The Role of Masked Solutions in the Accuracy of an Insight Problem-Solving Task[1]

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Abstract: The primary aim of the study was to test the alleged facilitating role of insight-like strategy in the detection of masked solutions Compound Remote Associates problems (CRA). 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 was randomly presented in a masked condition or no solution was provided. After each trial participants were requested to report whether they had used insight or analytical strategy, and were also required to complete a sensation seeking scale and a measure of creativity. 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 in creativity, and the outcome of the manipulation check did not reveal any influence on the CRA problems solution. 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; anomalous cognition; psi; creativity

Highlights

- Completely masked solutions improve the accuracy of creative problem-solving tasks
- This information can be detected at an unconscious level, but only by adopting insight/intuitive-like strategies
- The use of intuitive strategies may facilitate creative problem solving

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 et al., 2009).

Conversely, little is known about the influence of completely masked (without priming) information (Carpenter et al. 2021; Wilson, 2002), that is, information that cannot be detected even unconsciously by our sensory organs. The reason for this different consideration is obvious: how could a completely masked information affect the solution of a 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 anomalous cognition or psi. 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 such as 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), and dual-aspect monism (Walach, 2020).

In this exploratory study, we aimed to investigate 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) would make possible to unconsciously detect information useful for the solution of a problem-solving task.

Among the paradigms used in the study of problem solving, the validated Italian version of the compound remote associate problems (CRA problems; Salvi et al., 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

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to focus on their subjective experience and to self-report how they solved each problem - relatively more by analysis or 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 in problem solving-tasks (i.e., CRA problems), was reported (Olson et al., 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 would show a better performance in a creativity task, namely the Divergent Association Task (DAT, Olson et al., 2021).

Finally, we were interested in assessing individual difference that could correlate to such perception. Over the years, a small but reliable correlation has emerged between extraversion and performance on similar tasks (Honorton et al., 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 asses stimulus seeking as a possible moderator on the CRA problems solution, we used the two-statements scale developed by Bem (2011).

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, is predicted by James Carpenter's (2015) "First Sight" model. In his words (Carpenter, 2004):

> 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. (p. 1).

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Our main hypothesis was that the masked solution of CRA problems would influence their solution, but only when participants adopted an insight-type approach. Our secondary hypothesis was that sensation seeking level and creativity can 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 would also use insight-like process in the solution of CRA problems.

Method

Participants

One-hundred-thirty-one Italian participants were recruited through social media, 50 of them through the Prolific platform. In the latter, they received € 6.00 for their participation; 17 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 was composed of 114 participants: males = 55; females = 59, M_{age} = 31.2, *SD* (11.4), range 16-75.

Materials

The Sensation Seeking Scale. 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 have been found to moderate psi 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.

The Divergent Association Task. Participants were required to complete a measure of creativity, the Divergent Association Task (DAT; Olson et al., 2021). They 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* would not be close to each other and thus less semantically similar. According to the original study, the greater 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 form Italian web sites (Cimino et al., 2018). DAT scores ranged 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 gathering a higher amount of information about the preferred strategies of the participant over the manipulation of the level of difficulty. Thus, 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

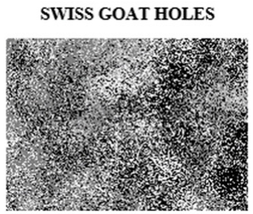
Participants were tested online through social media and Prolific platforms. Qualtrics software was used to implement the experimental procedure. They were told that the study aimed to investigate their ability to engage intuition. They were first presented with a two-items measure, assessing their tendency to seek stimulus. Subsequently, participants completed the 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 (contact the first author to get the version in Italian). After a 3-minutes relaxation period, participants were presented with the CRA problems, in which three cue words were presented and they were required to try to find a fourth word that created a compound word with the cues. In half of the conditions in random order the solution to the CRA problems were presented masked, in the other half no solution was presented. The instructions were:

> "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 do not 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., instinctively, 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 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 relaxation time of three minutes, the 20 problems were randomly presented for a maximum of 15 seconds. Each problem was presented as in Figure 1. The study was approved by Ethical Committee Prot: 2476 of the Dipartimento di Psicologia, Università degli studi di Padova, Italy.

Figure 1

Example of the English Version of CRA Problems. In the Masked Condition, the Solution Was Presented Under the Gray Square ("Cheese" in this Case)



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Manipulation Check. At the end of the CRA problems, participants were requested to respond to the following question: "In your own words, what is the purpose of the study you have just participated in?" Most 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 analyses were performed using the freeware software Jamovi (2021) v.1.8.1. Table 1 shows descriptive statistics related to percentages of correct solutions when the solutions were presented masked (%CRA problems_T) or not presented (%CRA problems_F). 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, t(113)=-.33; p=.74.

Table 1

Percentages of Correct Solution to 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.

Moderators Effects

In order to examine whether sensation seeking, creativity, and insight predicted masked problem solving, we carried out a multiple linear regression with the difference score in masked problem solving (DiffCRA = % CRA problems_T - % CRA problems_F) as the outcome and SSTot, DAT score, and the number of CRA problems solved using an insight-type strategy as predictors (this way to analyze the data was suggested by a reviewer). The corresponding violin plots are presented in Figures 2 and 3 and the results of the multiple linear regression are presented in Table 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 2

Difference Between CRA Problems when Solutions were Presented or Not

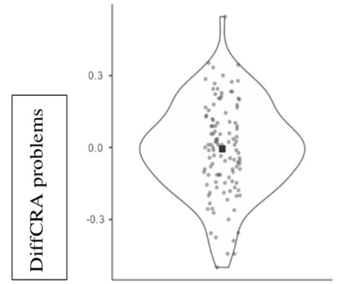
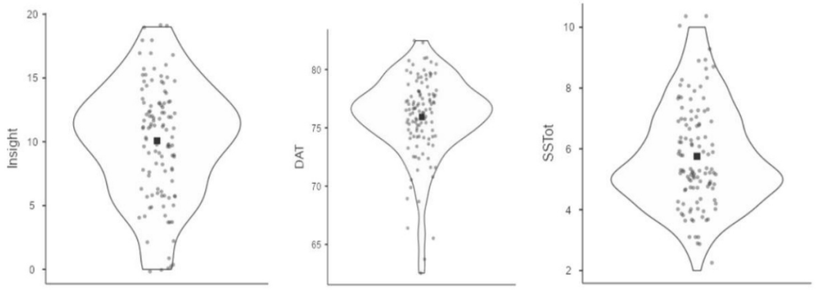


Figure 3

Violin Plots of Moderator Variables



The results clearly show that only insight, that is the number of CRA problems solved with an insight-type strategy influenced 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.

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Table 2

Multiple Linear Regression of the Moderators on the DiffCRA Problems

Model Coefficients

						95% Confidence Interval	
Predictor	Estimate	SE	*t*	*p*	Stand. Estimate	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.

Table 3

Linear Regression

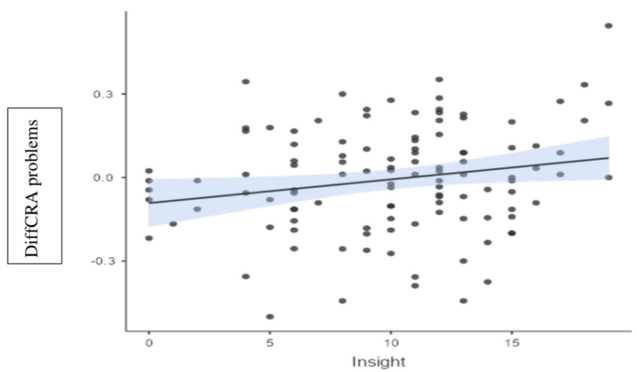
Model Coefficients

						95% Confidence Interval	
Predictor	Estimate	SE	t	*p*	SE	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 $R = .20$; $p = .027$.

Figure 4

Scatterplot of the correlation between Insight score and DiffCRA problems



A further hint about the specificity of the relation 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 and there were no statistical differences for the DiffCRA problems, $t(112) = .86$; $p = .39$ (for task detection, No - 33, DiffCra problems = 018 (.23), Yes – 81, DiffCra problems = 016 (.17)).

Discussion

This 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. 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 better performance in the masked stimulus condition. This suggests that masked stimulus presentation may indeed facilitate creative problem solving in those using insight rather than analytic strategies. The specificity of this influence is supported by the lack of influence of the two other moderators, sensation seeking level and the DAT score. The small effect size of the masked solution influence was expected considering that participants were in a normal state of consciousness and requested to solve a complex cognitive task and not to identify or guess the masked target as it is usually being used in this field (Tressoldi & Storm, 2021).

Despite unconscious perception remaining 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, where the visibility of a prime stimulus is only reduced by a visual masking (Van de Bussche et al., 2009). Adding to the existing literature, we explored 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 and so the information can only be detected unconsciously.

The main limitation of the study is its completely exploratory nature. Consequently, our results must be considered provisional and interpreted with caution. Only replication studies with a confirmatory approach, for example using a registered report protocol, could support our findings.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 un 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 underlaying processes in the Italian language and culture that only recently has been taken into consideration by researchers (Salvi and colleagues, 2016). Also, the present study represents the first attempt to adapt a new measure of creativity (i.e., DAT) to the Italian context.

Data Availability Statement

The dataset from this study can be found at: https://doi.org/10.6084/m9.figshare.13487571

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Appendix

Instructions and items translated from the Italian version of the Divergent Association Test.

Instructions and items 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 specialized 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…

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