T1	Does Clara dress up as "Little Red Riding Hood"?	?
13	T3	Did the circus have colored lights?	Y
14	T3	Can you see caged animals?	N
15	T3	When Zoe kisses a boy, is she in the woods?	?
16	T1	Does Zoe use a coffee cup?	N
17	T2	Do Clara and Zoe swing on a swing set?	Y
18	T1	Does Clara use a potion to stop growing?	?
19	T1	Does Clara use a candle?	Y
20	T2	Does Zoe eat a cookie?	N
21	T3	Is it nighttime when the characters drink the smoothies?	N
22	T1	Does Clara wear a green cape?	N
23	T3	In some scene, are Clara and Zoe in a playground?	?
24	T2	Does Clara ever start to feel more and more alone?	Y

Note: R = correct answer; Y = yes; N = no; ? = content not verifiable; T = type of content of each question; T1 = clothing and objects of the characters; T2 = behaviors and activities of the characters; T3 = places and spaces.

2.2.4. Self-deception questionnaire (SDQ-12)

The SDQ-12 self-report questionnaire was applied as a complementary measure to the MMSI-2 scales. This scale has 12 items or phrases, and for each question, participants must indicate their degree of agreement using the *Likert* model (from 1 -strongly disagree-to 5 -strongly agree-). The SDQ has two dimensions: *Manipulation* (6 items) and *Mystification* (6 items). The Manipulation scale measures the person's tendency to make manipulations when the individual misinterprets reality. In contrast, the Mystification scale measures the degree of subclinical dissociation presented by the participant. The SDQ-12 presents satisfactory psychometric properties. For example, the reliability coefficients show internal consistency indices of 0.81 for each dimension (see Moral & Sirvent, 2014; Sirvent et al., 2019). More specifically, the Spanish version of Sirvent et al. (2019) was used in this study.

2.3. Procedures

The design of this research is correlational and quasi-experimental. The procedure regarding the application of the materials for each case can be summarized as follows: (1) Providing informed consent and sociodemographic data, (2) watching the short film "Clara or the girl who wouldn't grow up"; participants could only watch the video once, (3) completing 24 questions about the short film, (4) completing 18 questions about COVID-19, (5) completing the MMSI-2 (K, L, F and Si scales) and SDQ-12 questionnaires, and (6) finalizing and telematically submitting the answers.

Participants were recruited via the Internet. The questionnaires and application materials were scanned into two types of online forms: Form A and Form B. The only difference was that the instructions on Form A were to answer the 24 questions about the short film, which included a challenge for the participant. To clarify, the instructions for the 24-question test were as follows:

1. **General instructions (for both forms A and B):** To answer, compare the contents of each question with the information you have observed in the short film and mark "YES" when the content of the question is TRUE, mark "NO" when the content of the question is FALSE, and mark the option "?" (or question) ONLY when the content of the question is inconclusive. The "question mark" option will only be correct when the contents of the question are not verifiable with the facts observed in the video. Therefore, the "question mark" option is not equivalent to "I do not know the correct answer". This is an important point to understand. You may not remember all the information in the short film, and you may feel that your answer will be wrong if you choose any of the above options. When this situation happens to you, we require you to choose the option "I don't know the answer". Please answer ALL questions.
2. **Please note (only in form A):** We propose a challenge. Imagine that another person asks you these questions and you have the possibility to lie. Don't worry, no one will know that you lied. We know you don't like to lie, but in this exercise, we require you to lie deliberately. You can do it on as many questions as you want. You can also use any answer option to lie: "Yes", "No", "?" or "I don't remember". There is only one condition: you must lie on at least one of the 24 total questions. For each question, indicate whether you have lied or not. Please do not choose the correct answer when you lie. If this situation occurs, your "lie" will be invalidated.

The instructions for the rest of the exercises did not include any extraordinary conditions and were the same for both types of forms. A total of 627 original forms were sent out, and each participant had to choose which form he or she wanted to answer. We previously reported that on form A, the participant had to lie on the first exam. These submissions were collected over 4 months. At the end of the fourth month, only 132 subjects had answered form A, and 136 chose to answer form B. In total, 359 subjects did not respond to the forms for unknown reasons.

The subjects who responded to form A composed the *quasi-experimental group,* and those who responded to form B composed the *control group*. Therefore, the methodology used was not experimental.

Once the raw data were obtained, purification of the matrix was carried out, eliminating unnecessary variables and calculating the scores of the applied tests. No missing values were identified. In total, there were 268 participants in this study.

2.4. Statistical analysis

The data were processed with *SPSS* (version 23) and *JASP* (see The Jamovi Project, 2020) software. JASP is a program that specializes in Bayesian inference, although it also includes classical hypothesis contrasts. Multiple linear regressions with the *forward method* were used to fit a parsimonious prediction model regarding lie detection. According to Pardo and San Martín (2015), when solid theoretical models are lacking in the prediction of a criterion variable (in this research it is 'lie'), the use of the *step-by-step method* is recommended. An example of this method is the forward method. The forward method consists of the progressive incorporation of the different predictor variables into the statistical regression model that aims to predict the criterion variable. In each step, a predictor variable is added with the aim of analyzing whether its inclusion contributes to the increase in the explained variance (measured as R^2). Therefore, knowing which MMSI-2 scales best predict lying justifies the use of this method.

The K, L, F and Si scales of the MMSI-2 were used as predictor variables, and the observed errors were criterion variables. The other scales were not included in the model as predictor variables because they did not meet the prior assumption of linearity. The regression model was applied to differentiate between the control group and the quasi-experimental group. A contrast of means was made between the two groups. The *t-test*, *Mann-Whitney U test* and *Cohen's d measures* of *effect size* were used for this comparison. A Bayesian inference was also performed to estimate the posterior distributions using the *Bayes factor* in favor of the alternative hypothesis (hereinafter BF_{10}). BF_{10} is the *likelihood ratio* that its parameters are obtained by *integration* procedures and not by *maximization*. In this research, BF_{10} was adapted to the Student's *t*-test model using the following equation:

$$BF_{10} = \frac{\int_{\Theta_{H_1}} P(D|\theta_{H_1}, H_1) \cdot \pi(\theta_{H_1}|H_1) d\theta_{H_1}}{\int_{\Theta_{H_0}} P(D|\theta_{H_0}, H_0) \cdot \pi(\theta_{H_0}|H_0) d\theta_{H_0}} = \frac{P(D|H_1)}{P(D|H_0)} \quad (1)$$

where.

$P(D|H_1)$ is the probability that the data fit the alternative hypothesis, and
$P(D|H_0)$ is the probability that the data fit the null hypothesis.

The prior probabilities were adjusted to 50%, so the following equation can be applied to obtain the posterior probability $P(H_1|D)$:

$$BF_{10} = \frac{P(D|H_1)}{P(D|H_0)} \approx P(H_1|D) = \frac{BF_{10}}{BF_{10}+1} \quad (2)$$

Bayesian inference differs from classical contrast because it enables the validation of alternative hypotheses. In classical contrasts, the alternative hypotheses can only be maintained if the null hypotheses are rejected, although this does not confirm that the alternative hypotheses are valid (see Jarosz & Wiley, 2014).

Further, a regression model was used with the forward method, using the number of questions in which the participant had lied as a criterion variable. This regression model could only be applied to subjects in the quasi-experimental group. This regression model differs from the former in that the criterion variable is the deliberate lie and not the automatic lie, since it was the participant who chose the number of lies they wished to realize.

3. Results

3.1. Descriptive analysis and correlation matrix

The descriptive statistics of the performed measurements are presented in Table 4 for both the control group and the quasi-experimental group.

Pearson's linear correlations were also calculated for all the variables represented in Table 4 as a previous step before applying the regression models. Tables 5 and 6 provide the correlation matrices for each group.

The number of questions on which participants in the quasi-experimental group deliberately decided to lie was used as a direct indicator of the tendency to lie. A subject who decided to lie on all the questions would have a greater tendency to lie than the subjects who had

Table 4
Descriptive statistics for the control group and the quasi-experimental group.

Groups	Variables measured	Mean	Standard deviation	Variance
CG	Inconsistencies (MMSI-2)	19.1	4.792	22.967
	Frauds (MMSI-2)	48.58	19.104	364.956
	Lies (MMSI-2)	60.79	21.112	445.72
	Simulation (MMSI-2)	12.26	4.288	18.389
	Manipulation (SDQ-12)	15.81	7.442	55.385
	Mystification (SDQ-12)	16.29	7.251	52.58
	Number of incorrect answers in 24 items exam	7.87	5.224	27.295
	Number of incorrect answers in COVID-19 exam	9.51	4.066	16.533
QEG	Inconsistencies (MMSI-2)	19.71	4.576	20.939
	Frauds (MMSI-2)	68.39	15.499	240.21
	Lies (MMSI-2)	66.86	15.326	234.882
	Simulation (MMSI-2)	19.59	3.062	9.373
	Manipulation (SDQ-12)	16.37	7.552	57.029
	Mystification (SDQ-12)	16.99	7.46	55.656
	Number of incorrect answers in 24 items exam	12.97	7.229	52.259
	Number of incorrect answers in COVID-19 exam	9.8	4.148	17.202
	Number of questions in which the participant decided to lie	9.9	6.138	37.677

Note: *CG= control group; QEG= quasi-experimental group.*

chosen to lie only on 1 item. This decision was free and voluntary. This clarification is important because it justifies the value of the regression models that will be discussed below.

In relation to the control group, the previous tables indicate that the highest correlations are present for variables F, L and Si when they are related to the number of errors in the 24-question test. Regarding the quasi-experimental group, the variables that show the highest correlations are the F and L scales, whether they are related to the number of errors in the test about the short film or if they are related to the number of lies made by the subjects. If instead of the number of errors, the correct responses were counted in the exams, then the correlations would be negative. However, it is much clearer to use the errors because they indicate the tendency towards bias or automatic lying.

3.2. Regression models

The scales related to the SDQ-12 were not included in the regression models because they present excessively low correlations with the errors and lies recorded in the tests. In the regression model, the forward method uses stepwise logic to include only those variables that are truly useful for predicting the criterion variable. In this way, the forward method begins its work by including the predictor variable with the highest correlation with the criterion. After this point, new variables are included until the maximum explained variance is reached to predict the criterion. The forward method stops including variables when the increase in the coefficient of determination is no longer significant (ΔR^2). This method allowed us to determine whether the MMSI-2 scales are effective in detecting the profile of the liar subject. Tables 7 and 8 present all this information for each group.

In the control group, the L, F, Si and K scales represent the best regression model to predict the errors in the short film exam. According to the R^2 statistic, these scales predict up to 89.4% of the errors made by the participants. In contrast, in the COVID-19 exam, the F and K scales were the only variables that allowed for estimating errors with a weight or statistical efficacy of 21.2%.

In the quasi-experimental group, the F, L and K scales significantly predicted 71.2% of the lies that each subject had decided to realize. No participant in the quasi-experimental group made mistakes in the lie decisions. Therefore, it was not necessary to weigh the number of lies that the subjects in this group made. These results indicate that the scales formed the most effective prediction model to detect the liar's profile. The errors on the COVID-19 test could be predicted with a weight of 41.5% using the F and Si variables.

However, if the K, L F and Si scales truly predict the liar's profile, significant differences should be observed between the scores of the control group and those of the quasi-experimental group. More specifically, the quasi-experimental group should obtain higher average scores on these scales than the control group. For this reason, statistical comparison of the means were made, as shown in Table 9.

Table 5
Correlation matrices between the measured variables for the control group.

V	K	F	L	Si	M1	M2	E1	E2
K	–							
F	0.21	–						
L	0.137	0.813*	–					
Si	0.073	0.655*	0.714*	–				
M1	0.413*	0.152	0.12	0.131	–			
M2	0.414*	0.116	0.081	0.007	0.509*	–		
E1	0.219	0.883*	0.895*	0.773*	0.143	0.067	–	
E2	0.251	0.445*	0.434*	0.344*	0.286	0.194	0.45*	–

Note: **p < 0.001; V= variables; K= Inconsistencies; L= Lies; F= Frauds; Si= Simulation; M1= Manipulation scale of SDQ-12; M2= Mystification scale of the SDQ-12; E1= Errors on 24-Item test; E2= Errors on COVID test.*

Table 6
Correlation matrices between the measured variables for the quasi-experimental group.

V	K	F	L	Si	M1	M2	E1	E2	LN
K	–								
F	0.32*	–							
L	−0.029	0.469*	–						
Si	−0.046	0.507*	0.593*	–					
M1	0.391*	0.258*	−0.148	−0.083	–				
M2	0.408*	0.296*	−0.061	−0.05	0.492*	–			
E1	0.287	0.722*	0.703*	0.544*	0.178	0.261*	–		
E2	0.213	0.588*	0.42*	0.539*	0.164	0.279*	0.506*	–	
LN	0.348*	0.734*	0.673*	0.523*	0.238	0.305*	0.99*	0.513*	–

Note: **p < 0.001; V= variables; K= Inconsistencies; L= Lies; F= Frauds; Si= Simulation; M1= Manipulation scale of SDQ-12; M2= Mystification scale of the SDQ-12; E1= Errors on 24-Item test; E2= Errors on COVID test; LN= Number of questions on which the participant decided to lie.*

Table 7
Regression model applied to the control group. Number of incorrect answers on the 24-item test and the COVID-19 exam were criteria variables.

V	Number of incorrect answers on the 24-item exam			
	β (s.e.)	β_z	R^2 (ΔR^2)	F
β_0	−5.583 (0.615)	–	0.799 (0.8)	536.817**
L	0.221** (0.010)	0.895		
β_0	−6.067** (0.498)	–	0.870 (0.071)	74.104**
L	0.129** (0.013)	0.521		
F	0.126** (0.015)	0.459		
β_0	−6.911 (0.485)	–	0.891 (0.021)	26.385**
L	0.101** (0.013)	0.408		
F	0.113** (0.014)	0.413		
Si	0.259** (0.050)	0.212		
β_0	−8.113 (0.723)	–	0.894 (0.004)	4.903*
L	0.102** (0.013)	0.411		
F	0.107** (0.014)	0.393		
Si	0.266** (0.050)	0.218		
K	0.07 (0.031)	0.064		
V	Number of incorrect answers on the COVID-19 exam			
	β (s.e.)	β_z	R^2 (ΔR^2)	F
β_0	4.913 (0.859)	–	0.192 (0.198)	33.102**
F	0.095** (0.016)	0.445		
β_0	2.602 (1.386)	–	0.212 (0.026)	4.438*
F	0.087** (0.017)	0.411		
K	0.140** (0.066)	0.165		

Note: *$p<0.05$; **$p<0.001$ V= variables; β = regression coefficients; β_z = standardized regression coefficients; R^2 = explained variance; ΔR^2 = variation and increase in R square; β_0 = constant of each model; F= Fisher's test; K= Inconsistencies; L= Lies; F= Frauds; Si= Simulation.

Table 8
Regression model applied to the quasi-experimental group. The number of questions in which the participant decided to lie and the number of errors related to the COVID-19 exam were criteria variables.

V	Number of incorrect answers on the COVID-19 exam			
	β (s.e.)	β_z	R^2 (ΔR^2)	F
β_0	−0.967 (1.331)	–	0.341 (0.346)	68.706**
F	0.157** (0.019)	0.588		
β_0	−6.558 (1.834)	–	0.415 (0.078)	17.447**
F	0.113** (0.021)	0.424		
Si	0.439** (0.105)	0.324		
V	Number of questions on which the participant decided to lie			
	β (s.e.)	β_z	R^2 (ΔR^2)	F
β_0	−9.990 (1.653)	–	0.536 (0.539)	152.179**
F	0.291** (0.024)	0.734		
β_0	−15.920 (1.6)	–	0.673 (0.139)	55.452**
F	0.213** (0.022)	0.537		
L	0.169** (0.023)	0.421		
β_0	−20.529 (1.838)	–	0.712 (0.041)	18.801**
F	0.175** (0.023)	0.443		
L	0.189** (0.022)	0.472		
K	0.294** (0.068)	0.219		

Note: *$p<0.05$; **$p<0.001$ V= variables; β = regression coefficients; β_z = standardized regression coefficients; R^2 = explained variance; ΔR^2 = variation and increase of R square; β_0 = constant of each model; F= Fisher's test; K= Inconsistencies; L= Lies; F= Frauds; Si= Simulation.

3.3. Mean comparisons between the groups

Table 9 shows the classical statistics and Bayesian inference through the BF_{10}.

Significant results are observed for the F and Si scales and for the 24-question test about the short film. On these scales, the quasi-experimental group tended to obtain mean scores significantly higher than those of the control group. In the case of the F and Si scales, the probability that the alternative hypothesis fits the data are between 0.9526 and 0.967. Therefore, this means that the probability that the MMSI-2 scales detect the tendency to lie fluctuates between 95% and 96%. The other scales did not show differences beyond the expected chance.

Table 9
Means comparison between the control and quasi-experimental groups.

V	*t-test (df= 266)*	*Mann-Whitney U test*	*Cohen's d test*	BF_{10}	*Errors associated To* BF_{10}	$P(H_1\|D)$
K	−1.064	8,317.5	−0.130	0.229	2.959e −5	0.1863
F	−3.415*	6,937	−0.417	32.129	2.905e −7	0.967
L	−2.358	7,62	−0.288	1.885	4.506e −6	0.6533
Si	−6.609*	5,350.5*	−0.807	4.817e +7 ≈ 20.09	8.374e −14	0.9526
M1	−0.614	8,623	−0.075	0.160	4.011e −5	0.138
M2	−0.777	8,502	−0.095	0.179	3.662e −5	0.1518
E1	−6.596*	5,290.5*	−0.806	4.388e +7 ≈ 18.93	9.268e −14	0.9498
E2	−0.559	8,631	−0.068	0.156	4.117e −5	0.135

*$p < 0.001$; df = degrees of freedom; V = variables; K= Inconsistencies.
L = Lies; F= Frauds; Si= Simulation; M1 = Manipulation scale of SDQ-12.
M2 = Mystification scale of the SDQ-12; E1 = Errors on the 24-Item test; E2 = Errors on the COVID-19 test.
BF_{10} = Bayes Factor in favor to alternative hypothesis; $P(H_1|D)$ = Probability that alternative hypothesis fits the empirical data.

4. Discussion

The objectives of this research were to examine the tendency to lie through the use of pseudoscientific beliefs and fake news about COVID-19. The main purpose was to test the predictive validity of the MMSI-2 scales to detect lies in the witness's verbal declarations and discourse. The results indicated that the F, L, and K scales predict up to 71.2% of the number of observed lies. Similarly, subjects in the quasi-experimental group (the liars) obtained scores on the F and Si scales that were higher than those in the control group. The applied regression analyses and the mean comparisons revealed that the L, F, Si and K scales of the MMSI-2 are effective in detecting lying.

The results offered by this research raise the following questions: (1) If participants could choose the option "I do not know the answer" in the short film test and in the COVID-19 test, why did they choose to take a chance, try to guess the right answer, and make a mistake? A person who did not feel like lying had no encouragement or pressure to invent a lie in this research (except for the quasi-experimental group). (2) What role do pseudoscientific beliefs play in detecting lies? (3) How can the MMSI-2 scales (K, L, F, and Si) be used in the field of forensic psychology?

4.1. Interpreting mistakes as a form of lying

Scientific literature indicates that errors or mistakes are not the same as fraud (e.g., Petersen & Morentin, 2019; Vrij, 2008). The number of errors observed in the COVID-19 and control groups questions regarding the children's short film may not be the result of deliberate lying, but they may be the consequence of multiple attempts to guess the correct answer. The question we ask ourselves is not whether the errors themselves are lies. Rather, it is about understanding why a person, with no apparent reason to risk his answers and make mistakes, chooses the path of divination or the riskiest option: guessing. The problem is that guessing can be a type of lie because the subject makes his or her evaluator believe that he or she knows a correct answer when in fact he or she has been able to get it right by other means (e.g., Wise, 2019). We have assumed that certain people have a tendency to lie (e.g., Vrij et al., 2001; Vrij et al., 2010). We have established the hypothesis that people with a tendency to lie commit more biases or perceptual errors than individuals with other types of profiles (e.g., Semrad et al., 2019). The results support

and reinforce this hypothesis. According to this logic, would it be possible that liars had tendency to risk and make errors by commission?

One measurement model that could explain and answer this question is the *theory of signal detection* (see Egan, 1975; Wixted, 2020). This is a measurement model that was originally created to identify the different conditions and minimum psychophysical properties that a signal-stimulus must have in order to be detected by an individual (examples of psychophysical properties are the levels of strength, frequency, latency, etc. that a stimulus presents) (e.g., Macmillan & Creelman, 2005). Through the measurement model itself, the theory developed was that there were subjects with a tendency to risk (called *reckless subjects*) and more prudent subjects (called *conservative subjects*). When they doubted their perceptions, the reckless subjects tended to make positive (yes) or negative (no) judgments about the signal they perceived. On the other hand, the conservative subjects presented a tendency characterized by the omission of answers. The first group made mistakes by "commission", and the conservative subjects made mistakes by "omission" (e.g., Nahari et al., 2014; Pittarello et al., 2016).

Considering the results of this research, we believe that the K, L, F and Si scales of the MMSI-2 also assess the tendency to risk or make risky decisions. Furthermore, this would explain why in the quasi-experimental group these scales have higher correlations with errors observed in the COVID-19 and the short film tests rather than the control group. Basically, by giving the participants of the quasi-experimental group the instruction "you must and can lie as you wish", it could have caused an increase in the tendency to risk in the subjects of this group themselves. In any case, this would be directly related to the theory of signal detection. Therefore, in future research, the regression models that have been used in this investigation should be replicated but by using the tendency to risk of the signal detection theory as a criterion variable.

4.2. Intervention of pseudoscientific beliefs in the lie

It should be noted that there is very strong evidence pointing to *search for control* as the main causal variable of irrational beliefs (e.g., Lange et al., 2019). In addition, the K, L, F, and Si scales consistently yield higher scores in those subjects who accept the existence of the paranormal (e.g., Escolà-Gascón, 2020a; 2020b). According to the results of this research, pseudoscientific beliefs reinforce the *sense of control* in the individual, facilitating a false sense of security and the tendency to take risks. Then, as pseudoscientific beliefs increase, the tendency to take risks and guess should also increase, consequently encouraging deception or lying (see Irwin et al., 2018). In fact, this hypothetical proposal would also explain why the errors of the COVID-19 test correlate positively with the respective MMSI-2 scales. It is a test that examines the subject's judgment to detect pseudoscientific lies.

4.3. The "number of lies" as an indicator of lying

When the subjects who answered Form A (the quasi-experimental group) were asked to lie on the short film exam, they were not given a limit on the number of questions which they could lie on. Why did some subjects lie on more questions than others? This question does not have a direct answer. There may be many variables that explain this tendency. However, according to the results shown in Table 9, the subjects who chose to lie and be part of the quasi-experimental group tended to score higher on the K, L, F and Si scales of the MMSI-2. This supports the theories of Vrij et al. (2019), who describe the profile of the lying subject and the psychological attributes that characterize lying. Therefore, there are rational reasons to believe that the tendency to lie is the factor that has led subjects to desire to lie on this test. However, this comment is simply an inference to be contrasted in future research.

4.4. Limitations

The limitations of this research can be grouped into three main points: (1) The generalizability of the results obtained to the forensic context related to the verbal statements of witnesses is questionable for a very obvious reason. In the forensic field, it is the witness who elaborates the contents of his or her discourse. Even the witness can sometimes ask his or her own questions to the interviewer (see Vrij, 2008). The statements that have been analyzed in this study were of a *forced-choice* and dichotomous type. This implies having a simpler decision system than the cognitive procedures that a witness must follow in his or her declaration. To have better external validity, these results should be replicated following an experimental methodology and increasing the levels of complexity in the cognitive tests. (2) There is no experimental evidence that the intention to lie (i.e., deliberate lying) is the main factor that explains why some subjects lied in more items than others (see section 4.3.). This leads to a similar problem as the dilemma presented by the experimental research conducted with the CBCA: the variables causing "credibility" or "lying" cannot be manipulated in experimental terms (see Nahari et al., 2019). Nevertheless, unlike the studies that were based on the judgment of credibility using the CBCA and those that had the dilemma of what was real or unreal (from the witness declaration) in the short film's exam, the subject does not examine facts from reality.

Actually, the questions are contrasted with the facts told by the video, and this is the reference criterion. Therefore, in this study, there is a direct empirical reference that allows us to determine what is true, what is false and what is not contrastable according to the short film's contents. This is very important because the procedures of this research can compensate for the limitations of classical research that uses the CBCA technique. (3) Finally, there are also certain difficulties related to the suitability of the subjects for the conditions of each test. It should be taken into account that the administration of both forms was done online and that the researcher was not present during the time the participant watched the short film and responded to the tests. The application of the questionnaires was done in this way due to the international coronavirus crisis, which forced the Spanish population to be confined to their homes for 57 consecutive days (see Escolà-Gascón et al., 2020). However, this research is essential because it proposes a new methodology to investigate lying: applying psychometric techniques and combining them with experimental trials that examine verbal biases and deceptions.

5. Conclusions

The results and discussion of this study contribute to the field of forensic psychology with the following conclusions:

[1] The difficulties observed in the identification and discrimination of fake news associated with COVID-19 suggest that pseudoscientific beliefs can be used to detect automatic errors or deceptions. Pseudoscientific beliefs could moderate the tendency to lie, thereby increasing the individual's sense of control. This increase in the sense of control produces a false sense of security that leads the subject to assume excessive risks and therefore to err.

[2] The theory of signal detection must be applied as a model of measurement in lie detection. If the results of this research are correct, then it should be possible to fit a valid and reliable measurement model based on this theory.

[3] The K (*Inconsistencies*), L (*Lies*) and F (*Frauds*) scales predict 71.2% of the lies made by the witness. Although these results must be replicated and recalibrated with more accurate regression models (e.g., *Poisson regression* models), they show a much stronger and higher prediction than those observed in other investigations (see Vrij et al., 2019).

[4] Evidence was obtained to support the hypothesis of the liar's profile (e.g., Vrij, 2008; Vrij & Turgeon, 2018). The K, L, F, and Si MMSI-2 scales enable the assessment of this profile.

[5] The *Manipulation* and *Mystification* variables of the SDQ-12 have low correlations (<0.3) with the number of lies. According to the

results, it seems more convenient to use the scales of the MMSI-2 in lie detection.

Ethics approval and consent to participate

Dr. Sacra Morejon Torné, Vice Dean of Research of the Faculty of Psychology of Ramon Llull University, representing the Committee of Ethical Guarantees of Ramon Llull University, (Barcelona, Spain) reviewed, favorably evaluated and approved this research. Likewise, the procedures of this study adhere to the Spanish Government Data Protection Act 15/1999 and the Declaration of Helsinki of 1975, revised in 2013.

Consent for publication

Not applicable for this section.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

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This study was not preregistered.

Declaration of competing interest

I wish to confirm that there are no known conflicts of interest associated with this publication and there has been no significant financial support for this work that could have influenced its outcome.

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