

Multi-modal RAG for Mental Health Diagnosis

Leveraging AI to for Mental Health Diagnostics



Introduction

Context:

The DSM-5 (Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition) is the standard reference for mental health professionals worldwide.

Purpose:

To enhance understanding and retrieval of mental health diagnostic criteria using the DSM-5.

Problem Statement:

Mental health diagnosis is complex and requires efficient access to precise information from DSM-5.

Solution:

Utilize RAG to extract, organize, and provide accurate answers to mental health queries.

Project Overview

Data Extraction: Use NLP techniques to pull text and structure it effectively.

Data Categorization: Categorize by disorder type, key criteria, and clinical significance.

Summarization: Use language models to condense information into easy-to-read summaries.

Embedding & Storage: Generate vector representations of text for efficient storage and retrieval.

Query & Retrieval: Input queries to retrieve and present the most relevant information.

Evaluation: Assess the effectiveness and relevance of retrieved content.

Data Source

Title:

Diagnostic and Statistical Manual of Mental Disorders (DSM-5)

Publisher:

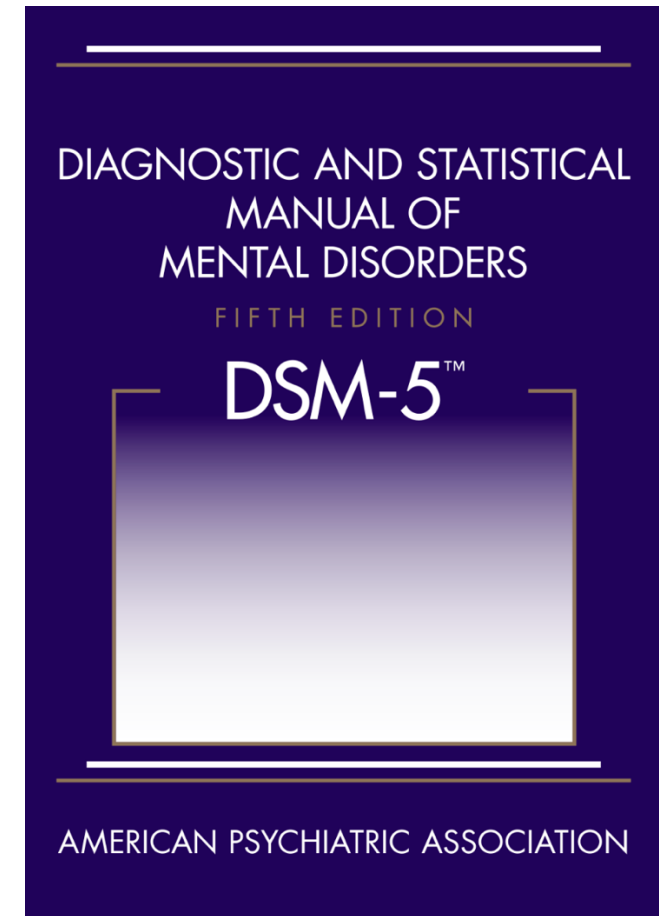
American Psychiatric Association (APA)

Number of Pages:

947 pages

Content:

The DSM-5 is a comprehensive classification of mental disorders used by clinicians and researchers. It includes diagnostic criteria, a summary of research, and descriptions of various conditions to aid in mental health diagnosis and research. The manual provides a standardized language for mental health professionals across the world.



Data Extraction & Categorization

Extract structured and unstructured content from the DSM-5 PDF.

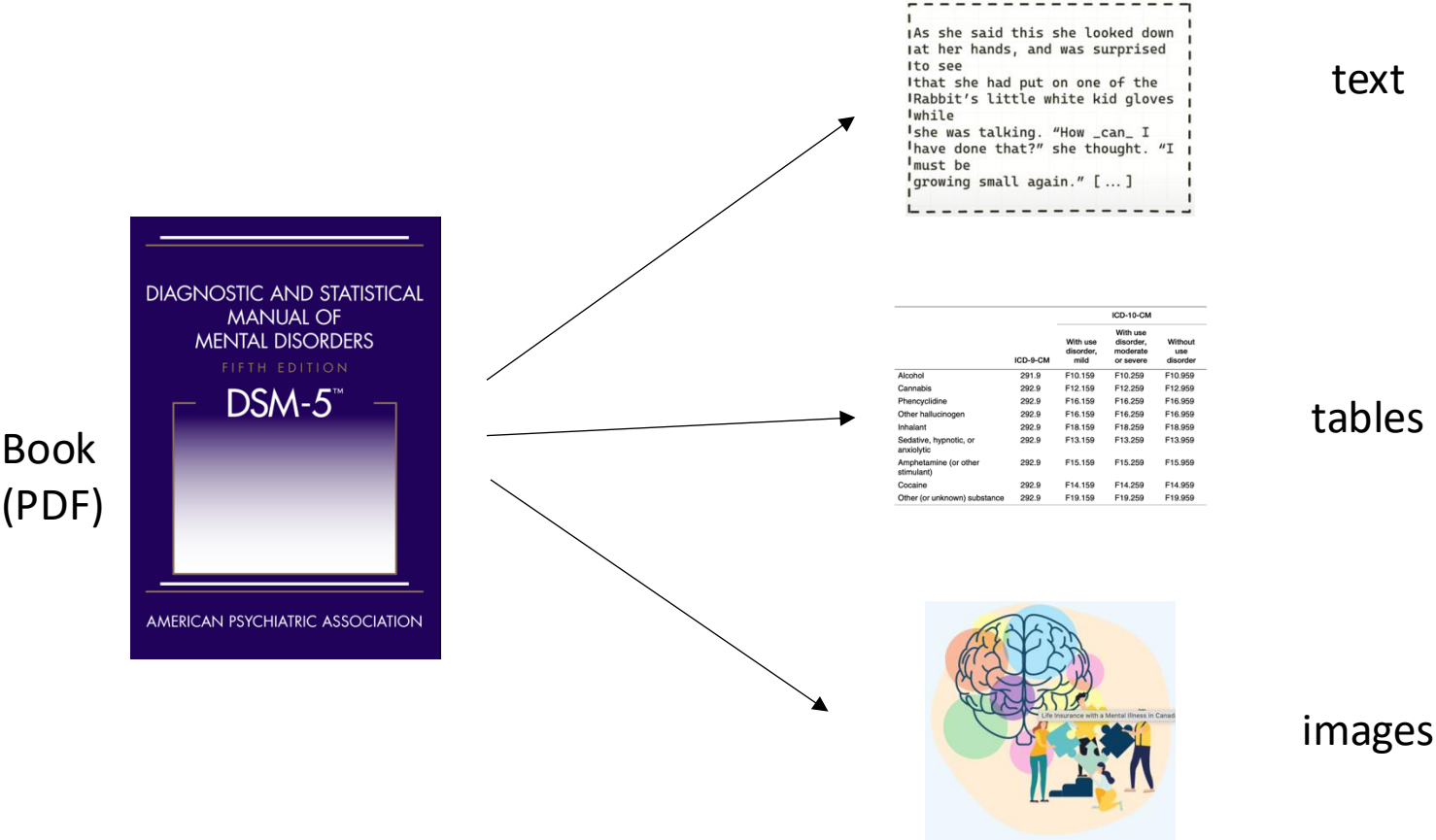
Categorizes the extracted elements into **tables**, **texts**, and **images** for further processing.

```
from unstructured.partition.pdf import partition_pdf

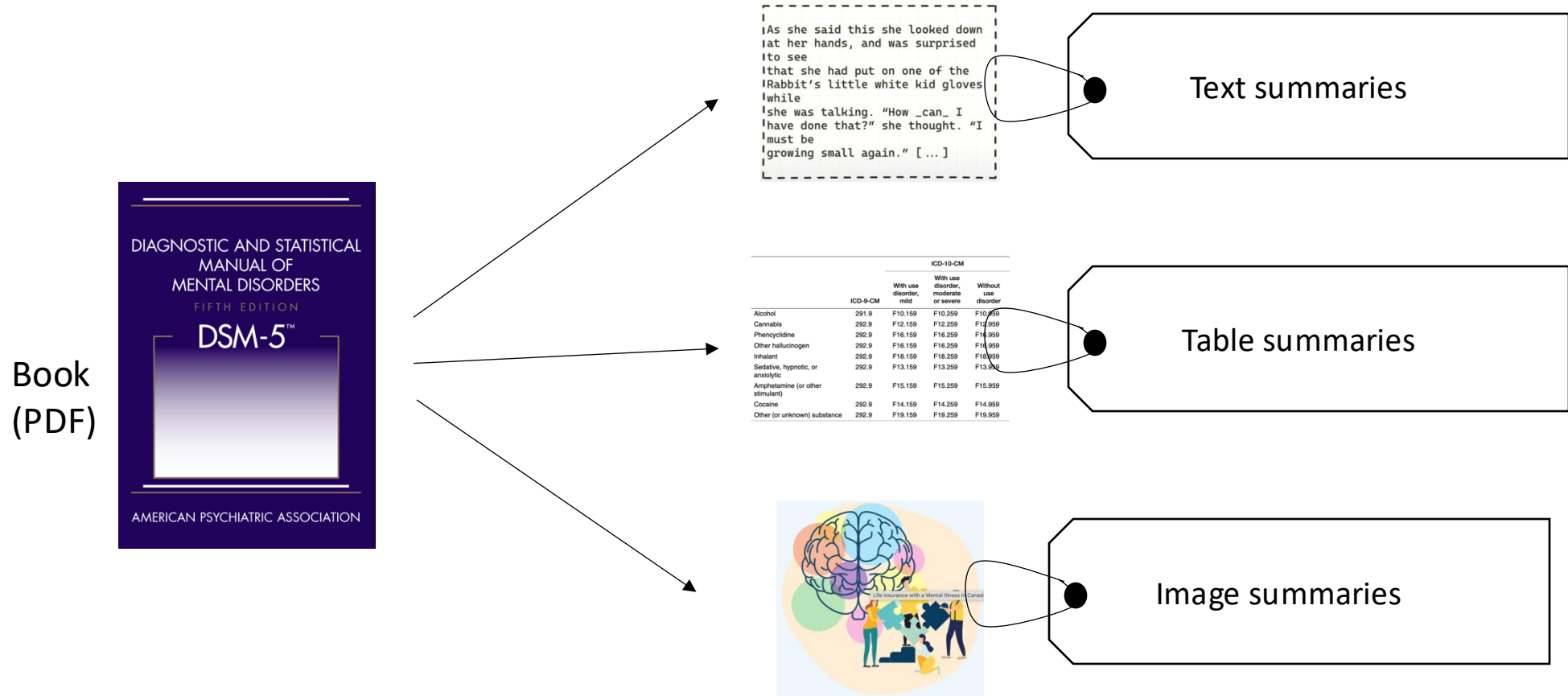
def extract_pdf_elements(path, fname):
    return partition_pdf(
        filename=path + fname,
        extract_images_in_pdf=True,
        infer_table_structure=True,
        chunking_strategy="by_title",
        max_characters=4000,
        new_after_n_chars=3800,
        combine_text_under_n_chars=2000,
        image_output_dir_path=path,
    )
```

```
def categorize_elements(raw_pdf_elements):
    tables, texts, images = [], [], []
    for element in raw_pdf_elements:
        if isinstance(element, Table):
            tables.append(str(element))
        elif isinstance(element, Image):
            images.append(element)
        elif isinstance(element, CompositeElement):
            texts.append(str(element))
    return texts, tables, images
```

Data Extraction & Categorization



Summarization



Summarization : Text & Tables

Use **OpenAI's GPT models** to provide **optimized summaries** for retrieval of diagnostic criteria.

```
def summarize_text_or_tables(text_or_tables, type_):  
    summarized_texts = []  
    for element in text_or_tables:  
        messages = [{'role': 'user', 'content': f"Summarize: {element}"}]  
        llm_response = client.chat.completions.create(messages=messages, **model_params)  
        summarized_texts.append(llm_response.choices[0].message.content)  
    return summarized_texts
```


Summarization : Images

Base64 allows binary data (like images) to be represented in a text format, which is essential for transmission over APIs.

```
import base64

# Function to encode the image
def encode_image(image_path):
    with open(image_path, "rb") as image_file:
        return base64.b64encode(image_file.read()).decode('utf-8')
```

The model is prompted :**“What is in this image?”** allowing it to generate a descriptive summary of the content.

```
def summarize_images(image_directory):
    summarized_images = []
    for filename in os.listdir(image_directory):
        image_path = os.path.join(image_directory, filename)
        base64_image = encode_image(image_path)

        response = client.chat.completions.create(
            model="gpt-4o-mini",
            messages=[
                {"role": "user", "content": f"What is in this image?"}
            ],
        )

        summarized_images.append(response.choices[0].message.content)
    return summarized_images
```

Text Chunking

Method Used:

RecursiveCharacterTextSplitter from LangChain library.

Key Parameters:

- chunk_size: 200 characters
- chunk_overlap: 100 characters

```
text_splitter = RecursiveCharacterTextSplitter(  
    chunk_size=200,  
    chunk_overlap=100,  
    separators=["\n\n", "\n", " ", ""]  
)  
chunks = text_splitter.split_text(combined_text)
```

Chunk Cleaning

Prepare chunks for embedding and retrieval by cleaning up formatting.

Cleaning Steps:

- Remove Special Characters
- Lowercase Conversion
- Whitespace Normalization

```
# Clean the chunks
for i in range(len(chunks)):
    # Remove any special character and replace them with a space
    chunks[i] = re.sub(r'^a-zA-Z0-9\s', " ", chunks[i])

    # Convert to lowercase
    chunks[i] = chunks[i].lower()

    # Replace newline characters with spaces
    chunks[i] = chunks[i].replace('\n', ' ').strip()

    # Replace multiple spaces with a single space
    chunks[i] = re.sub(r'\s+', ' ', chunks[i])

# Inspect the cleaned chunks
print(chunks)
```

Generating Embeddings

Model Used: OpenAI's text-embedding-ada-002

Why Embeddings?

Convert text into numerical representations for efficient searching.

Process

Each text chunk is embedded, creating a vector representation used for similarity searches.

Code Explanation:

Using embeddings allows for semantic searches, improving accuracy compared to keyword-based methods.

```
def embed_text(text):  
    embeddings_vector = embeddings.embed_query(text)  
    return embeddings_vector
```

```
# Embed the chunks  
embedded_chunks = []  
for chunk in chunks:  
    embedded_chunks.append(embed_text(chunk))
```

Vector Database (ChromaDB)

Objective:

Store the chunks and their embeddings for efficient retrieval.

Method Used:

Utilized ChromaDB to create a persistent database.

```
import chromadb
from chromadb import Client

# Path for the database storage
db_directory = '/path/to/chroma_db'

# Initialize Chroma Client with persistent storage (local directory)
chroma_client = chromadb.PersistentClient(path=db_directory)

# Create a collection
collection_name = "my_documents"
collection = chroma_client.get_or_create_collection(name=collection_name)
```

Documents Ingestion into ChromaDB

Ingest processed documents (chunks and their embeddings) into the database

```
# Ingest the documents into the collection database
for doc in documents:
    collection.add(ids=doc["id"],
                  embeddings=doc['embedding'],
                  documents=doc["text"])
```

Querying the Database

Retrieve relevant information based on complex user queries.

Query Process: Embed user query and find the 5 closest matching text in the database.

The system retrieves the top 5 most relevant chunks to answer the query effectively.

These chunks are stored and used as context for prompting

```
def query_database(query_text):  
    # Embed the user query  
    query_embedding = embed_text(query_text)  
  
    # Perform the query  
    results = collection.query(embedding=query_embedding,  
                               n_results=5) # Get top 5 results  
  
    return results
```

Connecting to the LLM

Use the retrieved context to answer user questions effectively.

```
def generate_response(user_question):  
    # Query the database to retrieve relevant context  
    context_results = query_database(user_question)  
  
    # Extract the top context document(s)  
    context = " ".join([result['document'] for result in context_results['document']])  
  
    # Construct messages for LLM  
  
    messages = [{ 'role': 'system', 'content': f'Here is the context: {context}' },  
                { 'role': 'user', 'content': f'{question}' }]  
  
    # Call the LLM with the constructed messages  
    response = openai.ChatCompletion.create(  
        model="gpt-3.5-turbo", # Replace with your model  
        messages=messages  
    )  
  
    # Return the LLM's response  
    return response['choices'][0]['message']['content']
```


Evaluation: LLM as a Judge

Objective:

Assess the relevance and accuracy of the responses generated by the LLM based on user queries regarding diabetes treatment. This ensures that the system provides useful and accurate information.

Scoring System:

- **Score:** Metric (out of 5) to quantify the quality of each response.
- **Feedback:** Provide qualitative feedback to highlight strengths and areas for improvement.

```
# Initialize lists to store scores and feedback
scores = []
feedbacks = []

# Iterate through each query and generated response
for question, answer in zip(queries['query_text'], queries['Generator_Response']):
    # Prepare the messages for LLM evaluation
    messages = [
        {
            'role': 'user',
            'content': f'Evaluate the following response for the query regarding d
        }
    ]

    # Call the LLM to get the evaluation
    llm_response = client.chat.completions.create(messages=messages, **model_param

    # Extract LLM's evaluation response
    response_content = llm_response.choices[0].message.content

    # Split the response into score and feedback
    parts = response_content.split('\n', 1) # Split into two parts
    score = parts[0] # First part is the score
    feedback = parts[1].strip() if len(parts) > 1 else '' # Second part is the fe

    # Append the score and feedback to their respective lists
    scores.append(score)
    feedbacks.append(feedback)

# Add scores and feedback to the dataframe
queries['Judge_Score'] = scores
queries['Judge_Feedback'] = feedbacks
```

Evaluation: LLM as a Judge

query_text	query_result	Generator_Response	Judge_Score	Judge_Feedback
What are the diagnostic criteria for Major Depressive Disorder, and how do they differ from criteria for Persistent Depressive Disorder (Dysthymia)?	summary of major depressive disorder diagnostic criteria summary of diagnostic features of persistent depressive disorder dysthymia summary of differential diagnosis for persistent depressive disorder this summary encapsulates the essential diagnostic criteria and classifications for persistent depressive disorder dysthymia for effective retrieval	The diagnostic criteria for Major Depressive Disorder (MDD) and Persistent Depressive Disorder (Dysthymia) differ primarily in the duration and severity of symptoms. ### Major Depressive Disorder (MDD) Diagnostic Criteria: According to the DSM-5, to be diagnosed with MDD, a person must experience at least five of the following symptoms during the same two-week period, and at least one of the symptoms must be either depressed mood or loss of interest or pleasure: 1. "Depressed mood" most of the day, nearly every day. 2. "Loss of interest or pleasure" in most activities.	5	The response provides a clear and accurate overview of the diagnostic criteria for Major Depressive Disorder (MDD) and Persistent Depressive Disorder (Dysthymia), as well as a concise comparison of their key differences. It correctly cites the DSM-5 criteria, outlines the required symptoms, and emphasizes the differences in duration, severity, and nature of the disorders. Overall, the information is relevant and informative for someone seeking to understand these mental health conditions.
How does the DSM-5 categorize and define different types of Anxiety Disorders, and what are the key symptoms used to differentiate them?	this summary encapsulates the diagnostic criteria and distinctions for various anxiety disorders focusing on their relationships with medical conditions and substance use summary of anxiety and obsessive compulsive disorders in dsm 5 summary of differential diagnosis for anxiety disorders	The DSM-5 categorizes anxiety disorders into several distinct types, each with specific diagnostic criteria and key symptoms that help differentiate them. Here's an overview of the main categories: 1. "Generalized Anxiety Disorder (GAD)": - "Key Symptoms": Excessive anxiety and worry occurring more days than not for at least six months, difficulty controlling the worry, and associated symptoms such as restlessness, fatigue, difficulty concentrating, irritability, muscle tension, and sleep disturbances. 2. "Panic Disorder":	5	The response is highly relevant and accurate. It provides a clear and comprehensive overview of the categories of anxiety disorders as defined in the DSM-5, along with the key symptoms that differentiate each disorder. The information is well-organized, making it easy for the reader to understand the distinctions among the various types of anxiety disorders. Additionally, it correctly addresses the diagnostic criteria, including the duration of symptoms and the need to rule out other conditions. Overall, the response effectively meets the user's query.
What updates or changes were made in the DSM-5 compared to the DSM-IV regarding the classification of Autism Spectrum Disorder?	summary of changes from dsm iv to dsm 5 this section outlines significant updates in diagnostic criteria and terminology in the dsm 5 compared to dsm iv organized by disorder category key changes include for a comprehensive overview of all changes refer to the expanded descriptions available online summary of changes from dsm iv to dsm 5 replacement of subtypes with presentation specifiers allowance for comorbid autism	In the transition from DSM-IV to DSM-5, significant changes were made regarding the classification of Autism Spectrum Disorder (ASD). Key updates include: 1. "Unified Diagnosis": The DSM-IV had separate categories for Autistic Disorder, Asperger's Disorder, and Pervasive Developmental Disorder Not Otherwise Specified (PDD-NOS). The DSM-5 combined these into a single diagnosis of Autism Spectrum Disorder, reflecting a more comprehensive understanding of the spectrum. 2. "Revised Diagnostic Criteria": The diagnostic criteria were updated to include two core domains of impairment: - Social communication and interaction	5	The response is highly relevant and accurate, providing a clear overview of the key changes made in the DSM-5 regarding Autism Spectrum Disorder compared to the DSM-IV. It effectively highlights the unification of diagnoses, revised criteria, introduction of presentation specifiers, allowance for comorbid diagnoses, and adjustments in symptom thresholds. The information is concise and well-organized, making it easy for the reader to understand the significant updates. Overall, it demonstrates a solid understanding of the topic.
What are the defining features of Post-Traumatic Stress Disorder (PTSD) in the DSM-5, and what are the specific criteria for diagnosis?	summary of posttraumatic stress disorder ptsd diagnostic criteria 309 81 f43 10 6 delayed expression if applicable full criteria met at least 6 months post trauma with possible immediate symptom onset summary of diagnostic features of ptsd 2 posttraumatic stress disorder ptsd pp 265 271 280 diagnostic criteria and features comorbidities and functional consequences summary of diagnostic features of acute stress disorder diagnosis requires nine or more symptoms from categories including intrusion negative mood dissociation avoidance and arousal which must begin or worsen	The defining features of Post-Traumatic Stress Disorder (PTSD) according to the DSM-5 include a range of symptoms that persist following exposure to a traumatic event. The specific criteria for diagnosis are outlined as follows: 1. "Exposure to a Traumatic Event": The individual must have been exposed to a traumatic event, which can include direct experience, witnessing the event, learning that a traumatic event occurred to a close family member or friend, or experiencing repeated or extreme exposure to aversive details of the event (e.g., first responders collecting human remains). 2. "Intrusion Symptoms": The individual experiences one or more intrusive symptoms associated with the traumatic event, such as: - Recurrent, involuntary, and intrusive distressing memories of the traumatic event. - Recurrent distressing dreams related to the event. - Dissociative reactions (flashbacks) in which the individual feels or acts as if the traumatic event is recurring. - Intense or prolonged psychological distress at exposure to internal or external cues that symbolize or	5	The response accurately outlines the defining features and specific criteria for the diagnosis of Post-Traumatic Stress Disorder (PTSD) as per the DSM-5. It comprehensively covers all necessary aspects, including exposure to a traumatic event, various symptom categories (intrusion, avoidance, negative alterations in cognition and mood, and alterations in arousal and reactivity), duration, functional consequences, and delayed expression. The information is well-structured and clear, making it easy for the reader to understand the criteria for diagnosis. Overall, it provides a thorough and relevant overview of PTSD.
How does the DSM-5 address Substance Use Disorders, and what are the factors that differentiate mild, moderate, and severe levels of substance-related disorders?	summary severity and specifiers of substance use disorders substance use disorders are classified by severity levels based on symptom criteria mild 2 3 symptoms moderate 4 5 symptoms and severe 6 symptoms severity can change over time influenced the table categorizes various substance use disorders based on severity moderate and severe and includes the following diagnoses severity with use moderate or mild disorders and severe disorders different	The DSM-5 (Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition) classifies Substance Use Disorders based on the presence and severity of specific symptoms. The disorders are categorized into three levels of severity: mild, moderate, and severe. 1. "Mild Substance Use Disorder": This is diagnosed when an individual exhibits 2 to 3 symptoms from a specified list of criteria related to substance use. 2. "Moderate Substance Use Disorder": This diagnosis is given when an individual displays 4 to 5 symptoms. 3. "Severe Substance Use Disorder": This classification applies when an individual meets 6 or more symptoms.	4	The response accurately summarizes how the DSM-5 addresses Substance Use Disorders, including the criteria for mild, moderate, and severe classifications. It correctly identifies the number of symptoms required for each level and mentions relevant factors that can influence the severity of the disorder. However, it could have provided more detail about the specific criteria used to diagnose these disorders and examples of the symptoms listed in the DSM-5. Additionally, mentioning the importance of individual differences and contextual factors could enhance the response. Overall, it is a solid answer but could benefit from more depth.