



## Opinion Paper

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# Associative thinking as a lever for diagnostic creativity

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**Abstract:** Creativity plays an important role in diagnostic reasoning, particularly in supporting calibration and insights. However, the cognitive mechanisms underlying creativity have not yet been clearly articulated in this context. This study focused on associative thinking, an essential component of creativity, and conducted a systematic examination in the context of diagnostic reasoning. To the best of our knowledge, this is the first such study. Specifically, this study explored how the four types of associative thinking—remote, chained, radial, and dissociative—contribute to the generation of diagnostic hypotheses by examining clinical cases. This article presents a theoretical reinterpretation, grounded in the cognitive perspectives of sophisticated reasoning processes routinely employed by expert clinicians. By illuminating the role of associative thinking in diagnostic hypothesis generation, this study provides a novel conceptual perspective that aims to enhance both creativity and diagnostic accuracy, ultimately contributing to improved quality of patient care.

**Keywords:** associative thinking; creativity; insight; diagnostic reasoning; diagnostic excellence

## Introduction

While cognitive biases facilitate the efficient selection and processing of information, they can also lead to erroneous conclusions [1]. In situations where cognitive biases strongly influence diagnostic reasoning and increase the risk of diagnostic errors or when clinicians encounter challenging cases that result in diagnostic impasses, it becomes necessary to generate hypotheses from a new perspective [2, 3]. These are moments in which creativity must be engaged [2]. Creativity involves the generation of novel and useful ideas or solutions that require approaching problems from new perspectives [4]. A perspective can be considered novel when it is newly adopted within the thinking process, even if it was known previously [5]. In recent years, associative thinking has been highlighted from a psychological perspective as the basis of creativity, and its close relationship with creative ability has become evident [6]. In diagnostic reasoning, hypothesis generation is a form of reasoning called *abduction* [7]. Abduction involves inferring a plausible explanation for the given facts [8]. This can be facilitated through associative thinking [9]. The underlying reason is that associative thinking can be classified based on the presence or absence of a goal. These include free association, in which concepts are spontaneously linked, and goal-directed association, in which concepts are strategically combined to satisfy specific task constraints or requirements [10]. The Bridge-the-Associative-Gap task [11], in which participants must find a mediating word (e.g., “mouse”) that links two seemingly distant words (e.g., “cheese” and “cat”), exemplifies such goal-directed associative processing. The diagnostic hypothesis generation has a similar structure. Clinicians often encounter multiple pieces of information that appear loosely related to one another, and search for a diagnosis that can serve as a common explanatory bridge between them. For example, given information such as “a 65-year-old man”, “acute-onset chest pain”, “pain aggravated by exertion”, and “a history of hypertension and diabetes”, a physician may think about coronary artery disease as a diagnostic hypothesis that can coherently account for all of these findings. In this sense, abductive reasoning in a

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diagnosis can be considered a form of goal-directed association. Abduction can occur intuitively (System 1) or analytically (System 2) [8] in terms of the dual-process theory in cognitive sciences [12]; the same applies to associative thinking, which also operates through both cognitive systems [13]. Therefore, focusing on associative thinking in diagnostic reasoning may facilitate a better understanding of the mechanisms underlying the generation of creative hypotheses. However, associative thinking has not been explicitly theorized in the context of medical diagnostic reasoning. To address this gap, we present the first systematic perspective, to our knowledge, of associative thinking as a core component of creativity in diagnostic reasoning, offering a novel perspective on diagnostic reasoning. Specifically, we reinterpreted hypothesis generation in diagnostic reasoning through associative thinking and elucidated its functional significance using clinical cases based on four distinct types of associations. Furthermore, existing diagnostic strategies and clinical expertise are referred to as forms of associative thinking, highlighting their potential integration with educational approaches and creativity research. In doing so, this study aimed to enhance clinicians' creative capacity, foster insight and calibration, and ultimately improve diagnostic accuracy.

Before introducing the four types of associative thinking, it is important to clarify their relationship with creativity. Creativity is commonly defined as the ability to generate novel ideas by combining concepts retrieved from memory, and has long been closely linked to the process of association [14, 15]. Human memory is organized as a *semantic network*, in which semantically related concepts are interconnected in a web-like structure [16] (Figure 1). In this semantic network, it is possible to consider the semantic distance between concepts. This semantic distance can be defined using a *distributional semantic model* constructed from linguistic corpora [17]. Creativity tends to develop when semantically distant concepts are combined [4–6].

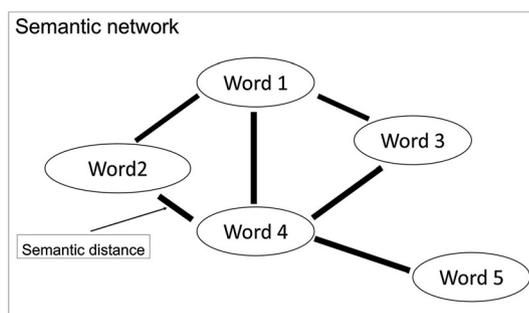


Figure 1: Semantic network and semantic distance.

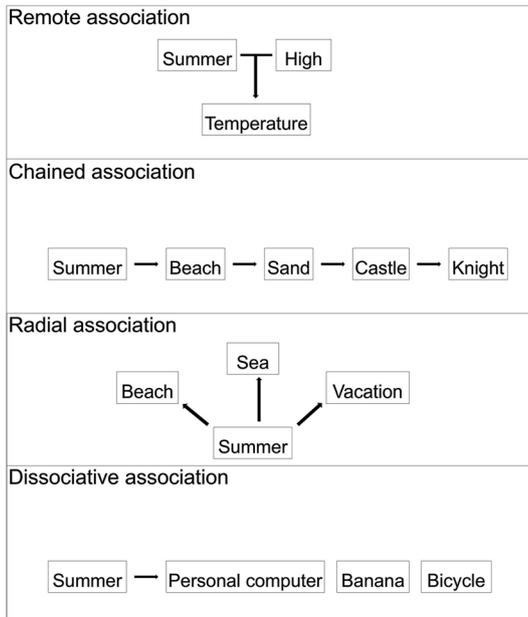
## Associative thinking as a core component of creativity

Benedek et al. [18] used four types of associative tasks – *associative combination task*, *association chain task*, *free-association task*, and *dissociation task* – to measure the following components of associative thinking: associative combination ability (the ability to connect semantically distant concepts), associative fluency (the ability to generate many related words), associative flexibility (the ability to generate words from diverse categories), and dissociative ability (the ability to generate unrelated words). In what follows, to highlight the distinction from other tasks, we refer to the free association task as the *radial association task*, which involves generating multiple semantically related words from a given stimulus concept in a divergent manner: They employed latent variable modeling to explore the relationships between these abilities, creativity, and intelligence [18].

The associative combination task used by Benedek was developed with reference to Mednick's Remote Associates Test [14]. Remote associations have long been associated with creativity [14]. Mednick defined creativity as “the forming of associative elements into new combinations which either meet specified requirements or are in some way useful” and developed the Remote Associates Test (RAT) to assess this ability [14, p. 221]. The original RAT asked participants to identify a compound word that could connect three seemingly unrelated words (e.g., “cheese” for “rat”, “blue”, and “cottage”). However, Benedek et al. [18] adapted this task by presenting participants with a pair of conceptually unrelated words and asking them to generate associations related to both words simultaneously. For example, for the word pair “summer” and “high”, participants might respond with “airplane”, “temperature”, or “expenses”. In this example, possible answers include “temperature” or “airplane” [6] (Figure 2).

Chained association involves listing a series of words in sequence, where each word is linked to the previous one (e.g., summer → beach → sand → castle → knight) (Figure 2) [19]. Creative individuals tend to produce word chains that diverge progressively in semantic distance from the initial word. This tendency is referred to as the forward flow [19].

Radial association involves listing words that are directly related to a starting word (e.g., summer → beach, seaside, summer vacation) (Figure 2) [20]. This task resembles the instance task developed by Wallach et al. [15, 20] to assess creativity through divergent thinking [20]. An example of an instance task is listing as many “round objects as possible”.



**Figure 2:** Four types of associative thinking in creativity.

Dissociative association involves the generation of words that are as different from each other as possible in meaning and use. (e.g., summer → computer → banana → bicycle) [6, 21] (Figure 2). This task is known as the *divergent association task* (DAT) and was recently established as a test to assess divergent thinking [21].

According to Benedek et al. [18], dissociative and associative combination abilities are particularly important for creativity [6]. Indeed, both the DAT and the RAT continue to be used as creative tests. Prior studies on the relationship between creativity and diagnostic reasoning [2] have shown that RAT performance can be improved by maintaining a positive mood [22], getting adequate sleep [23], or living in a moderately noisy environment [24]. These findings, showing that such manipulations increase creativity test scores, confirm that associative thinking is the fundamental cognitive process underlying creativity.

In summary, although associative thinking varies in both purpose and cognitive processing styles, it is widely regarded as the core mechanism underlying creativity. The next section explores how these theoretical insights may be applied to diagnostic reasoning.

## Application of associative thinking in diagnostic reasoning

In this section, the four types of associative thinking discussed in the previous chapter are organized as strategic

approaches to diagnostic reasoning, and their practical significance is considered through illustrative clinical cases.

### Remote association

The cognitive process of generating diagnostic hypotheses that coherently explain multiple semantically distant findings or symptoms, as well as generating hypotheses that integrate patient-specific information and a specific categorical framework (e.g., an etiological analysis (Table 1-I) or an anatomical approach (Table 1-II)), can be considered a form of remote association [25].

#### Example 1 of remote association

A teenage girl was admitted to the hospital due to seizures. In addition to the seizures, she exhibited facial erythema and proteinuria. Given her young age, a unifying diagnosis was considered appropriate, leading to the generation of a single diagnostic hypothesis: systemic lupus erythematosus.

#### Example 2 of remote association

A woman in her 60s presented with a one-month history of lower back pain and gait disturbance. Neurological examination revealed impaired vibration and position sense, along with exaggerated patellar tendon reflexes, but no motor weakness. A posterior column lesion was suspected. The serum levels of vitamin B12, folate, and copper were assessed, all of which were within normal limits. Given the mildly elevated inflammatory markers, posterior column compression due to an epidural abscess was considered. Magnetic resonance imaging (MRI) subsequently confirmed the presence of an epidural abscess.

### Chained association

When a particular disease is considered, the generation of a sequence of related hypotheses, such as associated conditions, risk factors, or potential causes (a process referred to as vertical tracing (Table 1-III) [26]), can be understood as a form of chained association.

#### Example of a chained association

An 80-year-old man presented with fever and shortness of breath. Given his age and bilateral leg edema, heart failure was initially suspected. The presence of third and fourth heart sounds, along with elevated jugular venous pressure,

**Table 1:** Correspondence between diagnostic hypothesis generation strategies and types of associative thinking.

Associative starting point	Category	Framework of diagnostic reasoning	Type of association
Clinical key feature	(I) Anatomy	Anatomical approach	Remote association
Disease name	(II) Etiology	Etiological analysis	Chained association
	(III) Cause, risk factor	Vertical tracing	
Symptoms	(IV) Cause	Symptomatologic approach	Radial association
Disease name	(V) Mimic	Pivot and cluster strategy	
Clinical key feature	(VI) To handle key features as disconnected data, or to interpret them from a perspective of pluralism	DECLARE	Dissociative association

This table includes only representative strategies commonly used in clinical diagnostic reasoning.

supported the diagnosis. However, auscultation revealed a diastolic murmur at the second right sternal border. In the context of low-grade fever, aortic regurgitation was suspected as the underlying cause of heart failure, prompting consideration of infective endocarditis of the aortic valve. This stepwise associative process, in which heart failure is linked to aortic regurgitation and then to infective endocarditis, illustrates chained association in diagnostic reasoning, where an initial hypothesis (heart failure) leads to a sequential chain of related diagnoses.

## Radial association

The generation of multiple diagnostic hypotheses from a single symptom (symptomatologic approach (Table 1-IV) [25]), or recalling mimicking conditions based on an initial diagnostic hypothesis (pivot and cluster strategy (Table 1-V) [27]), can be understood as forms of radial association in diagnostic reasoning.

### Example of radial association

A woman in her 60s presented with epigastric pain and vomiting. Although infectious enteritis was initially suspected, several other conditions known to present with similar symptoms were also considered. These included pancreatitis, diabetic ketoacidosis, acute myocardial infarction, and cholecystitis, forming a broad differential diagnosis. In this case, the epigastric pain was intermittent yet persistent, and the absence of diarrhea reduced the likelihood of infectious enteritis. Diabetic ketoacidosis was also excluded based on normal blood glucose levels. Given the patient's history of hypertension and diabetes, the physician considered atherosclerotic risk. Subsequently, an electrocardiogram revealed ST-segment elevation, confirming the diagnosis of acute myocardial infarction.

## Dissociative association

In diagnostic reasoning, a dissociative association may involve the hypothesis that certain findings are clinically insignificant or are attributable to comorbid or underlying conditions, thereby prompting the exploration of alternative diagnostic possibilities. Additionally, dissociative associations can occur when specific pieces of information are recombined in non-obvious ways to generate alternative diagnostic hypotheses (Table 1-VI) [28].

### Example of dissociative association

A man in his 70s with a history of heart failure presented with several days of fever, cough, sputum production, and dyspnea. Laboratory tests revealed hyponatremia, mild elevations in liver enzymes, and elevated creatine kinase levels. Attempting to unify the findings under a single diagnosis, *Legionella pneumonia* was initially considered, and the patient was about to be discharged with antibiotic treatment. However, upon recognizing the absence of hot spring exposure history, the rarity of *Legionella* infection, and the patient's history of heavy alcohol consumption, the physician reconsidered the diagnostic hypothesis. Hyponatremia was attributed to decreased oral intake secondary to pneumonia, while the elevated liver enzymes were considered alcohol-related. The elevated creatine kinase level raised concerns for rhabdomyolysis potentially triggered by infection. The patient subsequently recovered with treatment using only penicillin-class antibiotics.

These four types of associative thinking represent distinct cognitive strategies that enhance hypothesis generation and promote flexibility and multidimensionality in diagnostic reasoning. In each of the presented cases, the initial hypothesis proved insufficient, or the physician encountered a diagnostic impasse, necessitating calibration or insight. Additional diagnostic hypotheses are generated

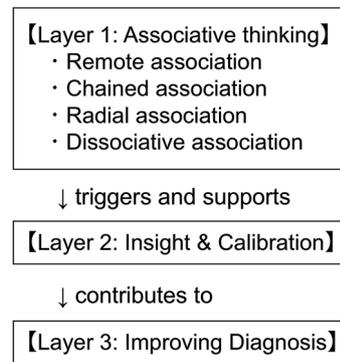
through associative thinking. Therefore, associative thinking functions as a mechanism that activates creativity and facilitates both diagnostic calibration and insight.

The use of a disease map (i.e., a semantic network in an illness concept space) may be effective in promoting associative thinking in diagnostic reasoning. A disease map can be visualized as a semantic network in which conceptually similar diseases are positioned closer together and dissimilar diseases are placed farther apart. For instance, several initiatives have sought to map the phenotypic and genetic relatedness among rare diseases with the aim of informing differential diagnoses and supporting clinical decision-making [29]. In cases where diagnostic hypothesis generation requires insight or calibration, meaning creativity is essential, clinicians may need to retrieve hypotheses that are semantically distant from the initial hypothesis. Training novice physicians to explore this conceptual space and deliberately generate semantically distant alternative diagnoses may help cultivate perspective shifting and flexible diagnostic thinking. Disease maps and associative thinking can be leveraged in diagnostic reasoning education.

## Discussion

A key implication of this study is that the practical value of associative thinking for clinicians lies in its capacity to serve as a cognitive scaffold for shifting perspectives during diagnostic reasoning. This shift may, in turn, promote insight and calibration, ultimately contributing to an improved quality of patient care. Associative thinking serves as a point of departure and functions as a cognitive process that supports the development of refined clinical judgment by bridging insight and creativity (Figure 3). Second, this study offers new insights into the ongoing discussions in psychology. Theoretical descriptions of diagnostic reasoning suggest that associative thinking contributes to generating creative hypotheses. Although psychological studies have reported a correlation between associative thinking and creativity, the causal relationship between them has not been sufficiently examined. Therefore, the context of diagnostic reasoning may serve as a valuable setting for reexamining the relationship between these constructs.

This study aims to theoretically position associative thinking, which serves as the foundation of creativity, within the context of diagnostic reasoning. Its central contribution lies in its reinterpretation of the four types of associative thinking (remote, chained, radial, and dissociative) through



**Figure 3:** Cognitive pathways from associative thinking to diagnostic excellence.

clinical cases. These cases illustrate how each type is employed in real-world diagnostic reasoning processes.

These novel implications are enabled by conceptualizing diagnostic reasoning as a form of abduction and acknowledging the potential role of creativity in the process. By focusing on associative thinking as a core cognitive mechanism underlying creativity, we theorized that the existing clinical frameworks are manifestations of distinct associative processes (Table 1). Various diagnostic strategies can foster creativity, particularly when they trigger a shift in perspective. From the standpoint of associative thinking, these strategies may also promote associative thinking. Diagnostic hypotheses generated through associative processes may vary depending on the category employed. For example, in the case of remote associations, clinicians often use etiological frameworks (i.e., etiological analysis), although other categories can also be employed. Identifying additional categories that facilitate diagnostic hypothesis generation may serve as the basis for developing novel clinical reasoning frameworks and positioning associative thinking as the foundation for the development of new diagnostic strategies.

This study had several limitations. First, this study only presents a theoretical framework and has not yet empirically verified it. Second, although the four types of associative thinking offer a useful conceptual lens, the boundaries between them are not always clearly defined, and certain aspects of clinical reasoning may not be easily categorized within this typology. Third, individual differences in the structure of semantic networks and the strength of conceptual connections may result in variability in how associations contribute to the diagnostic hypotheses [30]. Therefore, educational interventions may not have a uniform effect on all learners. Nevertheless, by reinterpreting existing diagnostic frameworks through the shared lens of associative

thinking, this study offers an initial step towards conceptualizing and communicating creativity in diagnostic reasoning. This contributes to a deeper understanding of the cognitive processes underlying clinical thinking.

Future empirical research is required to clarify how associative thinking contributes to the generation of diagnostic hypotheses in clinical and educational settings. For example, quantitative studies that could investigate the relationship between individual differences in RAT and diagnostic performance in clinical simulations. Moreover, educational interventions that incorporate explicit training in remote associative strategies (e.g., prompting learners to generate diagnostically plausible hypotheses that connect semantically distant symptoms) could be designed and evaluated for their impact on hypothesis generation and diagnostic accuracy. These efforts may further elucidate the role of associative thinking in diagnostic reasoning and contribute to both clinical practice and medical education.

## Conclusions

Associative thinking is a core cognitive mechanism underlying creativity that plays an important role in diagnostic reasoning by enabling shifts in perspective and generating novel hypotheses. Hypothesis generation through associative thinking can be conceptualized as a form of abduction that contributes to improved diagnostic accuracy by fostering both insight and calibration. By applying four types of associative processes to diagnostic reasoning and illustrating their respective clinical relevance, this study provides a structured reinterpretation of sophisticated cognitive strategies routinely employed by clinicians. Future research should focus on developing educational interventions that foster associative thinking and empirically evaluating their impact on the generation of diagnostic hypotheses.

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**Use of Large Language Models, AI and Machine Learning**

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