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About Linda Again: How Narratives and Group Reasoning Can Influence Conjunction Fallacy

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Received: 23 August 2019; Accepted: 2 October 2019; Published: 8 October 2019

Abstract: Conjunction fallacy (together with other systematic reasoning errors) is usually explained in terms of the dual process theory of reasoning: Biases should be ascribed to fast and automatic processes, whereas slow and deliberative processes are responsible of producing answers that are correct with respect of normative criterion. The dual process theory is related to Bruner's distinction between narrative and paradigmatic thought: Both modes of thought can be characterized by the two different processes of reasoning. In this paper, we explore the role of Bruner's mode of thought manipulating also the difference between group vs individual reasoning. We observed that the narrative strategy of response induces more wrong answers. However, narrative-based strategies have higher effectiveness in the case of group reasoning. Our results suggest that narrative reasoning and group reasoning may induce violations of the conjunction rule when acceptable by the verisimilitude of the story. Five models are also presented in order to predict answer correctness and strategy of reasoning using a text analysis software.

Keywords: conjunction fallacy; narrative thought; dual-process; group reasoning

1. Introduction

Within the internet science community, there had been many efforts to improve collective decision-making by means of specific technologies [1–4]. For example, understanding how people reason (and, eventually, commit mistakes) at individual level or in group is crucial to improve the design of online crowdsourcing systems and software [5,6]. In this paper, we investigate a paradigmatic reasoning error, the conjunction fallacy.

Conjunction fallacy has been investigated since the famous paper of Tversky and Kahneman [7] on extensional reasoning. In this paper they proposed a variety of scenarios in which they asked to rank the probability of different sentences. The most famous scenario is the Linda's problem. Given a description of Linda (suggesting that she might be a feminist), people ranked the sentence She is a bank teller (P(A)) less likely than She is a bank teller and is active in the feminist movement (P(A&B)). However, from a normative point of view, probability theory dictates that $P(A\&B) \leq P(A)$. The violation of this rule has been originally explained recurring to the concept of representativeness heuristic. People rate the probability of the various sentences on the bases of the degree to which an event (i) is similar in essential characteristic to its parent population, and (ii) reflects the salient features to the process by which it is generated. Therefore, when people have to rank the probability of the sentences related to Linda, using the representativeness heuristic means to employ the similarity between the description of Linda and the sentences to be ranked as a criterion of choice [8]. This problem has stimulated a great deal of research [9–12], including attempts to define more precisely the concept of

heuristic and a variety of other explanations [13–17]. For example, we can cite a paper of Tentori, Crupi, and Russo [18] sustaining that inductive confirmation is the critical factor for the conjunction fallacy. According to them, the crucial factor is not the high perceived probability of the added conjunction (the fact that Linda is a feminist) but how much the added conjunct appears to be likely in light of the Linda's description. On the contrary, Politzer and Noveck [17], on the bases of the conversational rules of Grice, Cole, and Morgan [19], supposed that the conjunction fallacy arises because of a misunderstanding of the conjunct option. Even if some findings are contrasting such hypotheses, conjunction fallacy is a firm phenomenon and it has been used under different conditions to test hypothetical scenarios and to explain real life task's biases (e.g., clinical diagnosis, sport predictions). In sum, the representativeness account (despite caution and criticism) is the standard interpretation of conjunction fallacy [20]. The explanation based on the representativeness heuristics (together with other biases that can be explained in terms of heuristic) has led to speculate the existence of two systems of reasoning. This idea is marked with the general label of dual- or two-system theories [21–27].

The judgment based on representativeness heuristic is immediate and effortless. Many authors [21,23,26] tend to contrast this rapid and automatic judgment with a deliberate and slower form of reasoning. In the literature there is a high number of different expression indicating these two forms of reasoning (see, for example [25]). The different terminologies are often associated with slightly different theoretical point of views. Sloman [25] speaks of the intuitive system (i.e., a basically associative system that operates on the bases of similarity and contiguity but it is also capable of representing causal structure) and the deliberative system (i.e., based on symbol manipulation, application of abstract rules). Within the dual-process framework, conjunction fallacy arises because there is an automatic and immediate similarity-based impression (e.g., the description of Linda is very similar to a feminist), whereas the deliberative system fails to inhibit this response (and suggesting a more formal analysis of the problem). This distinction has a central role in human sociality, including cooperation, honesty and altruism and other pro-social behaviors (see [28] for a review).

The dual systems view can be seen closely associated to the famous distinction about two types of thinking found in Bruner [29]. Bruner, in his famous essay, distinguished between two modes of thought: narrative and paradigmatic. In his opinion, narrative can be defined as the tendency of organizing experience into a form with a plot, structure, emphasizing intentionality and causal relations. On the contrary, the paradigmatic mode of thought is based on logic, mathematics, and abstract rules. In Bruner's opinion, narrative is a tool for sense-making, creating self-identity and apprehend and interpret the world. Among the many examples that Bruner cite to support this idea, there are the famous experiments of Michotte in which simple elements (triangles or circles) in motion on a screen are described in intentional terms. Keren and Schul [30] wrote: "despite the apparent similarity between Bruner's mode of reasoning and the other two-systems under discussion, we suggest that they are different in essence. As we discussed above, a fundamental requirement of any two-systems framework is that the system could be isolated [31] —namely, that each part could function without depending on the machinery of the other. Bruner's modes of reasoning, according to our interpretation, are free of this requirement." The point is that the two modes of thought in Bruner [29] are different ways to interpret reality (and each modality has different criteria for establishing truth). In our view, each mode of thought involves both the deliberative and the intuitive system. When constructing a narrative, there is a prevalence of intuitions (based on personal experience, imagination, associative memory) but also rule-based deliberations are used (the controlled use of language, the application of norms and rules within the narrative).

Similarly, the paradigmatic thought involves mainly deliberations (in order to make verifications, to make formal analysis) of course, but intuitions may be used too (lot of rules in mathematics and science are associated to intuition, see [32]). In this paper, we have investigated the influence of Bruner's modes of thought on conjunction fallacy. We think that the mode of thought involved in answering the Linda's problem is going to influence the strategy (narrative-based or paradigmatic-based) adopted by participants and thus the answer produced, in this paper, the expressions, "strategy of reasoning" and

"mode of thought" are employed as synonyms to refer to the paradigmatic/narrative distinction. It is possible to speculate that a narrative-based strategy should favor the violation of the conjunction rule, since the conjunctive sentence is more coherent with the starting scenario. Indeed, the probabilistic bias naturally arise from the implications of the story presented in the text. Another important feature related to the narrative thought is the social dimension. In Bruner's point of view, narrative is the primary mode of thought and it has a fundamental role in creating and negotiating meanings within a community. Without entering into the deep complexity of Bruner's position, according to his findings, humans tend to organize experiences and collective memories mainly in the form of narratives. Narrative is a conventional form, transmitted culturally and constrained by individual's level of mastery: unlike the constructions generated by logical and scientific procedures that can be weeded out by falsification, narrative constructions can only achieve "verisimilitude". Narratives, then, are a version of reality whose acceptability is governed by convention and "narrative necessity" rather than by empirical verification and logical requisites [33]. With regard to the group factor, as far as we know, only the study of Charness, Karni, and Levin [34] tried to determine the influence of group reasoning (versus individual reasoning). Their results support the idea that when subjects are allowed to consult with each other, the conjunction fallacy decreases. Moreover, some experiments carried out on children demonstrated that children who use stories to solve cognitive or socio-cognitive problems are more flexible in social interactions and tend to find arrangements with partners in order to get possible solution of problems [35,36]. In order to explore the variety of dimensions that may be involved in the Linda problem, we introduced two additional variables to the original study: group effect (individual/group discussion) and format of the answer (open-ended/multiple choice condition). So, to investigate how these different conditions (individual/group discussion and open/multiple choice answer format) affect performance, answers with an open response have also been classified depending on the explanation given in their scriptures.

Two extra dimensions are then introduced for the open format condition: narrative-based explanation and paradigmatic-based explanation. We also assessed words used in open ended answers using the Linguistic Inquiry and Word Count (LIWC) software. LIWC is a computerized text analysis program that outputs the percentage of words in a given text that fall into one or more of over 80 linguistic (e.g., first-person singular pronouns, conjunctions), psychological (e.g., anger, achievement), and topical (e.g., leisure, money) categories. It builds on previous research establishing strong links between linguistic patterns and personality or psychological state [37]. We used a LIWC analysis in order to estimate whether the use of some specific word patterns found in open ended answers could help us in predicting the correctness of the answers, the belonging to the group condition and the mode of thought used [38]. In particular, LIWC was employed in order to discriminate a classification of responses according to the dual process of thought [23] and narrative/paradigmatic modes of thought [29]. Indeed, in the dual-process of thought framework the usual approach involves an a-priori classification of the response options (e.g., sentence A is associated to deliberation whereas sentence A&B with intuition [18]). However, employing an open-format question, the use of LIWC may help to discriminate narrative/paradigmatic modes of thought by using words classification in psychologically meaningful categories [38].

2. Method

2.1. Participants

The sample has been collected by means of a voluntary census on the Italian territory and balanced for what concern the gender and the assignment to the experimental conditions. The 120 participants (60F, 60M) reported an average age of 27.32 (sd = 11.23). 78.9% of the sample reports a high school or higher degree of education, 71.5% to be a student. All participants have Italian citizenship. The subjects' attribution to the different conditions is summarized in Table 1.

Table 1. Table are reported the subsamples size, showing the number of different subjects assigned to each experimental condition.

	Format of Answer		
	Multiple C.	**Open**	**Tot.**
Group factor Alone	30	30	60
Group	30	30	60
Total	60	60	120

2.2. Procedure

In order to assess the effects of the principal factors under investigation (i.e., group factor and format of the answer), as well as of their combined effects, first of all we randomly assigned the subjects to the four different conditions, maintaining the gender balance. Participants assigned to the group condition have been asked to discuss about the solution to the Linda's problem in a group of 3 people, and then to individually answer the question. In the open-ended format of the answer condition participants were asked to write in 400 characters the explanation for their choices, while in the multiple-choice condition participants had to simply rank the given sentences. After the subjects' recruitment and their attribution to the experimental condition, the Linda problem has been submitted as follows:

Linda is 31 years old, single, outspoken, and very bright. She majored in philosophy. As a student, she was deeply concerned with issues of discrimination and social justice, and also participated in anti-nuclear demonstrations. (A) Linda is a bank teller. (B) Linda is a bank teller and is active in the feminist movement.

The experimental dimensions took into account the kind of requested answer (i.e., multiple choice/open-ended format of the answer), as well as the group effect (i.e., individual/group discussion), creating four possible conditions: Alone-multiple choice, alone-open-ended answer, group-multiple choice, group-open-ended answer. Nevertheless, in each condition the subjects were requested to furnish their final answer (Which option has more probability to be true? Choose between options "A" and "B") individually even when the group was asked to discuss explicitly the problem together. Disregarding the experimental condition, the time given to solve the problem have been maintained the same: In particular, each subject was asked to elaborate the answer (i.e., "alone-multiple choice" and "alone-open-ended answer" conditions) or discuss with the group (i.e., "group-multiple choice" and "group-open-ended answer" conditions) for 5 min.

At the end of this phase, few minutes were given to individually answer the question properly. In order to capture the cognitive processing behind the answers, beyond the correctness of the answer, we assessed its strategy of reasoning separating those answers produced following a paradigmatic way of thinking (e.g., "...there is no logical relation between to have being a political activist during the college and to be a feminist in the future..."), from those providing a narrative-based reasoning (e.g.,"...since she is a bank teller, I don't think she could have the time for being active in a feminist movement...") as found in Bruner [29]. We used inter-rater reliability (in terms of accordance between two senior researchers, informed about the aim of the research) in order to estimate the correct mode of thought used. Answers have been collected automatically and analyzed extracting the interesting features. Subsequently answers with the open-ended format have been collected and analyzed using the LIWC software for linguistic inquiry and word count. Since participants were only Italian, we adopted the approved Italian dictionary of the LIWC software [39].

3. Data Analysis

We divided the data analysis into four different phases. In the first one (Sociodemographic Effects) the data pre-processing was accomplished, assessing the required conditions of the statistical

analysis. In particular, the age distribution was transformed (i.e., logarithmic transformation) in order to obtain values of skewness and kurtosis within the range (−1, +1). In the second phase (Experimental Conditions Effect) we assessed the effect of the sociodemographic and experimental factors separately on the order parameters (i.e., answer correctness, strategy of reasoning). For such a task we used the χ^2 statistic [40]. In the third phase (Multivariate Effects) we explored the combined effects of the two experimental factors (i.e., group effect and strategy of reasoning), by means of a logistic regression analysis [41]. In the fourth phase we ran a discriminant analysis [42], linking the narrative dimensions taken by means of the LIWC software analysis to the group effect, the expressed strategy of reasoning and the answer correctness. Finally, a *t* test [43] has been carried out in order to predict the group effect, comparing the individual group discussion. All the analysis has been carried out adopting the SPSS Version 22.0 software [44].

4. Results

The preliminary analysis confirmed no significant effect for the sociodemographic features of the sample on the operative observables under scrutiny. Participants' age, gender and education have no significant effects on the performance (Age: $\chi^2 = 0, 06$; $p = 0, 80$; Gender: $\chi^2 = 0, 16$; $p = 0.69$; Education: $\chi^2 = 6.82$; $p = 0.08$) and on the mode of thought expressed in the narrative format of the answer conditions (Age: $\chi^2 = 1.22$; $p = 0.27$; Gender: $\chi^2 = 1.57$; $p = 0.21$; Education: $\chi^2 = 2.80$; $p = 0.42$). Once we assessed such a fact, not excluding that such no significant effects are due to the sample size (in particular for what concerns Education), we proceeded with the inferential analysis studying the experimental condition effects on the answers correctness.

4.1. Experimental Conditions Effect

In this analysis we explored the effects related with the main factors under scrutiny (i.e., group factor and strategy of reasoning) on the correctness of the answer. Given the natural dichotomic nature of such observables we adopted a χ^2 analysis, thus considering in this first approximation just the main effects (i.e., without considering the combined effects) (Table 2).

Table 2. Table are reported the χ^2 tests assessing the significant differences in the relations between the order parameter (i.e., the answers correctness) and the control parameters of our study: The social condition (i.e., alone vs group of three subjects) in which the answer was elaborated/discussed, and the strategy of reasoning expressed in the open-ended answers.

General Effect	Condition	% of Corr.	χ^2	Sig.
Group	Alone	12.1%	9.189	$p < 0.01$
	Group	46.7%		
Strategy of reasoning	Paradigmatic	75%	22.653	$p < 0.01$
	Narrative	12.8%		

Both the factors show a significant effect on the criterion, as indicated in Figure 1a,b, with the higher effect appearing to be played by the strategy of reasoning factor ($\chi^2 = 22.653$, $p < 0.01$), with the group factor explaining a smaller portion of variance ($\chi^2 = 9.189$, $p < 0.01$). The subsequent analysis investigated the relation between the experimental conditions and the adopted strategy of reasoning. Of course, the sample used to assess such strategies, which is a property measurable only with the open format of response, was composed by the half of the sample (60ss).

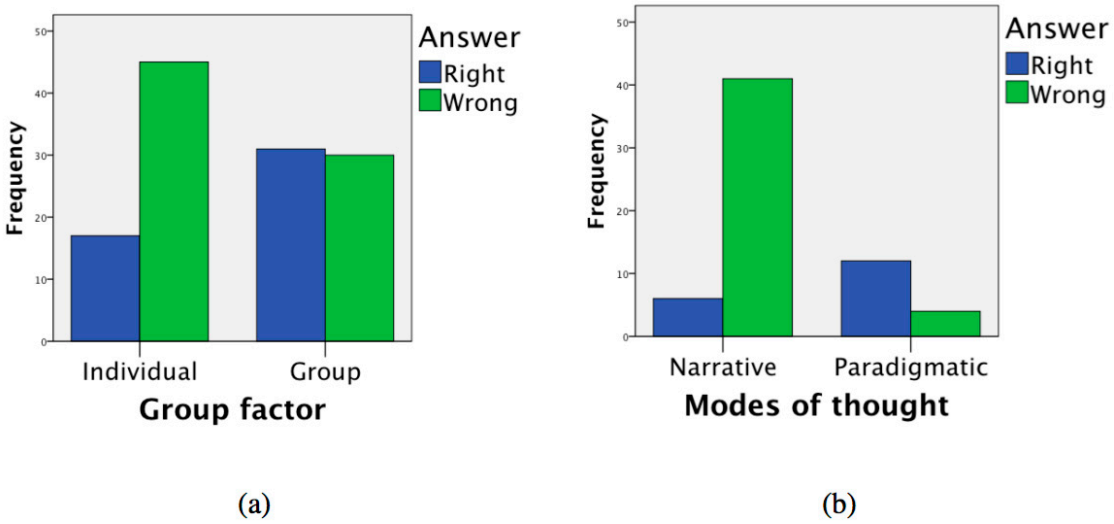

Figure 1. The subfigures reported show the absolute frequencies of right and wrong answers with. respect to the three main order parameters defined by our study. In particular: The subfigure (**a**) highlights the difference in subjects performance with respect to the experimental condition "group factor" and 231 in the subfigure (**b**) with respect to the adopted strategy of reasoning.

4.2. Narrative Strategy: Group Factor vs Correctness

A very interesting effect arose from the analysis regarding the apparent difference in effectiveness of the strategy of reasoning along with the experimental conditions. In particular, the percentage of correct answers is significantly different between the group and the individual condition, as shown in Figure 1a. Nevertheless, no significant relation emerged between the strategy of reasoning used and the group effect. In other words, it appears that the narrative strategy changes its effectiveness because of the group condition. Another interesting aspect is related with the few number of "paradigmatic" participants in both the subsamples: Such a fact attracts the attention toward a possible different effectiveness of the two strategies when introduced in a group condition. As shown in Figure 2, the percentage of correct answers, if only the narrative strategy is considered, variates significantly with the group condition ($\chi^2 = 4.57$, $p < 0.05$), in particular again the group condition (correctness of 38.1%) appears to be more efficient than the individual condition (11.5%).

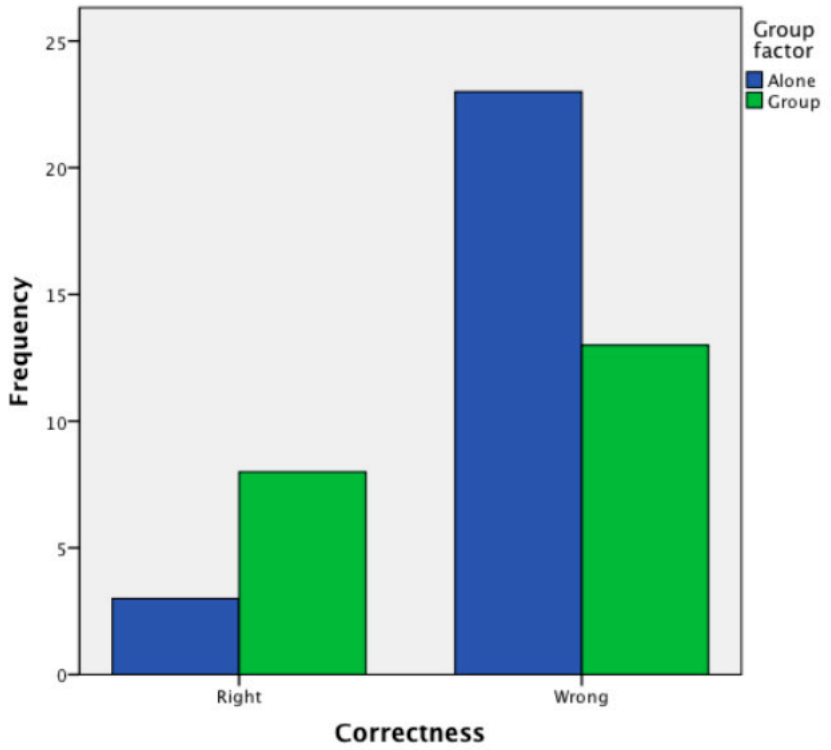

Figure 2. In figure is reported the relation between the answers correctness and the group factor, Only for the narrative strategy (n = 60).

4.3. Multivariate Analysis

Once the principal effects were assessed, we moved toward a multivariate analysis to investigate the combined and complex effects due to factors interaction on the correctness of the answer. In order to estimate both the principal as well as the combined effects of the experimental factors, we adopted a multiple linear regression modeling. In this analysis only, half of the samples has been considered (n = 60) to estimate the relevance of the control parameters strategy of reasoning (that can be assessed only in the open-ended format of answer). As a consequence, within such a model we had just two factors (i.e., group condition and strategies of reasoning). In Table 3 is reported the best multiple logistic model parameters. It should be noted that that negative coefficients refer to wrong answers and positive to correct answers. Results show how the model is able to address the 58.1% of the variance (Nagelkerke = 0.581), suggesting the relevance of the strategy of reasoning factor (Wald = 12.230) with respect to the group factor (Wald = 6.675). Even in this case no combined effect linking the two model factors emerged from the analysis, in other words the factors considered by the model do not present a significant relation and appear to not interact in affecting the dependent variable.

Table 3. Reports the parameters of the best multiple logistic model, describing the effects due to the group factor combined with the strategy of reasoning factor (i.e., only for the open-ended answer), on the answers correctness, (n = 60).

Factor	β	Wald	Sig.
Group	−2.867	6.675	$p < 0.05$
Strategy of reasoning	−3.899	12.230	$p < 0.01$

4.4. T Test LIWC vs Individual/Group Discussion

We ran a *t* test in order to predict the group effect (i.e., individual vs group discussion) on the dimension emerged from the LIWC analysis. This analysis allows a preliminary exploration of possible

mechanisms underlying the cognitive strategy adopted by the subjects, as well as, to investigate possible antecedents of the "modes of thoughts" adopted to answer to the question. As shown in Table 4 answers provided in consequence of a group discussion have more words (i.e., "Word Count"), more words longer than 6 letters (i.e., "Sixitr") and more words related to "possibility" (i.e., "possib") than in the individual condition. On the other side, answers provided in consequence of a single individual show more first singular person pronouns (i.e., "I") of those provided after the group discussion.

Table 4. Test LIWC vs group discussion/individual elaboration. *: The statistic is significant at a level of $p < 0.05$, **: The statistic is significant at a level of $p < 0.01$.

Group Factor	Mean	Std. Dev.	*t*
WC Individual	47.85	19.43	−2.257 *
Group	62.07	29.92	
SixItr Individual	28.21	6.91	−2.608 **
Group	32.70	6.75	
IIndividual	1.43	2.04	2.507 *
Group	0.41	0.90	
Possib Individual	1.97	1.84	−2.812 **
Group	3.81	3.22	

4.5. Discriminant Analysis

We now show the different models obtained with a discriminant analysis in order to predict the correctness of the answer (Right vs Wrong) by means of the data obtained from the LIWC analysis of the open-ended answers. Please note that to accomplish this phase of the research we used the approved Italian dictionary of the LIWC software [39] so that results must be evaluated taking into account the use of the Italian language.

4.5.1. Model 1: Prediction of the Narrative Style of the Answer (Narrative vs Paradigmatic Strategy of Reasoning)

In the Model 1 we used a discriminant analysis in order to predict the strategy of reasoning (Narrative vs Paradigmatic) by the dimensions emerged from the LIWC analysis on the open-ended answers. The general model explains a significant portion of the variance (Wilks Lambda = 0.359 and $\chi^2 = 58.32$) and a canonical correlation of 0.80 as described in Table 5. For each parameter, the table reports Wilks Lambda in order to show its significance and its coefficient in the discriminant function. The parameters emerged from the LIWC analysis (Table 6) show a significant effect in predicting a paradigmatic strategy for: Use of numbers, use of words expressing tentative, anxiety or feelings and the use of conditional verbs (e.g., "I choose the "A" option: In the text provided there are no specification on Linda's job. The probability of option "A" to be right is higher because that option has just one hypothesis, while option "B" has two"). LIWC analysis also show a significant effect for the use of 3rd singular verbs, words expressing positive emotions and words referred to act of seeing (i.e., in the Italian language the verb to see is frequently used in a figurative form indicating the evidence of something) in predicting the use of a narrative strategy (e.g., "Linda is a professor at the faculty of Philosophy. She also had a political role in her city. She chose not to marry to maintain her role in defending woman's rights and the ecologist cause"). The degree of accuracy of the discriminant function correctly identifies the 97.9% of the paradigmatic answers, and the 87.5% of the narrative answers, providing both a way to identify the "cognitive style" used to answer the question, as well as some antecedents of the answers.

Table 5. Table is reported the general statistics for the first discriminant model (Model 1). In this phase we wanted to predict the Narrative/Paradigmatic strategy by the data emerged from the LIWC analysis.

	Wilks Lambda	χ^2	Sign.	Canonical Correlation
Model 1	0.359	58.32	$p < 0.01$	0.80

Table 6. Table is reported the best discriminant function linking the the variables representing narrative dimensions taken by means of LIWC software analysis with the strategy of reasoning (i.e., narrative vs paradigmatic answer). *: The statistic is significant at $p < 0.01$.

Parameter	Wilks Lambda	Coefficient
Number	0.831 *	0.538
Tentative	0.698 *	0.810
Anxiety	0.559 *	0.676
Feel	0.504 *	0.513
3rd Singular Verb	0.467 *	−0.531
Pos. Emotion	0.420 *	−0.378
See	0.390 *	−0.415
Conditional verb	0.359 *	0.379

4.5.2. Model 2: Prediction of the Correctness of the Answer (Individual Mode)

The Model 2 predicts the correctness of the answer (Right vs Wrong) by the dimensions emerged from the LIWC analysis on the open-ended answers with an individual game mode. The general model explains a significant portion of the variance (Wilks Lambda =0.747 and χ^2 =8.767) and a canonical correlation of 0.503 as described in Table 7.

Table 7. Table is reported the general evaluation of the third discriminant model. In this phase we wanted to predict the correctness of the answer (Right vs. Wrong answer) by the data emerged from the LIWC analysis on the individual elaboration game mode.

	Wilks Lambda	χ^2	Sign.	Canonical Correlation
Model 3	0.747	8.767	$p < 0.01$	0.503

The significant parameters emerged from the analysis (Table 8) show a significant role of words referred to the writer himself (e.g., "me", "my") in predicting right answers ("In my opinion right answer is the "A". In both answers is explained that she's a bank teller and that made me think that she actually is."), and of words referred to socially-oriented actions in predicting wrong answers (e.g., "Option "B" because politically involved women usually care about feminine pride and dignity, so I guess she is a feminist."). The degree of accuracy of the discriminant function correctly identifies the 75.0% of correct answers and the 79.3% of the wrong answers.

Table 8. In table is reported the best discriminant function linking the variables representing the narrative dimensions taken by means of LIWC software analysis with the correctness of the answer (i.e., right vs wrong) on the individual elaboration game mode. *: The statistic is significant at $p < 0.01$.

Parameter	Wilks Lambda	Coefficient
Social	0.747	−0.792
Self	0.858	1.037

4.5.3. Model 3: Prediction of the Correctness of the Answer (Group Elaboration Mode)

The Model 3 predicts the correctness of the answer (Right vs. Wrong) by the dimensions emerged from group discussion game mode. The general model explains a significant portion of the variance (Wilks Lambda = 0.450 and χ^2 = 21.149) and a canonical correlation of 0.741 as described in Table 9.

Table 9. Table is reported the general evaluation of the fourth discriminant model. In this phase we wanted to predict the correctness of the answer (Right vs. Wrong answer) by the data emerged from the LIWC analysis on the group discussion game mode.

	Wilks Lambda	χ^2	Sign.	Canonical Correlation
Model 4	0.450	21.149	$p < 0.01$	0.741

The significant parameters emerged from analysis (Table 10) show a significant role of future and transitive verbs in predicting right answers (e.g., "Linda is a bank teller because, in terms of probability, it is more probable that she might be a bank teller than being a bank teller and a feminist at the same time."), and of words related to the present in predicting wrong answers (e.g., "I think that she is a feminist too, because since she has an active role in politics, she is a person that fights for her beliefs."). Obviously, our results about verbal cues have to be interpreted considering the Italian nature of the sample, indeed in Italian the verbal structure of the periods can be very different from the English one. The degree of accuracy of the discriminant function correctly identifies the 85.7% of correct answers and the 81.3% of the wrong answers.

Table 10. Table is reported the best discriminant function linking the variables representing the narrative dimensions taken by means of LIWC software analysis with the correctness of the answer (i.e., right vs wrong). *: The statistic is significant at $p < 0.01$.

Parameter	Wilks Lambda	Coefficient
Present	0.563	−0.860
Future	0.450	0.640
Transitive	0.745	0.892

4.5.4. Model 4: Prediction of the Correctness of the Answer (Narrative Mode of Thought)

The Model 4 predicts the correctness of the answer (Right vs. Wrong) by the dimensions emerged from the open-ended answers using a narrative mode of thought. The general model explains a significant portion of the variance (Wilks Lambda = 0.897 and χ^2 = 4.821) and a canonical correlation of 0.320 as described in Table 11.

Table 11. Table is reported the general evaluation of the fourth discriminant model. In this phase we wanted to predict the correctness of the answer (Right vs. Wrong answer) by the data emerged from the LIWC analysis on answers using a narrative mode of thought.

	Wilks Lambda	χ^2	Sign	Canonical Correlation
Model 5	0.897		$p < 0.05$	0.320

The significant parameters emerged from the analysis (Table 12) show a significant role of future and conditional verbs in predicting wrong answers (e.g., "Option "B", because she could have continued her politically involved activities.").

Table 12. Table is reported the best discriminant function linking the variables representing the narrative dimensions taken by means of LIWC software analysis with the correctness of the answer (i.e., right vs wrong) on the answers provided using a narrative mode of thought. *: The statistic is significant at $p < 0.01$.

Parameter	Wilks Lambda	Coefficient
Future	0.914	0.787
Conditional	0.822	0.762

The degree of accuracy of the discriminant function correctly identifies the 50.0% of correct answers and the 73.2% of the wrong answers.

Narrative mode of thought seems to be inadequate for this task, in which a logical-deductive approach seems to be required. Using a narrative mode of thought lead participants to an error independently from the narration style.

4.5.5. Model 5: Prediction of the Correctness of the Answer (Paradigmatic Mode of Thought)

The Model 5 predicts the correctness of the answer (Right vs Wrong) by the dimensions emerged from open-ended answers using a paradigmatic mode of thought. The general model explains a significant portion of the variance (Wilks Lambda = 0.211 and χ^2 = 19.472) and a canonical correlation of 0.888 as described in Table 13.

Table 13. Table is reported the general evaluation of the fourth discriminant model. In this phase we wanted to predict the correctness of the answer (Right vs. Wrong answer) by the data emerged from the LIWC analysis on answers using a paradigmatic mode of thought.

	Wilks Lambda	χ^2	Sign.	Canonical Correlation
Model 6	0.211	19.472	$p < 0.01$	0.888

The significant parameters emerged from the analysis (Table 14) show a significant role of words referred to affection, time and socially-oriented in predicting wrong answers (e.g., "Option "B" because information provided doesn't suggest us anything about feminism but lead us to a person that actually cares for ethics, politics and human rights."). The degree of accuracy of the discriminant function correctly identifies 100% of correct answers and 100% of the wrong answers.

Table 14. In table is reported the best discriminant function linking the variables representing the narrative dimensions taken by means of LIWC software analysis with the correctness of the answer (i.e., right vs wrong). *: The statistic is significant at $p < 0.01$.

Parameter	Wilks Lambda	Coefficient
Future	0.914	0.787
Conditional	0.822	0.762

5. Discussion and Conclusions

Results support the idea that conjunction fallacy may arise from the use of narrative thought, especially when people think in isolation. More specifically, the main effect related to the group factor showed a greater amount of wrong responses when participants responded individually compared to the group condition. This observation is in line with [34] results that found a decrease of conjunction fallacy in group reasoning compared to individual reasoning. This can be explained in terms of a possible influence of paradigmatic minority on the result of the elaboration of the narrative majority in a group condition. In other words, there can be a tendency of small groups to reason in a paradigmatic, conventional way. Another option is that this effect is present because the paradigmatic mode of thought induces easier social negotiation processing.

Independently by the group factor, the narrative mode of thought was more associated to conjunction fallacy responses compared to open answers provided with the paradigmatic mode of thought. However, taking into account only the narrative responses, we observed that conjunction fallacy arises mostly when participants responded alone. On the contrary, when people take a decision in group, the majority of narrative-based responses were correct. So, the narrative mode of thought has its effectiveness increased (in terms of the normative criterion) if exposed to a group discussion. This finding is already known in literature: as found in [35] and in [36] the presence of individuals expressing both modes of thought (i.e., narrative/paradigmatic) in a collaborative group problem

solving can substantially modify participants' way to classify the task. In our study, we think that the presence of a paradigmatic approach of someone (the minority) within the group, modified the narrative majority's mode of representing the task and its solution. Narrative participants could have then reorganized the task in consequence of the presence of a paradigmatic participant within their group. However, at the moment of writing their answer, individually as requested, they shifted back to their original narrative mode of thought. This interpretation goes against of the trivial equivalence narrative mode of thought matches with intuition and paradigmatic mode of thought matches with deliberation. This work can be seen as a first step in studying the relationship between Bruner's modes of thought and the two systems accounts of reasoning. More research is needed to find out the actual relationship between those two distinctions.

The use of LIWC analyses allowed to identity a set of words or expressions associated to different kinds of predictions. First, responses characterized by use of numbers, conditional verbs, terms related to tentative, anxiety and feelings were associated to a paradigmatic modality of thought. On the contrary, it was possible to identify the use of a narrative strategy of reasoning with the use of third singular person in the answers, words referred to the act of seeing and words referred to positive emotions.

Some interesting results obtained with the LIWC analysis are related to the words that are used in wrong/right answers. Considering all the experimental conditions together (individual vs group; paradigmatic vs narrative), LIWC analysis showed that the use of words referred to socially oriented actions, the use of conditional verbs and words related to affections and time are associated with wrong answers. This can be explained by the willing of participants to create a narration of Linda's life, instead of calculating the probability of the option provided. For example, the use of words expressing socially oriented actions may be related to the fact that Linda is described as a socially engaged person and participants wanted to restate those aspects in order to justify their answer. On the contrary, we found an intensive use of transitive verbs and words referred to the writer himself in association to right answers. This can be explained with the fact that transitive verbs are generally used for simple statements (e.g., facts, not hypothesis) in Italian, and that the use of "in my opinion" formula could be related to the willing of being honest and describing facts in a statement.

The main limitations of this work are the limited sample size (and thus a low statistical power) and the different size of each samples, as well as the possibility of the presence of other non-measured confounding variables (such as the working memory capacity of the participants, cultural differences, the IQ). Indeed, it is important to note that our results are also compatible with other explanations: for example, the higher proportion of correct answers of individuals participating in group discussion compared to the other condition could be explained in terms of diversity of ideas instigating individuals to think from different perspectives. With regard to the modelling attempts, we train the parameters of each model with the same datasets; in order to achieve an actual validation of such attempts, future research is required to test the models with other datasets.

Concluding, taking into account Bruner's modes of thought in conjunctive reasoning can help to highlight how the narrative mode of thought is strongly associate to the violation of conjunction rule. This violation can be seen as a mistake by the normative criterion of probability theory, but it's extremely likely within the narratives constructed by participants. Given the importance of dual-process theory of thought for prosocial behavior [28], integrating Bruner's perspective with the dual-process framework may give clues for the design of crowdsourcing technologies. Given the importance of dual-process theory of thought for prosocial behavior [28], integrating Bruner's perspective with the dual-process framework may give clues for the design of crowdsourcing technologies. In particular, both the size imposed to the operative sub-communities characterizing complex network devoted to crowdsourcing activities, as well as the narrative (i.e., the semantic and logical structures) adopted to present the issues should be designed considering also the factor under scrutiny in our research. In this way it should be possible to further improve the intervention effectiveness, and promote a specific cognitive approach (i.e., narrative versus paradigmatic) to the social interaction devoted to the crowdsourcing dynamics.

Author Contributions: A.S. and A.G. conceived of the study and discussed with G.G. the initial idea, and corrected and organized the subsequent versions of the manuscript. C.D. wrote the manuscript and collected data. G.G. assisted in drafting the initial manuscript and subsequent versions. A.G. analyzed data and developed the statistical models. A.S. supervised each phase of the research.

Funding: This research received no external funding.

Conflicts of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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