The Role of Masked Solutions in the Accuracy of Insight Problem-Solving Task

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Abstract

Objective: The primary aim of the study was to test the allegedly facilitating role of insight-like strategy in the detection of masked solutions Compound Remote Associates problems (CRA problems).

Method: A sample of 114 participants solved 19 CRA problems presented online. Participants were requested to solve the problems in which either the solution to the CRA problems was randomly presented in a masked condition or no solution was provided. After each trial participants were requested to report whether they used insight or analytical strategy. Participants were also required to complete a sensation seeking scale and a measure of creativity.

Results: The results showed a small, but robust correlation between the CRA problems accuracy and the degree of insight-type strategy used for their solution. The degree of sensation seeking, the score of creativity and the outcome of the manipulation check did not reveal any influence on the CRA problems solution.

Conclusion: The use of intuitive strategies may facilitate psi-related creative problem solving, but confirmatory research is needed.

Keywords: Compound Remote Associate problems; insight; intuition; masked stimuli; extrasensory-perception; creativity

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Introduction

The influence of subliminal information on perceptual and cognitive processes, including problem-solving, represents a strongly debated topic in the field of psychology that has received considerable empirical attention (Erdelyi, 2004; Goldstein et al., 2020; Kihlstrom, 2004; Merikle, 2000). A frequently used method for studying subliminal processing is the masked priming paradigm in which some stimuli are presented for very short time and masked in order to prevent their overt conscious identification, but can be detected by our visual system (Van den Bussche, Noortgate & Reynvoet, 2009).

Conversely, little is known about the influence of completely masked (without priming) information (Carpenter et al. 2012; Carpenter, Simmonds-Moore & Moore, 2009; Wilson, 2002), that is information that cannot be detected not even unconsciously by our sensory organs.

The reason for this different consideration is quite obvious: how could a completely masked information affect the solution of whichever problem given that no sensory information can be transmitted even unconsciously to the agent?

The only plausible hypothesis is that information conveyed by masked information can be detected only if our mind (cognitive system) can detect it by using a sort of extra-sensory perception. Whereas this possibility is excluded if we assume that our mind is merely a byproduct of our neurophysiological system as assumed by different models of mind-brain relationship, e.g. Identity theory (Smart, 2017), it can be possible if we adopt a model where mind is not constrained by the neurophysiological limits of the sensory organs, e.g. Idealism (Kastrup, 2018), Advanta-Vedanta (Sedlmeier & Srinivas, 2016), dual-aspect monism (Walach, 2020).

In the present exploratory study, we aimed at investigating if adopting fast-thinking insight-intuitive like strategies, that is decisions not based on reasoning, very similar to the System 1 strategies described in the dual-aspect model of reasoning (De Neys & Pennycook, 2019; Stanovich & West, 2000) make possible to unconsciously detect information useful for the solution of a problem-solving task.

Among the paradigm used in the study of problem solving, the validated Italian version of the compound remote associate problems (CRA problems; Salvi, Costantini, Bricolo Perugini & Beeman, 2015), has been employed. The CRA problems are commonly used for assessing insight problem solving. Importantly, they belong to a new generation of problems that relative to the classic ones are easier, so that many of them may be correctly solved in the same session, generating more data, they do not require domain-specific knowledge to be solved, and they use a more rule-consistent task. In addition, in line with a recent and more bottom-up approach, problem solvers were asked to focus on their subjective experience and to self-report how they solved each problem - relatively more by analysis, or relatively more by insight. In doing so, participants' self-reports about solving were used as the discriminative criteria to categorize the solving processes.

In general, solving problems by sudden insight is considered a significant form of creative cognition. Recently, a positive correlation between creativity and performance on problem solving-tasks (i.e., CRA problems), has been found (Olson, Nahas, Chmoulevitch, & Webb, 2021). As a consequence, in the present study we aimed to test the possibility that those participants who engaged in insight-like process to solve CRA problems more frequently, showed a better performance in a creativity task, namely Divergent Association Task (DAT, Olson et al., 2021).

Finally, we were interested in assessing individual difference that could be correlated to such a type of perception. Over the years, a small but reliable correlation emerged between extraversion and performance on similar tasks (Honorton, Ferrari and Bem 1992). Specifically, the component of extraversion that underlines this correlation appears to be the susceptibility to boredom and a tendency to seek out stimulation. To assess stimulus seeking as a possible moderator on the CRA problems solution, we used the two-statements scale developed by Bem (2011).

Objective

We aimed to test if making available the solution of the CRA problems in a masked form, could improve their solution simply warning the participant of its presence, but without any possibility to see it neither before nor after the problem solution. An enhanced performance was also expected when an insight-like strategy was used to solve the masked form of CRA problems.

This experimental paradigm has been rarely used. Usually, participants are requested to guess or describe the target before its overt presentation and not to use it to solve problems without any possibility to overtly see it as in our case. However, the possibility that the mere presence of an information can be used by humans even if at an unconscious level if necessary for them, it is predicted by James Carpenter's (2015) "First Sight" model. By using Carpenter's words "*This model assumes that each organism, by its nature, extends beyond itself into the larger pre-sensory surround. Psi [extra-sensory-perception] is assumed to be neither knowledge nor action, but to belong to the outermost temporal edge of those normal pre-experiential mental processes by which the mind structures all its experiences and commences all its actions. Psi processes are posited to function normally as the unconscious leading edge of the development of all consciousness and all intention. This unconscious functioning is normal and continuous, and is a constituent element of all experience*" (Carpenter, 2004, pag.1).

Our specific hypotheses were as follow:

Main hypothesis: We expected that the masked solution of CRA problems can influence their solution, but only when participants adopt an insight-type approach.

Secondary hypotheses: sensation seeking level and creativity can both act as moderators on the CRA problems solution. We expected that especially those participants who showed a tendency to seek stimuli and higher DAT scores, also used insight-like process in the solution of CRA problems.

Method

Ethical Considerations

The study was approved by Ethical Committee Prot: 2476 of the Dipartimento di Psicologia, Università degli studi di Padova, Italy.

Participants

One-hundred-thirty-one Italian participants were recruited through social media, 50 of which through the Prolific platform. In this last condition they received (€ 6.00) for their participation. Seventeen participants had to be discarded from further analyses because they did not complete the test or declared to have seen the solution of the CRA problems at least once. The final sample is composed of 114 participants: males = 55; females = 59. Mean chronological age = 31.2, *SD* (11.4), range 16-75.

Materials

Moderators

Two Statements stimulus seeking measure

As a potential moderator of the CRA problems solution, participants were requested to respond to two items related to the Sensation Seeking Scale (Zuckerman, 1974): "*I am easily bored*" and "*I often enjoy seeing movies I've seen before*" (reverse scored), that were found to moderate some intuitive tasks (Bem, 2011). In the present study, responses were recorded on a Likert 5-point scales, from 1 (Very Untrue) to 5 (Very True). In our sample, the two scores were summed into a single score ranging from 2 to 10 ($M = 5.7$, $SD = 1.68$). Higher scores indicate higher levels of stimulus seeking.

Divergent Association Task

As a second potential moderator variable, participants were required to complete a measure of creativity, namely the Divergent Association Task (DAT; Olson, Nahas, Chmoulevitch & Webb, 2021). Participants were asked to name 10 words that are as different from each other as possible, in all meanings and uses of the words. The words *pen* and *pencil*, for example, would be close to each other, and thus semantically similar, since they are often used in similar context. The words *astronaut* and *apple* wouldn't be close to each other and thus less semantically similar. According to the original study, the greater is the semantic distance between the words, the higher participants score on other creativity and insight problem-solving tasks (e.g., CRA). The original English version of the task computes the semantic distances using a model based on a corpus called Common Crawl, which contains the text of billions of web pages. Given that this model is not readily available in Italian, a different one was used to compute the average semantic distance between words. Specifically, a pre-trained model was used based on a corpus of text from Italian web sites (Cimino, De Matte, & Dell'Orletta, 2018). DAT scores can range from 0 to 200, with higher scores indicating a greater semantic difference between the words.

Compound Remote Associates problems

Twenty CRA problems were selected from the Italian version list validated by Salvi et al (2016). Given the exploratory nature of the present study, we decided to favor the possibility to gather a higher amount of information about the preferred strategies of the participant over the manipulation of the level of difficulty. For this reason, we decided to select them among the first quartile of difficulty, resulting in the least difficult problems. A similar recommendation is also reported on the original study (Salvi et al., 2016). All problems and instructions were presented online using the Qualtrics platform.

Procedure

Participants were tested online through social media and Prolific platform. Qualtrics software was used to implement the experimental procedure. They were told that the study aimed to investigate their ability to engage intuition. They were firstly presented with a two-items measure, assessing their tendency to seek stimulus. Subsequently, participants completed the creativity task (i.e., Divergent Association Task - DAT). Given that no validated Italian version of the DAT is available, the instructions and the items used in the present research were translated into Italian by the first author and back translated by an independent translator before arriving at a final version that all authors agreed best capture the original meaning (see Appendix). After a 3-minutes relaxation period, participants were presented with an insight problem-solving task i.e., CRA problems, in which three cue words were presented and participants were required to try to find a fourth word that create a compound word with the cues. In half of the conditions, the solution to the CRA problems were masked presented, while in the other half no solution was presented in random order.

The instructions were the following ones: *“Now you will be presented with some problems. For each problem you will be shown three words. Your task is to find a fourth that can be combined with each of the three presented, forming a compound word or sentence. You have 15 seconds to find the solution. In case you don't find the solution in time, you will move on to the next problem.*

The solution will be presented to you even if disguised. We ask you to ignore this information and use your pure intuition (i.e. instinctive, without reasoning) to find the solution.

After you have provided your answer, you will be asked to indicate if you have found the solution using an INSIGHT or ANALYTICAL strategy.

INSIGHT means that the answer came to your mind suddenly (i.e., unexpectedly) while you were trying to find the solution, without being able to explain how you found it.

ANALYTICALLY, it means that you have identified the answer after deliberately and consciously trying several words until you have found the correct one. In this case, for example, you would be able to indicate the steps that led you to the solution”.

After two examples and a relax time of three minutes, the 20 problems were randomly presented for a maximum of 15 seconds. Each problem was presented as in Figure 1.

SWISS GOAT HOLES

Figure 1. Example of the English version of CRA problems as presented to participants. In the masked condition, the solution was presented under the gray square (“cheese” in this case).

After each response, participants were requested to report whether they used an Insight-type (i.e. suddenly, without reasoning) or an Analytical strategy (i.e., as a result of deliberate reasoning).

Manipulation Check

At the end of the CRA problems, participants were requested to respond to the following open question: “*In your own words, what is the purpose of the study you have just participated in?*”. The majority of participants (71.1%) named at least the words “insight” and / or “reasoning” in their responses.

Results

Due to technical reasons, a problem was not presented, consequently, all statistics refer to the solution of the remaining 19 problems.

All statistical analyses were performed using the freeware software Jamovi (2021) v.1.8.1

In Table 1 are shown the descriptive statistics related to percentages of correct solutions when the solutions were presented masked (%CRA problems_T) and when they were not presented (%CRA problems_F).

Table 1. Descriptive statistics relating to the percentages of correct solution of CRA problems

	% CRA problems_T	% CRA problems_F
Mean	.69	.69
SD	.20	.21

Note: CRA problems_T = masked response true; CRA problems_F = masked response false.

Comment

The percentage of CRA problems accuracy when their solutions were presented masked and when they were not presented are almost identical. Their correlation is .58; 95%CI: .44 - .69. Their mean difference is -.006; $SD = .19$; one-sample t-test with null hypothesis = 0: $t(113)=-.33$; $p=.74$.

Moderators effects

In order to examine whether sensation seeking, creativity, and insight predict masked problem solving, we carried out a multiple linear regression with the difference score in masked problem solving ($\text{DiffCRA} = \% \text{ CRA problems}_T - \% \text{ CRA problems}_F$) as the outcome and SSTot, DAT score, and the number of CRA problems solved using an insight-type strategy as predictors².

The corresponding violin plots are presented in Figure 2 and Figure 3 and the results of the multiple linear regression are presented in Table 2.

Figure 2. The violin plot with all data of the difference between the percentage of correct CRA problems solution (DiffCRA problems) when the solution was presented minus when it was not presented. Black square corresponds to the mean.

Figure 3. Violin plots of the three moderator variables

² This way on how to analyze the data was suggested by a reviewer.

Table 2. Results of the multiple linear regression of the three moderators on the DiffCRA problems as dependent variable.

Model Coefficients

Predictor	Estimate	SE	t	p	Stand. Estimate	95% Confidence Interval	
						Lower	Upper
Intercept	-0.507	0.400	-1.26	0.208			
Insight	0.008	0.004	2.04	0.043	0.194	0.006	0.383
SSTot	-0.006	0.011	-0.54	0.589	-0.051	-0.237	0.135
DAT	0.006	0.005	1.173	0.243	0.111	-0.077	0.299

Note: The overall model fit is $R = .22$; $p = .14$; $N = 114$. The model satisfied the assumption of independence of the residuals, Durbin-Watson Test = $-.12$; $p = .23$ and absence of multicollinearity, variance inflation factors ranged from 1.005 to 1.022.

Comment

The results clearly show that only insight, that is the number of CRA problems solved with an insight-type strategy influence the CRA problems accuracy even if the effect size is small. This interpretation is supported by the result of a simple linear regression analysis using only insight as covariate, see Table 3 and Figure 4. As a side note, almost identical results are obtained standardizing all variables as z scores.

Table 3. Linear regression results

Model Coefficients

Predictor	Estimate	SE	t	p	SE	95% Confidence Interval	
						Lower	Upper
Intercept	-0.092	0.043	-2.12	0.036			
Insight	0.009	0.004	2.18	0.031	0.202	0.018	0.385

Note: The overall model fit is $R = .20$; $p = .027$, almost identical to those obtained with all three moderators.

Figure 4. Scatterplot of the correlation between Insight score (the number of CRA problems solved using an insight-type strategy) and DiffCRA problems (the difference between the percentage of correct CRA problems solution when the solution was presented minus when it was not presented).

A further hint about the specificity of the relationship between the Insight score and the CRA problems when solutions were presented masked (%CRA problems_T) derives from their correlation: .179; $p=.057$ whereas when the solutions were not presented (%CRA problems_F), the correlation is: -.01; $p=.91$.

Manipulation Check

Participants were divided in two categories according to the detection or not of the aim of the task. Descriptive statistics are presented in Table 4.

Table 4. Descriptive statistics related to the categories of participants detection of the task with the manipulation check.

Task detection	DiffCRA problems
No - 33	.018 (.23)
Yes - 81	-.016 (.17)

Comment

As it appears from the descriptive statistics, there are neither raw nor statistical differences between the DiffCRA problems between the two categories, $t(112)=.86$; $p=.39$.

Discussion

The present study was designed to examine whether completely masked stimulus presentation could influence creative problem solving, and whether this effect was related to individual differences in creative ability, the use of insight strategy, and sensation seeking

personality. Results showed that there was no main effect of the masked stimulus paradigm, suggesting that creative problem solving was not generally facilitated by completely masked stimuli. However, unlike creative ability or sensation seeking, the use of insight strategies did predict greater performance in the masked stimulus condition. This suggests that masked stimulus presentation may indeed facilitate creative problem solving, but more so in those using insight rather than analytic strategies. The specificity of this influence is supported by the lack of influence of the two further moderators, sensation seeking level and the DAT score that when included in the regression model, give a p value of .14. The small effect size of the masked solution influence is expected, considering that participants were in a normal state of consciousness and were requested to solve a complex cognitive task and not to identify or guess the masked target as it is usually being used in this research field (Tressoldi and Storm, 2020).

Despite the fact that unconscious perception remains one of the most intriguing and strongly debated topic of research, the vast majority of the studies have investigated the topic using a masked priming paradigm, in which the visibility of a prime stimulus is only reduced by a visual masking (Van de Bussche et al., 2009).

Adding on the existing literature, we explore the possibility that the adoption of an insight like strategy can positively influence the solution of a problem-solving task; especially when the solution is completely masked presented and so the information can only be unconsciously detected.

Study limitations

The main limitation is the completely exploratory approach of our study. Consequently, our results must be considered provisional and their interpretation with caution. Only replication studies with a confirmatory approach, for example using a Registered Report protocol could support our findings.

Conclusions

Our results, even if carried out with an exploratory approach, support Carpenter's first sight model positing that "pre-sensory" (alias extra-sensory, nonlocal) information can be detected at an unconscious level, influencing our behavior and cognitive tasks, but only adopting insight/intuitive like strategies, bypassing those ones based on reasoning that is, those deriving from conscious cognitive processing of information.

In addition, they also inform and expand our understanding of insight problem solving procedure and underlying processes in the Italian language and culture that only recently has been taken into consideration by researchers (Salvi and colleagues, 2016). Much in the same line, the present study represents the first attempt to adapt a new measure of creativity (i.e., DAT) to the Italian context. This limit in the availability of validated experimental material, could in part justify the lack of influence between participants' DAT score and CRA problems accuracy.

Author's Contribution

EP: designed the study and was actively involved in revisiting the manuscript. PT: designed the study, carried out the statistical analyses, and drafted the first version of the manuscript. DT: organized the data collection.

Declaration of interests

The Authors declare that there is no conflict of interest.

Data availability statement

The dataset presented in this study can be found at:

<https://doi.org/10.6084/m9.figshare.13487571>

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Appendix

Instructions and items comprising the Italian version of the Divergent Association Test.

Instructions

Please write 10 words that are as different from each other as possible, in all meanings and uses of the words.

Rules

1. Only single words.
2. Only nouns (e.g., things, objects, concepts).
3. No proper nouns (e.g., no specific people or places).
4. No specialised vocabulary (e.g., no technical terms).
5. Think of the words on your own (e.g., do not just look at objects in your surroundings).
6. You will have 4 minutes to complete this task.

Words

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____
9. _____
10. _____