Hazy memories in the courtroom: A review of alcohol and other drug effects on false memory and suggestibility

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ABSTRACT

Alcohol and other psychoactive drugs are oftentimes implicated in legal cases. A pertinent question herein is whether such substances might adversely affect testimonies of victims, eyewitnesses, or suspects by propelling the formation of false memory and increasing susceptibility to suggestion. In the current review, we amassed all available evidence on the effects of intoxication on false memory formation and suggestibility, including the substances alcohol, benzodiazepines, cannabis, stimulants, hallucinogens, and antipsychotics. Our review indicated that alcohol and cannabis under certain conditions increased the susceptibility to false memories and/or suggestion with effect sizes ranging from medium to large. When intoxicated during an event, alcohol is most likely to increase this susceptibility at high intoxication levels or after a delay, whereas cannabis exerts detrimental effects during acute intoxication but not necessarily once sober. For other substances, ecologically valid research separating different memory phases is needed. Overall, differences between substances regarding false memory effects exist, suggesting that a nuanced approach is needed when dealing with intoxicated individuals in a legal context.

1. Introduction

Human memory does not operate like a video camera. That is, memories are not exact replicas of the original event but are reconstructions of past experiences (Conway and Pleydell-Pearce, 2000; Johnson and Raye, 1998). During such reconstructions, errors can occur, resulting in false memories. False memories can refer to people remembering events that never happened or remembering them differently from the way they happened (Roediger and McDermott, 1995). Research has shown that people can be led to have false memories of even highly implausible events, traumatic experiences, or bizarre actions (Otgaar et al., 2009; Porter et al., 1999; Thomas and Loftus, 2002). However, the seriousness of such false memories becomes evident when they appear in legal cases (Howe and Knott, 2015). Of importance here is the fact that the lion share of false memory studies have been conducted on participants in a sober state of mind while in many legal cases, witnesses, victims, or suspects might be under the influence of drugs (e.g., alcohol, cannabis). Strikingly, research on the impact of alcohol and other drug intoxication on false memory formation and susceptibility to suggestion is still relatively scarce, aside from perhaps alcohol and cannabis effects on false memory proneness (e.g., Evans et al., 2019; Kloft et al., 2020). The main aim of this article is to review findings on alcohol and other drug effects on false memory production and interrogative suggestibility. In order to examine the problem and demonstrate the relevance of these drug effects, we will also provide a review of the prevalence of intoxicated witnesses, victims and suspects.

Testimonies play a critical role in advancing a criminal investigation and securing a conviction. In many criminal trials, testimonies are the sole piece of evidence available and are strongly relied on by triers of fact in the courtroom (Howe et al., 2017). Therefore, the validity of these testimonies is of utmost importance. A factor that may influence the validity of statements is the level of alcohol and/or other drug intoxication. Eyewitnesses, victims, and suspects might be intoxicated during the criminal event or when giving a statement, or both (Evans et al., 2009). Intoxication during an event may lead to perceptions of reduced credibility in legal professionals (e.g., Kassin et al., 2001) and jurors (Evans and Schreiber Compo, 2010), thus reducing the likelihood of a conviction. Equally relevant, however, is the question whether intoxication might impact false memory creation and suggestibility in individuals involved in crime. It is imperative to understand how...
intoxication during the crime and/or during questioning may affect testimonial accuracy. To examine this, we will first present an outline of the prevalence of legal cases that involved substance intoxication in several selected countries with accessible data. The latter is important because it can show how large the problem of intoxicated witnesses, victims and suspects can be in legal cases. This will be followed by an explanation of key methods and theoretical accounts of false memory formation in general as well as linked to substance effects. We will end with a discussion on the effects of several commonly used drugs/drug classes on false memories and suggestibility.

### Table 1

| Country          | Source/Type of data                  | Who was intoxicated                                                                 | Findings/prevalence in %                                                                 | Reference                                      |
|------------------|--------------------------------------|--------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------|------------------------------------------------|
| Australia        | Professional case law database "LexisNexis" | Unknown                                                                             | 4.3 % of case reports involve alcohol/drug influence/intoxication                          | https://www.lexisnexis.com                     |
|                  | Drug use monitoring in Australia (DUMA) program - urinalysis | Police detainees                                                                   | 75 % positive for at least one drug type, 40 % for >1 drug type                          | Patterson et al., 2018                        |
|                  | Toxicology reports                   | "King hit" fatality victims                                                         | 79 % positive for substances (73 % alcohol, 15 % other drug)                              | Pilgrim, Gerostamoulos, & Drummer, 2014       |
|                  | Toxicology reports                   | Homicide victims                                                                    | 63 % positive for substances (42 % alcohol, 33 % illicit drug, 25 % multiple)             | Darke and Duflou, 2008                       |
|                  | Police records and state coronial records | Homicide victims                                                                     | 32 % alcohol, 26 % illicit drug use                                                       | Bryant & Bricknell, 2017                      |
|                  | Police log data                      | Unknown (police-attended incidents)                                                 | 23 % alcohol-related, 2% drug related, 1% alcohol and drugs                               | Palk, Davey, & Freeman, 2007                  |
|                  | Police survey data                   | Person interacting with police                                                      | 59 % of police officers report daily/more than weekly interactions                        | Monds et al., 2020                           |
| Indonesia        | National legal database              | Unknown                                                                              | 1.2 % of court rulings are drug related                                                  | https://putusan.mahkamahagung.go.id/          |
|                  | Police survey data                   | Person interacting with police                                                      | 24 % of police officers report daily/more than weekly interactions                        | Monds et al., 2020                           |
| Netherlands      | National legal database "De Rechtspraak" | Unknown                                                                            | 2.0 % of court cases with a verdict involve alcohol or drug influence                    | https://www.rechtspraak.nl/                   |
|                  | Violent offenders                    | Violent offenders                                                                    | 75 % intoxicated with alcohol and/or drugs                                                | CVV, 2011                                     |
|                  | Violent offenders                    | Violent offenders                                                                    | 37–78% intoxicated with alcohol                                                          | van Laar and van Gestel, 2018                 |
| England + Wales  | National legal database "BAILII"      | Unknown                                                                              | 2.4 % of case law rulings involve alcohol or drug intoxication                           | https://www.bailii.org/                       |
|                  | Crime Survey for England and Wales (CSW) | Police-recorded data                                                                  | 25 % alcohol, 10 % illicit drugs, 4% both                                               | Office for National Statistics, 2016; 2017    |
|                  | Violent offenders                    | Homicide victims                                                                     | 24 % alcohol, 3% illicit drugs, 7% both                                                   |                                                 |
|                  | Violent offenders                    | Offenders                                                                            | 40 % alcohol, 19 % drugs                                                                 |                                                 |
|                  | Police survey data                   | Witnesses                                                                            | 82 % of police officers say it is a common occurrence (alcohol)                          | Crosland et al., 2018                        |
| US               | Professional case law database "LexisNexis" | Unknown                                                                             | 2.1 % of case reports involve alcohol/drug influence/intoxication                          | https://www.lexisnexis.com                    |
|                  | Arrestee Drug Abuse Monitoring (ADAM) | Arrestees                                                                            | 63–83% drug positive across jurisdictions                                               | Hunt et al., 2014                            |
|                  | Police survey data                   | Victims/witnesses                                                                   | 73 % say it is common/very common                                                         | Evans et al., 2009                           |
|                  | Victim data                         | Suspects                                                                             | 83 % say it is common/very common                                                         |                                                 |
|                  | Archival court files (testimonies)   | Eyewitnesses                                                                         | 13 % intoxicated during crime with alcohol or other drug                                 | Palmer et al., 2013a,b                        |
|                  | Survey                               | Rape victims (college women)                                                        | 72 % alcohol-intoxicated during assault                                                   | Mohler-Kuo et al., 2004                       |
|                  | Survey                               | Violence victims (college students)                                                  | 63–74% consumed alcohol and/or other drugs                                                | Bureau of Justice Statistics, 2005            |
|                  | Review                               | Sexual assault victims/perpetrators                                                  | ~50 % of cases occur when either or both drank alcohol                                   | Abbey et al., 2014                           |
|                  | Toxicology reports                   | Sexual assault victims                                                               | 78 % positive for any substance (31 % alcohol, 66 % other drugs)                          | Fiorentin and Logan, 2019                     |
|                  | Toxicology reports                   | Homicide victims                                                                     | 59 % positive: 30 % alcohol, 28 % cocaine, 19 % cannabis, 11 % opiates                   | Tardiff et al., 2005                          |

Notes.

a Urine sample taken within 48 h of detention.

b Data includes victim toxicology reports but usually lacks toxicological confirmation for offenders.

c Suspected drug-facilitated sexual assault cases only.
2. Prevalence of legal cases involving alcohol and drug influence across countries

Before reviewing the literature of the effects of intoxication on false memory and suggestibility, we will first address the question of how often in legal or criminal cases it generally happens that one of the involved is intoxicated with alcohol or another substance. Hence, we will review the prevalence of intoxicated witnesses, victims, and suspects in several countries across the globe. The purpose of this is to help illustrate the importance and magnitude of this issue. Official national statistics on the number of cases where suspects, witnesses or victims were intoxicated with alcohol and other drugs at the time of the crime or at the time of their interview are not always available, since this information is not consistently assessed or documented in police files and reports (van Laar and van Gestel, 2018; Yuille and Tolstorup, 1990). Therefore, we will review a number of relevant findings collated from numerous sources in order to elucidate the problem from different angles and provide an overview of the prevalence with which legal cases and intoxication co-occur.

Although it is already well documented that alcohol use and crime are closely related (e.g., Martin, 2001), people frequently combine alcohol with other substances (e.g., Winstock et al., 2017) which makes it difficult to separate alcohol from other drug use. Hence, our review was aimed at identifying data on the prevalence of substance use (including alcohol and other drugs, alone or in combination) in crime. The search focus was on several Western countries and nations (Australia, the Netherlands, England and Wales, United States [US]) but also included Indonesia. This selection occurred for practical reasons, such as one of the authors being fluent in these countries’ native language, as well as data being readily accessible or available. First, databases containing legal case judgments per country (England and Wales: “British and Irish Legal Information Institute”, Australia and US: “LexisNexis” accessed through Nexis Uni, Netherlands: “Rechtspraak”, Indonesia: “Direktori Putusan”) were searched for official national statistics on court case decisions of offenses involving alcohol or drug influence (either by searching for categorized offenses or by keyword search). This was to identify an overall proportion of legal cases involving substance use. Additionally, governmental criminological resources monitoring crime and drug use were consulted.

Second, a literature search was performed in PsycINFO, using intoxication, witnesses, suspects and victims as keywords (intox* AND DE “Witnesses” OR DE “Suspects” OR DE “Victims”; search date March 24, 2020). This search was performed primarily as a guide rather than an exhaustive summary, and as a starting point to identify other relevant papers and findings. The selection criteria were that the study was published in English, and only journal articles and dissertations were included. This search resulted in 30 search hits, which led to identification of further 9 relevant articles. In order to illustrate the timely situation, we focused on recent references only (years 2000–2020). In contrast to the numbers obtained from governmental legal databases, information from these sources more often focused on a specific subset of cases (e.g., violent crime). Table 1 integrates results from both searches, presenting an overview of the described prevalence findings by country in alphabetical order. The detailed results from this review can be found in the Supplementary Online Materials (SOM).

2.1. Summary

The findings reviewed in this section stemmed from several resources, including official national statistics, governmental legal databases, police survey research, case file research, toxicology analysis, and victim surveys. Together, these findings demonstrate the frequent occurrence of intoxication within criminal cases. Legal cases or court rulings involving alcohol or other drug use were found to represent 1.2–4.3 % of all court cases. These numbers were based on national as well as commercial legal databases, including a wide range of cases. Limitations here are that we cannot draw any inferences on how precisely substance use played a role (e.g., who was intoxicated). However, they help provide a general estimate that seems consistent across countries (see Table 1 and SOM for details).

In contrast, the other resources reviewed more often focused on subsets of legal cases representing more serious types of crime (i.e., violent crime, homicide, sexual assault). In these violent crime cases, numbers for intoxicated potential perpetrators (i.e., suspects or people detained) were found to range from 25 to 78% for alcohol and from 10 to 83% for illicit drugs. For victims, numbers ranged from 24 to 72% for alcohol, and from 3 to 66% for other drugs. For eyewitnesses specifically, only one study gave a statistical finding that 13 % were intoxicated with alcohol or other drugs, but law enforcement officers reported that they were frequent. Thus, we conclude that incidence of alcohol and drug use in violent crime cases is much higher than the ~1.2-4.3 % of cases where substance use was involved.

The numbers reviewed vary of course substantially with the type of population surveyed and the type of crime in question. Another crucial reason for the varied results may be differences in methods of verifying substance use: while some of the reviewed resources were data from rather objective sources such as toxicological analysis, some relied on self-report (e.g., admissions from victims or suspects) or estimates (e.g., from victims or police staff). The latter two thus suffer from obvious drawbacks and actual numbers might be higher. Findings especially highlight the pervasive nature of alcohol across a range of criminal incidents, and that this substance is likely to be the most common substance used by witnesses, victims, and suspects. Other very commonly identified substances include cannabis (e.g., Fiorentin and Logan, 2019; Palmer et al., 2013a), as well as stimulants such as amphetamines and cocaine. This reflects general global trends of substance use which show that alcohol, cannabis, and stimulants are by far the most widespread substances (Winstock et al., 2017). However, in the context of crime, substance use occurs at an even higher prevalence compared to daily population use patterns, increasing the risk of violent incidents, whether through direct drug effects or through violence surrounding substance use (Darke and Duflo, 2008).

Taken together, non-trivial percentages exist for intoxicated witnesses, victims, and suspects. These prevalence numbers underscore the importance of amassing the evidence on whether intoxication puts them at risk to produce false memories.

3. False memories

When assessing drug effects on false memories in a laboratory setting several experimental paradigms have been applied. In general, the scientific literature distinguishes between two major types of false memories (Brainerd, 2013; Mazzoni, 2002): spontaneous and suggestion-induced false memories. When false memories arise without external suggestive influence or manipulation but are the result of endogenous mechanisms (e.g., spreading activation of items stored in memory, Roediger et al., 2001a) they are referred to as spontaneous false memories. Importantly, these are essentially memory errors due to normal associative and reconstructive memory processes (e.g., Gallo, 2010; Mazzoni, 2002). Spontaneous false memories are common in neurological and psychiatric conditions where they are often labeled confabulation (e.g., frontal lobe pathology, psychotic conditions, dissociative conditions; Kopelman, 1999), but are also a frequent occurrence in everyday life in healthy individuals (e.g., Schacter, 1999).

Spontaneous false memories are typically induced by using the Deese/Roediger-McDermott (DRM) paradigm, in which lists of associatively related words are presented during encoding (e.g., bed, dream, wake, rest, tired, etc.) with one prototypical exemplar of the word category (the critical lure: sleep) missing (Deese, 1959; Roediger and McDermott, 1995). When participants have to report which words they can still recollect, a significant proportion of subjects falsely recall or recognize the critical lure (Gallo, 2010). Some studies have also...
employed visual variants of these tasks, and sometimes included emotional top of neutral stimuli (e.g., Guarnieri et al., 2016; Moritz et al., 2006).

Three major theories can account for the occurrence of spontaneous false memories: Associative-Activation Theory (AAT; Otgaar et al., 2019), Activation/Monitoring Theory (AMT; Roediger et al., 2001), and Fuzzy-Trace Theory (FTT; Brainerd and Reyna, 2019). AAT is derived from spreading activation models and predicts the formation of false memories through spreading associative activation, where the processing of one word activates a corresponding node (i.e., concept) in one’s knowledge base that may spill over to neighboring related but non-presented nodes, leading to formation of false memories. For example, processing a word such as tired might activate related concept nodes, such as night, bed, or sleep, increasing the chance that they will be remembered even though not presented. Also belonging to the family of spreading activation models and noteworthy in this context is Activation/Monitoring Theory (AMT; Roediger et al., 2001b), which postulates that in addition to activation processes, monitoring (memory editing, e.g., deciding where the activated information originated) plays a role in DRM false memory too: while activation increases false memories, monitoring can reduce them (Gallo, 2019). Whereas AAT assumes that false memories are primarily evoked at encoding (Howe et al., 2009), AMT specifies that activation and monitoring processes occurring during both encoding and retrieval affect the probability of false memory in the DRM paradigm (Roediger et al., 2001b).

According to Fuzzy-Trace Theory (FTT), when experiencing an event, people process the surface information and the underlying meaning of an event, which they store as a separate verbatim (item-specific surface information) and gist (meaning-based information) memory traces. For example, in context of the DRM, verbatim refers to specific features of each word, such as word size or color, and gist to the theme of the list of words. Verbatim retrieval supports true memory as well as false memories of events that are consistent with the gist. Hence, false memories are thought to occur when people rely on the underlying meaning of an event, particularly when the verbatim trace has faded. In an eyewitness memory context, this can explain the occurrence of eyewitness misidentifications: verbatim information such as specific facial features fades quickly whereas gist information like age, race, gender, and body build remains (‘The attacker was a muscular teenage Caucasian male’; Brainerd and Reyna, 2019).

In addition to measuring acceptance of critical lures that share many strong associative relations with the studied lists, studies with the DRM also typically employ a measure of baseline false responding to new and unrelated words. Whereas false alarms for critical or related items are also typically employed a measure of baseline false responding to new andresponse bias (i.e., the general tendency to respond to items in a systematic but potentially false direction, such as a yes-bias, Wright et al., 2019). The term spontaneous false memory oftentimes pertains to false memories elicited in the DRM paradigm. In contrast, the response criterion that an individual adopts for their memory decisions under conditions of uncertainty can be influenced by factors such as the experimental instructions given or feedback from an experimenter (Rotello and Macmillan, 2007; Verde and Rotello, 2007). However, it has been critically noted that simply any false alarm on a recognition memory task is sometimes termed a false memory, despite that different cognitive mechanisms might underpin these false alarms (Pezdek and Lam, 2007).

Note that while the DRM paradigm is the chief method used in studies to induce spontaneous false memories, there are other methods to study naturally occurring false memories (e.g., Lindsay et al., 2004; see also Mazzoni, 2002). A particularly relevant example here comes from context-dependent false memories: While context reinstatement (explicitly matching environmental cues between encoding and retrieval) has been linked to improved memory retrieval (Smith and Vela, 2001) and is a commonly used interview technique to improve eyewitness memory (e.g., Geiselman et al., 1986), it can also lead to memory-undermining effects. When context reinstatement is employed (e.g., depicting the same visual scene at retrieval as at encoding) with different but perceptually similar lure objects as the ones presented in the study phase, this can distort memory and elevate the risk of false recollection (Doss et al., 2018c).

The formation of suggestion-induced false memory occurs due to external suggestive influence (coming from an outside source, e.g., a co-witness). Several methods exist to evoke suggestion-induced false memories with the misinformation and implantation method being perhaps the most studied and forensically relevant ones. In the misinformation paradigm, participants first witness an event, such as a staged crime, and are later exposed to erroneous information about the details of the event, such as the false detail that the perpetrator carried a gun (while in fact he did not have a weapon). In a later memory test, people often incorporate the suggestion and falsely report having seen the suggested detail (i.e., the gun). This phenomenon is called the misinformation effect (for a review see Loftus, 2005). Different studies have employed misinformation in various forms, most often consisting of narrative descriptions containing false statements. Such false memories are thought to arise in response to both internal (endogenous mechanisms, e.g., source confusion) and external (e.g., compliance) processes (Brainerd et al., 2008; Otgaar et al., 2012). Here, social factors play a major role in influencing the malleability of memory; for example, social interactions (whether containing misinformation or not) serve as a mechanism enabling the spread of a memory from one person to another, a process referred to as social contagion or memory conformity (e.g., Brown et al., 2011; Edelson et al., 2011).

Also important to mention in this context are measures of interrogative suggestibility, which has been defined as the extent to which an individual comes to accept information communicated during formal questioning within a closed social interaction (Gudjonsson, 1997). Most prominent here is the Gudjonsson Suggestibility Scale (GSS), which exposes participants to a narrative and, disguised as a memory test, measures how much they yield to suggestive questions and shift their responses under interrogative pressure from an examiner. Other suggestibility measures in the applied memory context have used misleading questions. Suggestibility and other suggestion-based measures, such as susceptibility to the misinformation effect, are terms that are often used interchangeably in the legal psychological context, even though they tend to be only weakly correlated (Bernstein et al., 2018). Other forms of suggestibility have been proposed, such as primary suggestibility (Eysenck and Furneaux, 1945), defined as the induction of thoughts or actions through suggestive procedures (e.g., imagination, see Carhart-Harris et al., 2015).

While false memories elicited in the misinformation paradigm focus on the formation of false memory for details, the implantation method (also called lost-in-the-mall technique) aims to plant entire autobiographical events that never occurred into a person’s memory (Loftus and Pickrell, 1995; Wade et al., 2002). Typically, participants in this paradigm receive narratives of supposedly experienced events and are encouraged to recall these events over the course of multiple interviewing sessions. A myriad of suggestive techniques such as guided imagination, the help of family members, social pressure, and the use of fake photographs have been employed in such experiments to convince participants of remembering events that, in reality, never happened. This suggestive manipulation causes an average of 30 % of participants to partially or fully falsely remember entire rich complex events, such as a flight in a hot air balloon (Loftus, 2002; Otgaar et al., 2012; Scoboria et al., 2017).

An influential account to explain suggestion-dependent false memories is the source monitoring framework (SMF; Johnson et al., 1993), which is concerned with how people discriminate between memories from different sources (e.g., internally vs. externally generated).
According to the SMF, false memories arise when information from one source is attributed to another (erroneous) source, which is then called source misattribution. For example, a witness might report details of a crime learned through discussion with a co-witness because they confuse the source of the information and attribute it to their own memory (Zaragoza and Lane, 1994). Memories from different sources are thought to differ in terms of perceptual characteristics (e.g., richness), and evaluation of these characteristics can help to distinguish between memories from different sources. According to the discrepancy detection principle, people are more prone to suggestive influences such as misinformation if their memory for the original event is poorer, as it becomes more difficult to distinguish truly encoded information from external, for example, suggested details (Schooler and Loftus, 1986; Tousignant et al., 1986).

The distinction of spontaneous, or naturally occurring, versus suggestion-induced false memories is not a mutually exclusive one, and in fact the boundaries are fuzzy and sometimes overlap (Mazzoni, 2002). Its function is to distinguish disparate research traditions as well as different underlying mechanisms of memory distortions; e.g., social psychological factors can play a prominent role in suggestion-based false memories, whereas basic cognitive processes are more likely to underlie spontaneous false memories. There are also some false memory paradigms that do not neatly fit into the dichotomy (e.g., boundary extension, Liu et al., 2016), or that blend elements from both (e.g., combining cognitive reconstructive mechanisms with misinformation to elicit memory errors, Dos et al., 2016).

For the current review, a critical question is whether susceptibility to spontaneous and suggestion-based false memories and suggestibility decreases or increases when suspects, eyewitnesses, or victims are under spontaneous and suggestion-based false memories and suggestibility (Doss et al., 2016). Memory performance is measured using retrieval, production, but also studies that were conducted using an eyewitness or perpetrator misinformation or suggestibility framework. Although these links might fuel new research enterprises in this field. Applying theoretical accounts of false memory production to what effects substances might have in this regard leads us to a number of predictions.

4. Intoxication effects on false memory and interrogative suggestibility

In the following sections, key findings from studies investigating effects of intoxication on false memory and suggestibility will be reviewed (see Table 2 for a summary). We included studies that made use of word list paradigms such as the DRM to assess false memory production, but also studies that were conducted using an eyewitness or perpetrator misinformation or suggestibility framework. Although studies that employed methods specifically designed to induce false memories were the primary focus of this review, some of the findings using these paradigms have also been demonstrated in other memory paradigms that did not necessarily focus on false memories. Thus, supportive data using non-false memory paradigms will be added where relevant. The sections are organized by substance or substance class, covering all those that have been, to our knowledge, investigated in this context, i.e., alcohol, cannabis, stimulants (amphetamine, MDMA), benzodiazepines, antipsychotics, and hallucinogens.

An important distinction in psychopharmacological research is between acute, residual, and persistent (long-term) effects of a drug. Accordingly, there are studies looking into either one, testing effects of an acutely administered substance during its duration of action, versus testing effects of a substance sometime after its immediate drug effects have subsided, or both. Similarly, there can be methodological differences among memory studies, as memory is thought of as operating in different stages. According to basic memory models the three necessary stages in the learning and memory process are encoding, storage, and retrieval (White, 2003). Encoding is defined as the initial acquisition of information; storage refers to maintaining information over time; retrieval is the ability to access information when needed, such as in a memory test. Effects of substances on memory can be tested at each of these stages. Memory performance is measured using recall (involving reproduction of information) or recognition tests (involving the selection of correct from incorrect information). Memory studies distinguish between true memory, i.e., memory of an event that truly occurred, which can be measured in terms of completeness and accuracy (Evans and Fisher, 2011; Koriat et al., 2000), and on the other hand false memory. This review will primarily focus on studies that specifically manipulated false memory and interrogative suggestibility, the two often being used interchangeably in the context of eyewitness memory and both of major relevance to the legal field (e.g., Evans et al., 2019). Although possibly of legal relevance, studies on other forms of suggestibility (e.g., primary) have been conducted outside of the applied memory context and are beyond the scope of this review; however, they will briefly be pointed out. Similarly, results on true memory have been covered elsewhere but will briefly be touched upon for each substance.

4.1. Linking false memory theories to substance classes

Before reviewing the false memory findings for each substance or substance class, in this section the aim is to link the previously mentioned false memory theories to substances and arrive at specific predictions as to how false memory might be affected. At the broadest level, drugs can be classified in terms of stimulants, depressants, and hallucinogens, corresponding to their respective effects on the central nervous system (CNS; e.g., Julien, 2013; Porath and Beirness, 2019). Stimulants (e.g., amphetamines, cocaine, caffeine) increase activity of the CNS, thereby invigorating mental and physical function, whereas depressants (e.g., alcohol, benzodiazepines, opioids, GHB) have the opposite effect, slowing down activity of the CNS and inducing effects ranging from increased relaxation to tiredness to coma. Hallucinogens encompass a wide range of substances that differ in and are classed by their pharmacological mechanism of action (e.g., serotonergic hallucinogens such as lysergic acid diethylamide (LSD), psilocybin, mescaline; N-methyl-D-aspartate (NMDA) antagonists, e.g., ketamine; anticholinergic agents, e.g., scopolamine, among others). They are characterized by their ability to elicit marked altered states of consciousness, including for example altered perception of self, time, space and one’s surroundings, plus eye-closed complex and vivid visual imagery (Nichols, 2004; Pallavicini et al., 2019). This is a simplistic classification and matters are more complicated as some substances fall into multiple categories; for example, MDMA is primarily a stimulant but has some hallucinogenic properties, whereas cannabinoids combine effects from all three categories.

In general, stimulants are thought to enhance cognition and memory processing whereas depressants are thought to interfere with it. Similarly, hallucinogens may interfere with cognition and produce memory loss (e.g., ketamine, Morgan and Curran, 2006). However, effects may be reversed, depending on the timing or, in other words, at which memory stage a drug is involved: to illustrate, alcohol as well as other pharmacologically similar sedatives (e.g., benzodiazepines) generally impair learning (encoding) but can facilitate memory for learned material if given after learning, a phenomenon known as retrograde facilitation (e.g., Fillmore et al., 2001; Reder et al., 2007; Wixted, 2004). Depending on memory stage and drug type, a substance might therefore facilitate or interfere with memory.

Because of the gamut of cognitive effects that certain drugs might have, it is challenging to come up with specific predictions on how each drug type might affect false memory creation and suggestibility. Nonetheless, our argument is that it is imperative to link existing false memory theories to drug effects on false memory and suggestibility as these links might fuel new research enterprises in this field. Applying theoretical accounts of false memory production to what effects substances might have in this regard leads us to a number of predictions. According to Associative-Activation Theory, Activation/Monitoring Theory, and Fuzzy-Trace-Theory, associative activation and gist processing, respectively, support false memory. Drugs that impair encoding (i.e., produce amnesia) might reduce or prevent these mechanisms.
Table 2
Summary of reviewed false memory and suggestibility studies organized by substance.

| Sample size + design | Dose | Paradigm | Memory stage affected/ tested | Primary finding regarding false memory/ suggestibility | Effect size<sup>a</sup> | Reference |
|----------------------|------|----------|-------------------------------|-------------------------------------------------------|------------------------|------------|
| Alcohol (depressant) | N = 32, between-subjects | 0.6 g/kg DRM (implicit + explicit recall) | Alcohol/placebo at encoding, retrieval sober | Reduced false memory rates for once presented lists (false explicit recall); no effect on implicit false memory | N = 32. – 0.10 (medium) | Garfinkel et al., 2006 |
|                      | N = 20, within-subjects | 0.26 – 0.28 g/kg DRM (recall and recognition) | Alcohol/placebo at encoding + retrieval | No effect | – | Milani and Carrau, 2000 |
|                      | N = 18, within-subjects | 0.27 and 0.60 g/kg DRM (recognition) | Alcohol/placebo at encoding + retrieval | No effect | – | Mintzer and Griffiths, 2001b |
|                      | N = 83, between-subjects | mBAC 0.065% Misinformation (presented via written narrative) | Encoding + retrieval while sober, alcohol/reverse placebo/control after encoding but before misinformation | Alcohol protected against misinformation (retrograde facilitation) | N = 32. + 0.12 (medium-large) | Gavrylovicz et al., 2017 |
|                      | N = 51, between-subjects | high: 1.32 mL/kg, medium: 0.6 mL/kg, low: 1.32 mL/kg, placebo (using 95% alcohol) Gudjonsson Suggestibility Scales | Encoding + immediate recall while sober, alcohol/placebo before suggestive pressure and delayed recall | Alcohol decreased yielding to leading questions (potential retrograde facilitation) but had no effect on shifting responses after pressure | unknown | Sanstila et al., 1999 |
|                      | N = 93, between-subjects | mL BAC 0.07% Misinformation (presented via experimenter phone call) | Alcohol/placebo/control at encoding + retrieval | No effect | – | Schreiber Compo et al., 2012 |
|                      | N = 210, between-subjects | BrAC 0.06 – 0.08% Misinformation (pre-circled answers by alleged co-witness) | Immediate: alcohol/placebo/control at encoding + retrieval Delayed: 3 × 3 counterbalanced conditions | Alcohol increased suggestibility in the delayed but not immediate condition; alcohol at encoding but not retrieval heightened suggestibility | N = 32. + 0.13 (medium-large) | Evans et al., 2019 |
|                      | N = 80, between-subjects | mL BAC 0.06% Misinformation (narrative by alleged previous participant) | Alcohol/sobriety at encoding (counterbalanced with expectancy), misinformation + retrieval sober | No effect | – | Flowe et al., 2019 |
|                      | N = 67, between-subjects | mL BAC 0.01 – 0.16% Suggestive questioning | Alcohol (high/moderate/low) at encoding + immediate retrieval, delayed sober retrieval | High intoxication levels increased suggestibility at immediate and delayed retrieval | N = 32. + 0.12 (medium-large) | van Oorsouw et al., 2015 |
|                      | n = 86 + n = 189, continuous design | BAC 0.00 – 0.16%, and BAC 0.00 – 0.20% Misinformation (false alternative, leading, + affirmative questions) | Alcohol at encoding + immediate retrieval, delayed sober retrieval | Misinformation acceptance increased with rising intoxication levels but mixed findings regarding time of testing | unknown | van Oorsouw et al., 2019 |
| THC (depressant/ stimulant/ hallucinogen) | n = 25, within-subjects | 0, 7.5, and 15 mg DRM (recognition) | THC at encoding, retrieval sober 48 h later | THC reduced false memory compared to dextroamphetamine but not placebo | N = 32. + 0.23 (large) | Ballard et al., 2012 |
|                      | N = 23, within-subjects | 0 and 15 mg DRM (recognition) | Encoding sober, THC at retrieval 48 h later | THC increased false memory compared to placebo | N = 32. + 0.36 (large) | Doss et al., 2018b |
|                      | N = 156, between-subjects | self-determined (field study) DRM (recognition) | Intoxicated/sobriety/control at encoding + retrieval | Higher false memory for unrelated but not critical lures in intoxicated and sober cannabis users, compared to controls | N = 32. + 0.11 (medium-large) | Kloft et al., 2019 |
|                      | N = 32, between-subjects | – DRM (modified; recognition) | Not applicable | Higher false memory rates in abstinent heavy users compared to controls | N = 32. + 0.79 (medium-large) | Riha et al., 2015 |
|                      | N = 64, within-subjects | 300 μg THC/kg DRM (recognition) | THC at encoding + immediate retrieval, delayed retrieval sober | Immediate: THC increased false memory (related + unrelated); Delayed: THC increased | N = 32. + 0.58 + 1.0; – 0.38 + 0.27 (medium-large, small) | Kloft et al., 2020 |

<sup>a</sup> Effect size: N = 32. = 0.58 (large), N = 32. = 0.79 (medium-large).
### Table 2 (continued)

| Sample size + design | Dose | Paradigm | Memory stage affected/ tested | Primary finding regarding false memory/ suggestibility | Effect size<sup>a</sup> | Reference |
|----------------------|------|----------|-------------------------------|-------------------------------------------------------|---------------------|-----------|
| N = 64, between-subjects | Misinformation (2 virtual reality scenarios, suggestive co-witness + suggestive questioning) | 0 and 15 mg | Context reinstatement mnemonic similarity task (MS-Dox, recognition) | THC at encoding, retrieval sober 48 h later | THC increased context-based false memories when item and context were semantically congruent | d = 1.34 (large) |
| N = 24, within-subjects | | | | | | |

**Stimulants**

| N = 25, within-subjects | 0, 10, and 20 mg dextroamphetamine (AMP) | DRM (recognition) | AMP at encoding, retrieval sober 48 h later | AMP increased false memory compared to THC but not placebo | $\eta^2_p = 0.23$ (large) | Ballard et al., 2012 |
|--------------------------|--------------------------------|------------------|--------------------------------|-------------------------------------------------|-----------------|-----------|
| N = 64, within-subjects | | DRM (recognition) | MDMA at encoding + immediate retrieval, delayed retrieval sober | Immediate: MDMA increased false memory (related lures only); Delayed: MDMA decreased critical lure false memory; Immediate: No effect; Delayed: reduced suggestion-based false memory in eyewitness condition | $d = 0.77$ (medium - large) | |
| N = 64, between-subjects | Misinformation (2 virtual reality scenarios, suggestive co-witness + suggestive questioning) | 0 and 75 mg MDMA | | | | Kloth et al., submitted |

**Benzodiazepines/ anticholinergics (depressants)**

| N = 36, between-subjects | diazepam 0.3 mg/kg or lorazepam 0.038 mg/kg | DRM (recognition) | Diazepam/lorazepam/placebo at encoding + retrieval | Benzodiazepines had no effect on false memory of critical lures but lorazepam elevated false memory of unrelated lures | unknown | Huron et al., 2001 |
|--------------------------|--------------------------------|------------------|--------------------------------|-----------------------------------------------------------------|-----------------|-----------|
| N = 24, within-subjects | 0.125 and 0.25 mg/70 kg | DRM (recognition) | Triazolam (high/low)/placebo at encoding + retrieval | Triazolam produced dose-related decreases in false memory of critical lures, but increased false memory of unrelated lures | unknown | Mintzer and Griffiths, 2000 |
| n = 18 + n = 18 | 0.25 mg/70 kg triazolam | DRM (recognition) | Triazolam/placebo at encoding + retrieval | Repeated lists increased false memory for triazolam but decreased for placebo; shorter lists reduced false memory in both conditions | unknown | Mintzer and Griffiths, 2001c |
| N = 24, within-subjects | 0.3 and 0.6 mg/70 kg scopolamine | DRM (recognition) | Scopolamine (high/low)/placebo at encoding + retrieval | Scopolamine produced dose-related reductions in false memory (critical lures) | unknown | Mintzer and Griffiths, 2001a |

**Antipsychotics**

| N = 24, between-subjects | 400 mg sulpiride | DRM (verbal + visual stimuli, recognition) | Sulpiride/placebo at encoding + retrieval | Sulpiride increased false memory of related and unrelated lures in the verbal DRM, and of unrelated lures in the visual DRM | $\eta^2_p = 0.16$ (medium - large) | Guarnieri et al., 2016 |
|--------------------------|----------------|-------------------|--------------------------------|-------------------------------------------------|-----------------|-----------|
| N = 24, between-subjects | 4 mg haloperidol | DRM (visual, recognition) | Haloperidol/placebo at encoding + retrieval | Haloperidol increased false memory of related lures | $\eta^2 = 0.38^p$ (large) | Guarnieri et al., 2017 |

**Notes.**

<sup>a</sup> Original effect sizes included from articles where possible. Interpretation based on Lenhard and Lenhard (2016).
through reduced processing of to-be-encoded materials, resulting in reduced associative or gist-based false memory, whereas drugs that facilitate learning of new information might fuel false memory by enhancing associative activation and gist processing. However, it could also be argued that the reverse might be true, with cognition enhancers supporting verbatim encoding or successful monitoring, thus facilitating enhancing associative activation and gist processing. However, it could reduced associative or gist-based false memory, whereas drugs that leave us less susceptible to external suggestion due to improved ability original memory is poor, which it could be due to an amnesia-producing -ories from experiences that were only dreamed or imagined. In terms of memory might be affected.

Based on the source monitoring framework, we use internal cues such as sensory or contextual details to help distinguish genuine memories from experiences that were only dreamed or imagined. In terms of suggestion-induced false memory and suggestibility, it could be the case that due to a poorer original memory from an amnesia-producing drug at encoding, people would be more lenient in the internal criteria they use to judge a memory’s genuineness (Nash and Takarangi, 2011). That is, a weaker original memory might make it harder to rule out a suggestion as incorrect, therefore more likely incorporate a suggestion into their own memory to fill in the blanks. This is also consistent with the discrepancy detection principle, dictating that detecting discrepancies between suggestions and one’s original memory becomes harder if the original memory is poor, which it could be due to an amnesia-producing drug (e.g., alcohol). Following this reasoning, we could predict that drugs that enhance true memory ability (e.g., amphetamines) might leave us less susceptible to external suggestion due to improved ability to correctly identify discrepancies and avoid source misattributions. More substance-specific theories (i.e., regarding alcohol) are added in the next section.

4.2. Depressants

4.2.1. Alcohol

Alcohol (ethanol) is the substance that has been investigated the most in terms of its influence on (false) memory and suggestibility. It facilitates activity at the GABA \(_A\) receptor, therefore acting sedatively, but can also induce initial stimulatory effects (Doss et al., 2018d; Hendler et al., 2013). Alcohol can produce partial (fragmentary) or full (en bloc) memory loss for new events (i.e., blackouts or alcohol-induced anterograde amnesia) owing to its disruptive effect of the brain’s episodic memory network (i.e., fronto-hippocampal functioning, White, 2003). The general conclusion based on several studies and a recent meta-analysis from the applied memory context is that while alcohol consumption prior to the encoding of an event decreases the completeness of memory accounts when questioned immediately or after a sobering delay (i.e., fewer details recalled, moderate effect size \(g = 0.40\), it does not appear to reduce accuracy or increase error rates (Altman et al., 2018c; Crossland et al., 2016; Flowe et al., 2020, 2016; Jores et al., 2019; van Oorsouw and Merckelbach, 2012). The effect was moderated by intoxication level, with highly intoxicated witnesses providing the least complete testimonies. Intoxicated witnesses have thus been designated as “better than their reputation” (Schreiber Compo et al., 2012, p. 77). Some evidence, however, suggests that under certain conditions, accuracy can also be negatively affected, but these conditions remain to be specified (see Altman et al., 2018d).

To explain variations in how alcohol sometimes affects memory in individuals, three proposed mechanisms have been employed in the applied memory context: State Dependent Retrieval, Alcohol Myopia, and Alcohol Hypervigilance. Briefly, State-Dependent Retrieval occurs if a person attempting to retrieve a memory is more accurate in a similar state as when they encoded that information (i.e., intoxicated at both time points) relative to if the person is not in the same state. However, the usually observed benefits of state-dependent retrieval do not seem to apply to intoxicated states, as memory has been shown to be most impaired when both encoding and retrieval take place when intoxicated and tested separately (e.g., see Schreiber Compo et al., 2017; Söderlund et al., 2005; Weissenborn and Duka, 2000). Alcohol Myopia Theory proposes that alcohol restricts the range of cues to which a person can attend while intoxicated and thus may only report salient/central items (Steele & Josephs, 1990). The previously described meta-analysis found evidence for alcohol myopia, with intoxication during encoding being detrimental to the recall of peripheral but not central details (Jores et al., 2019; however, Oorsouw et al., 2019 only found limited support). Alcohol hypervigilance suggests that people who are aware or expect that they have consumed alcohol may be expecting impairment and this can affect their performance over and above any actual alcohol effects (e.g., Evans et al., 2017), highlighting the importance of placebo-controlled studies. For example, Schreiber Compo et al. (2011) found more conservative reporting behavior in participants who received placebo compared to an alcoholic beverage. Taken together, these accounts can explain how some memory studies report no impairment during alcohol intoxication, while others report reduced completeness or increased errors.

In terms of DRM false memories, in one study participants received alcohol or placebo and encoded DRM lists (once vs. three times), followed by a sober test of both explicit (free recall) and implicit (stem completion task and post-hoc awareness measures) false memory 24 h later (Garfinkel et al., 2006). Alcohol appeared to decrease associative activation leading to a reduction in both true recall and false recall of critical lures for lists presented once, but no statistical differences for repeated lists and implicit false memory were found (\(N = 32\), between-subjects). In particular, it appears that increased learning with repetition, which increases the rejection of false memories under placebo, is reversed under alcohol leading to a decrease in rejection of critical lures. Furthermore, in a study by Milani and Curran (2000) a low dose of alcohol (0.26–0.28 g/kg) before encoding with retrieval shortly after exerted no effect on true and false recall or recognition rates of critical lures, but increased recollective experience of false recognition responses (increased level of remember vs. know judgments; \(N = 20\), within-subjects; however, for recent evidence that alcohol impairs both recollection and familiarity of episodic memory see Doss et al., 2018d). Finally, in Mintzer and Griffiths (2001a) it was found that neither a low or a moderate alcohol dose (0.27 and 0.60 g/kg, before encoding with retrieval shortly after) affected false recognition of critical lures (\(N = 18\), within-subjects), although the high alcohol dose did reduce true recognition and induced a more conservative response bias. A more conservative response bias during acute alcohol intoxication has also been observed in other episodic memory tasks (see Mintzer, 2007).

In the two latter studies, both encoding and retrieval took place while intoxicated. Thus, these seemingly contradictory findings might stem from methodological differences in terms of the memory stage affected by alcohol, and since encoding and retrieval phases can be differentially affected by drugs that regularly impair true memory function, it is complicated to interpret findings from studies where these phases have not been separately tested (see also section on cannabis). Alternatively, it is possible that a substantial delay is needed in order to reveal the drastic effect of alcohol on both true and false memory, given that alcohol-induced memory impairments are not always detected when immediately tested (Carlyle et al., 2017) – a phenomenon that is also apparent in more applied studies as will be described in the following paragraphs.

With regard to misinformation/suggestibility studies, in one study, participants (\(N = 83\), between-subjects) watched a crime film while...
sober, and then afterwards received alcohol, reverse placebo (received alcohol but were told it was non-alcoholic)\(^1\), or control (told no alcohol and received no alcohol), before they were exposed to misinformation about the film (alcohol present during encoding of misinformation). The following day they completed a cued-recall test (sober). It was found that control participants were more likely to report misinformation compared to the alcohol and reverse placebo groups, showing that alcohol consumption after a criminal event can protect memory from misinformation, thus providing evidence that alcohol-induced retrograde facilitation can also be detected in a more applied paradigm (Gawrylowicz et al., 2017). The fact that both groups who had alcohol were less suggestible indicates that the facilitating memory effect was more likely due to pharmacological effects of alcohol, rather than due to alcohol-related beliefs. A study by Santtila et al. (1999) had previously found similar effects using the Gudjonsson Suggestibility Scales (\(N = 51\), between-groups; alcohol conditions: high, medium, low, control). These studies are of forensic relevance, showing that alcohol can at times have beneficial effects on eyewitness memory by protecting against misleading post-event information.

In another lab study (Schreiber Compo et al., 2012), participants were assigned to an intoxication condition (dosed up to 0.08 g/210 l, or Breath Alcohol Concentration (BrAC) of 0.08 % vs placebo vs control, \(N = 93\), between-subjects), after receiving their drink were exposed to a staged theft, received misinformation shortly after, and finally were interviewed about the crime. Intoxication was thus present during encoding of the event, the misinformation, and its retrieval, and had no impact on susceptibility to misinformation. However, both intoxicated and placebo participants had higher false recall rates for cued open-ended questions than controls (misinformation and control items combined). Importantly, as it is not always possible for police to immediately interview a witness after they have experienced the event, studies investigating the role of a delay on suggestibility are also necessary. To this end, in another study by this group (Evans et al., 2019), participants were assigned to the same intoxication conditions as above, but a further condition was included whereby some participants recalled the event immediately after encoding (while necessarily still in the same intoxication state as encoding), and others recalling after a delay of one week (at which point they were randomly assigned to be intoxicated, in a placebo group, or sober; intoxication state at encoding and retrieval were fully crossed in the delayed condition, BrAC 0.06–0.08%, \(N = 210\)). In this study, participants watched a film and misinformation was introduced via a forced-choice retrieval test with answers already circled (half were correct, half were incorrect), supposedly by a previous participant. It was found that although again following immediate recall there were no intoxication condition effects, intoxication was significantly related to increased suggestibility (acceptance of incorrect suggested answers) and decreased accuracy (correct responses divided by the total number of responses) a week later. Specifically, it was intoxication during encoding, combined with a delay before the first retrieval attempt that made participants less accurate and more likely to accept false suggested answers, while intoxication state at retrieval was unrelated to memory performance (see Schreiber Compo et al., 2017 for true memory results). This study provides important information about the timing of police interviews, particularly as in many jurisdictions the current recommendation is to avoid interviewing currently intoxicated people and await the ‘sobering-up’ of the witness prior to interview.

In Flow et al. (2015) being questioned after a delay was also found to increase susceptibility to misinformation (recall and recognition), but this did not vary with having had alcohol during the encoding of a hypothetical rape case scenario (\(N = 80\), between-subjects, mbAC = 0.06 %, alcohol vs. sober with alcohol expectancy controlled). Here, misinformation was given after a delay in form of a post-event narrative of part of the scenario by an alleged past participant, but separately from retrieval. However, alcohol expectancy interacted with actual alcohol condition, with a mismatch in expectancy and beverage associated with higher levels of confabulations (i.e., recalling details that were not in the actual scenario) in an interview. Although adding extra details could stem from the experimental instructions asking participants to imagine themselves in the scenario, a higher tendency to confabulate when having had alcohol without knowing so might be forensically relevant. As for true memory, alcohol during encoding was related to reduced completeness of accounts.

One common criticism of lab-based studies on intoxication and memory relate to the fact that, for ethical reasons, most lab studies only include participants who have blood alcohol concentrations around the legal driving limit (BAC 0.05–0.08 %), but in real-life crime scenarios, higher intoxication levels are likely. So, several field studies have been conducted to combat this limitation and have recruited participants at elevated BAC levels. For example, in a field study by van Oorsouw et al. (2015), bar patrons (with blood alcohol concentrations ranging from 0.01–0.16) were instructed to commit a mock crime and then were immediately given a memory test that included misleading questions in a procedure akin to the Gudjonsson Suggestibility Scale. Memory was tested again 3–5 days later and it was found that severely intoxicated participants (BAC > 0.11 %) displayed a greater tendency to go along with the suggestive cues compared with sober participants at both time points (\(N = 67\), between-subjects). A drawback of this study is that the same memory tests were repeated at delayed test and therefore testing effects (i.e., retrieval practice, the improvement of long-term memory after retrieval, Roediger and Butler, 2011) might have played a role, although the authors argued that the findings cannot be explained solely based on practice effects.

In line with this, it has been demonstrated across two recent field studies (\(n = 86\), BAC 0.00–0.16%, and \(n = 189\), BAC 0.00–0.20%, mixed design with alcohol as continuous predictor) that overall, intoxication increased the acceptance of misinformation in response to suggestive questions (misinformation in the form of a combination of false alternative, affirmative, and leading questions) about a staged interaction (Oorsouw et al., 2019). The misinformation effects were mediated by memory completeness, supporting the discrepancy detection principle. Findings regarding whether effects on misinformation acceptance were more detrimental at immediate intoxicated testing versus delayed sober testing were inconsistent; however, immediate intoxicated testing was superior to a delayed-only (sober) test. This study also evaluated the effects of repeated testing and found that only previously sober participants benefited from this, whereas previously severely intoxicated participants showed a reduction in peripheral memory accuracy (i.e., fabrication of new details or modifying details).

Overall, it is clear from the available research that it is important to study the dose–response effect of alcohol on memory. Most lab studies indicate no increased risk of false reporting when intoxicated and tested immediately (Evans et al., 2019; Milani and Curran, 2000; Mintzer and Grifiths, 2001b; Schreiber Compo et al., 2012), although at higher levels of intoxication this risk may increase (Oorsouw et al., 2019; van Oorsouw et al., 2015). However, when witnesses were intoxicated during an event and questioned after a substantial delay, they may become more vulnerable to suggestibility (Evans et al., 2019). DRM false memory, despite scarcity of rigorous studies, findings point in the same direction, in that a delay is necessary to reveal more impairment. These results from both basic and applied memory literature suggest that alcohol affects encoding more drastically than retrieval, but some non-false memory studies also detected retrieval impairments under some conditions (e.g., during the ascending limb of the BAC curve, Söderlund et al., 2005) or that memory was most impaired when both encoding and retrieval occurred when alcohol was given during both

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\(^1\) Many alcohol-memory studies control for alcohol expectancies by varying expectancy with intoxication condition, given that alcohol-outcome expectancies can influence different behaviors and cognitions (see e.g., Evans et al., 2019, or Jores et al., 2015, on the importance of this)
and GABA (Soderlund et al., 2005; Weissenborn and Duka, 2000). The literature on alcohol effects on encoding, retrieval, and their interaction thus contains gaps and inconsistencies (e.g., Mintzer, 2007; Weissenborn and Duka, 2000) and additional research is required to further explore these promising findings.

### 4.2.2. Benzodiazepines

Benzodiazepines (e.g., Valium), like alcohol, are CNS depressants and GABA_A positive allosteric modulators, and have been widely documented to produce transient anterograde amnesia, i.e., impairing encoding but not retrieval processes (Curran, 1991; Huron et al., 2001; Taylor and Tinklenberg, 1987). With regard to false memory, a handful of studies have been conducted on the effects of different benzodiazepines using the DRM procedure, producing mixed findings. In a placebo-controlled study by Huron et al. (2001), lorazepam and diazepam administered before encoding with retrieval shortly after both impaired true recognition but had no effects on false recognition of critical lures in healthy volunteers (n = 12 per group, between-subjects). However, lorazepam elevated false alarm rates of unrelated words. In contrast, across two studies encompassing three experiments, Minster and Griffiths (2000, 2001) found that the benzodiazepine hypnotic triazolam (at encoding, retrieval shortly after) produced dose-related decreases in both true recognition and false recognition of critical lures, despite producing increases in false recognition of unrelated words (N = 24, and N = 36, respectively, within-subjects).

Moreover, similar to results with alcohol by Garfinkel et al. (2006), studying lists twice versus once increased false recognition of critical lures in the triazolam condition, whereas it decreased false recognition in the placebo condition. These results were interpreted in light of Fuzzy-Trace Theory: whereas placebo participants benefited from repeated list presentation and were better able to discriminate between targets and lures, resulting in betterverbatim (i.e., item-specific) memory, the opposite happened with triazolam, where intoxicated participants’ verbatim processing seemed impaired, leading them to rely on gist-based memory. However, the findings from once-presented lists, indicate that normal memory functioning in the sense of semantic or gist extraction is impaired by triazolam. This is also in line with other studies reporting more global memory deficits of benzodiazepines and other GABA_A positive allosteric modulators (Doss et al., 2018d; Kamboj and Curran, 2006), and generally poor memory could also account for the increase in false alarms to unrelated lures that was detected with two of the tested benzodiazepines, as guessing might be increased. Triazolam also increased intrusions and false alarms in an episodic but non-verbatim memory study (Mintzer and Griffiths, 2003b). It is interesting that despite their similar pharmacological effects, benzodiazepines seem to produce different memory patterns from alcohol: for instance, whereas the evidence thus far points to non-specific increases in false alarms under benzodiazepine influence, indicating more liberal responding, alcohol as well as alcohol placebo has often been found to increase conservative responding in memory tasks (Mintzer, 2007; Schreiber Compo et al., 2012). It has been put forward that benzodiazepines might be more sedative than alcohol and thus participants may also be less aware of the degree of drug effects (Mintzer and Griffiths, 2002; Roache et al., 1993). In contrast, conservative responding during alcohol and its placebo point to the importance of drug expectancies and compensating behaviors (Palmer et al., 2013b), that might perhaps be more successful the more one is familiar with the substance in question, given that alcohol is usually what participants are most familiar with (Monds et al., 2020). In all of these studies, however, memory was tested shortly after encoding, so that intoxication was present during both encoding and retrieval and effects are not separable (however see Pernot-Marino et al., 2004 for a study on lorazepam on retrieval of autobiographical memories).

### 4.3. Cannabinoids

#### 4.3.1. Δ-9-Tetrahydrocannabinol

Cannabis can be classified as a depressant, hallucinogen, or stimulant. Its main psychoactive constituent Δ-9-Tetrahydrocannabinol (THC) is a cannabinoid receptor agonist and well known for its memory-impairing effects (for a recent review see Brody et al., 2016). However, the role of cannabis in relation to false memory production and suggestibility is less well elucidated. A handful of studies have investigated the link between DRM false memory and cannabis use. Ballard et al. (2012) administered THC (0.75, and 15 mg) shortly before participants (n = 25, within-subjects) encoded DRM lists, whereas retrieval of the lists took place 48 h later under sober conditions. Both true and false memory (the latter defined as false recognition of critical lures) were found to be statistically significantly reduced, but only when compared to a dextroamphetamine condition (a memory-enhancing drug, separate study thus between-subjects) and not the placebo condition. The inverse of this study design was employed by Doss et al. (2018a), who had participants (n = 23, within-subjects) study DRM lists while sober and administered THC (15 mg capsule) 48 h later at retrieval. They found no statistically significant difference for correct recognition, but false alarms for both critical and unrelated lures were significantly increased compared to a placebo condition, indicating a cannabis-induced response bias. When hits and critical false alarms were adjusted for response bias, placebo participants outperformed intoxicated participants on true recognition, but adjusted false alarms did not differ between conditions. The fact that false alarms were also elevated in an emotional memory task, made with high confidence and increased subjective judgments of recollection, made the authors speculate that response bias alone does not account for the observed effects but that actual memory effects were at play. Together, these studies showed that different memory stages (encoding and retrieval) might be differentially affected by THC, and that people might be more vulnerable for false memories when intoxicated during retrieval rather than encoding.

In a recent field study conducted in Dutch coffeeshops (Kloft et al., 2019), three groups were subjected to the DRM procedure: intoxicated cannabis users, sober cannabis, and a non-using control group recruited at other public locations (N = 156, between-subjects). No differences between groups with regard to true recognition or false memory for critical lures was detected; however, both groups of cannabis users showed elevated susceptibility to false alarms in response to new, semantically unrelated words. Although in this study retrieval took place shortly after encoding, it aligns well with findings by Doss et al. (2018), indicating that acute but also residual cannabis influence during retrieval elevates liberal responding. Using a modified DRM task version, Riba et al. (2015) also found increased susceptibility of abstinent but formerly heavy cannabis users to false memories in response to related lures, compared to healthy controls (n = 16 per group, between-subjects). Moreover, studies investigating acute effects of THC on word list tasks other than the DRM paradigm, with THC administered prior to encoding and retrieval shortly after, have detected an increase in intrusions (recalling non-presented items; e.g., Miller and Cornett, 1978; Miller et al., 1977; Pfeifferbaum et al., 1977) and false alarms (recognition of non-presented items; e.g., Hart et al., 2010; Iian et al., 2004) in frequent as well as non-frequent users. Together, the evidence shows that THC at retrieval, not encoding, increases response or ‘yes’-saying bias. The bias is most visible for unrelated items, thus is dependent on the presence of associations between stimuli and test items, and appears to be present not only with acute but also residual intoxication.

This interpretation of an association-dependent response bias was also supported by findings from a recent experimental study from our lab (Kloft et al., 2020). In a placebo-controlled study (N = 64, mixed design), cannabis was administered prior to encoding, with memory tested shortly thereafter while still intoxicated, and at a 1-week sober follow-up, using the DRM and misinformation paradigm. THC elevated the susceptibility to false memory in the DRM paradigm for related and
unrelated lures, but did not affect critical lures or true recognition. At sober retrieval one week later, false memory for unrelated lures was still increased, while it was reduced for critical lures and true recognition. In the misinformation tasks, cannabis-intoxicated participants were more susceptible to false alarms in response to suggestive and non-suggestive questions about a virtual reality eyewitness scenario and virtual reality perpetrator scenario. The main effects observed in this study can be assumed to stem from THC affecting retrieval, and were not detected at 1-week follow-up, which has important implications for interviewing contexts. A drawback of this study is that the follow-up tests included some items that had previously been tested on the first memory test, thus potential testing effects (e.g., source confusion from initial memory test) cannot be differentiated from actual false memory effects.

A recent study also investigated the effects of THC given prior to encoding on context-dependent false memories, testing retrieval when sober 48 h later (N = 24, within-subjects, Doss et al., 2020). They found reductions in true memory for perceptual details of the objects studied, and that under some conditions, THC increased the context-based memory illusion. Specifically, when context was reinstated (e.g., visual beach scene) and was semantically congruent with the item (e.g., beach ball), THC increased false recognition of similar lure items (i.e., different beach ball). The reverse was however true when item and context were not congruent, in which case THC abolished context-based false memories. THC did not affect false recognition of dissimilar lures here, indicating that the response bias observed when tested sober in Kloft et al. (2019, 2020) may perhaps be specific to verbal stimuli.

In sum, there is evidence that acute cannabis but also residual use can increase false memory proneness and suggestibility, which seems to be driven largely by THC at retrieval elevating response bias but also increasing the potential for false memories when an event was experienced while intoxicated. For general studies on cannabis and eyewitness memory see Vredeveldt et al. (2018); Pezdek et al. (2020) and Yuille et al. (1998).

4.4. Stimulants

Moderate doses of stimulant drugs are known to enhance memory encoding when present at the time of study (Ballard et al., 2015), but they may also fuel false memory formation in associative memory tasks such as the DRM. In the previously mentioned paper by Ballard et al. (2012), the stimulant dextroamphetamine when administered at encoding (n = 25, within-subjects) increased true recognition memory but also false memory for critical lures – although these effects were only apparent when compared to THC rather than a placebo condition. True and false memory in these analyses were corrected for response bias, and although analyses for how drug condition affected unrelated false alarms were not provided in the paper, it appears that dextroamphetamine at encoding numerically reduced response bias, while it did not consistently vary with THC (see Table 3 in Ballard et al., 2012). No other study has looked at effects of amphetamines or other classic stimulant drugs of abuse using a false memory task. However, in Ballard et al. (2014), dextroamphetamine administered at retrieval also increased false recall and recognition rates in a word and a picture memory task, compared to placebo (N = 31, within-subjects). The increase in false recognition was accompanied by an increase in confidence in participants’ responses, suggesting the presence of an actual memory illusion rather than a simple response bias. In addition, the world’s most widely consumed CNS stimulant caffeine also increased both true recall and false recall of critical lures relative to placebo in the DRM paradigm, when administered prior to encoding with retrieval tested shortly after (N = 37, between-subjects; Capek and Guenther, 2009). Taken together, these findings suggest that stimulants support both true and false memory, perhaps by supporting (healthy) associative activation or gist-based memory mechanisms.

3,4-methylenedioxyamphetamine (MDMA) is a derivative of amphetamine and a potent indirect monoaminergic agonist, producing both release and reuptake inhibition of serotonin (5-HT) and to a lesser extent of dopamine (Vollenweider et al., 1998). It acts as both a stimulant and a hallucinogenic drug. In contrast to more traditional amphetamines, MDMA produces acute memory impairment, seemingly affecting both encoding and retrieval (Doss et al., 2018b; Kuypers and Ramaekers, 2005), effects that seem to be mediated by its 5-HT2A agonism (van Wel et al., 2011). Doss et al. (2018b) administered MDMA (1 mg/kg) either before encoding, retrieval, or placebo at both instances (n = 20 per group, between-subjects), to test effects in an emotional episodic memory picture task. MDMA at encoding did not affect hits but decreased recollection accuracy, indicating reduced encoding of salient visual details. They also reported a trend for MDMA at retrieval but not encoding to increase false rates alarm rates, especially for positive material (n = 20 per group, between-subjects).

The only study that tested how MDMA affects false memory formation using tasks specifically designed to induce false memories used the same design and method as the one by Kloft et al. with cannabis, described above (2019). In this study (Kloft et al., submitted), MDMA reduced true recognition in the DRM, both when encoding and testing took place immediately during intoxication, as well as at 1-week sober follow-up. False memories for related lures, but not critical or unrelated lures, was increased by MDMA at the immediate test, providing some evidence of false memory susceptibility when MDMA affects retrieval. Similar to the authors’ results with THC, MDMA slightly decreased false recognition of critical lures at the delayed test, likely due to their high similarity to studied items. In the two misinformation tasks, MDMA did not reduce true memory or increase susceptibility to misinformation. Verbal memory tasks might be more sensitive to MDMA’s memory-impairing effects than applied tasks, but more research on MDMA and suggestibility is warranted.

4.5. Hallucinogens

Dissociative drugs constitute a subclass of hallucinogens that distort sensory perception and induce feelings of detachment from the environment and self. Examples include ketamine (NMDA antagonist) and salvinorin A (a κ-opioid receptor agonist derived from the plant salvia divinorum), which have been found to interfere with true memory performance when administered before encoding (MacLean et al., 2013; Morgan and Curran, 2006). Similarly, the dissociative anaesthetic and NMDA antagonist nitrous oxide, better known as laughing gas, has been found to cause anterograde amnesia and heightened imaginative suggestibility during acute intoxication (Dwyer et al., 1992; Whalley and Brooks, 2009). Moreover, a study with the dissociative dextromethorphan (NMDA antagonist) and psilocybin (psychoactive ingredient of ‘magic mushrooms/truffles’, serotonin 2A receptor or 5-HT2A agonist) indicated impairments of true memory (verbal recall) in response to both drugs (given before encoding and retrieval shortly after; Barrett et al., 2018). With the exception of the described substances, effects of hallucinogens on true memory ability as well as false memory and interrogative suggestibility are largely unexplored. However, several older studies as well as one recent study provide evidence that classic psychedelics (i.e., 5-HT2A agonists), including lysergic acid diethylamide (LSD), psilocybin, and mescaline may induce heightened states of suggestibility, using tests of primary suggestibility such as imaginative procedures (Carhart-Harris et al., 2015; Middlefell, 1967; Sjöberg and Hollister, 1965). It is worth noting that classic psychedelics but also MDMA have been observed to increase mental visual imagery or vividness of memory (e.g., Carhart-Harris et al., 2012, 2014; de Araujo et al., 2012). Mental imagery has been associated with enhanced false memory (e.g., Dobson and Markham, 1993; Hyman and Pentland, 1996; Roberts, 2002). Considering this together with the fact that psychedelic psychotherapy is currently experiencing a renaissance (e.g., Johnson et al., 2019), this gap in memory research is striking and both basic and applied studies on true and false memory are warranted.

Anticholinergic drugs (‘deliriants’) are muscarinic acetylcholine receptors.
receptor antagonists, which also fall under hallucinogens. The anticholinergic scopolamine seems to produce similar patterns of true memory impairment as benzodiazepines (Mintzer and Griffiths, 2003a). In Mintzer and Griffiths (2001a), scopolamine produced dose-related decreases in both DRM true and critical false alarm rates, but had no effect on unrelated words (N = 18, within-subjects). These results were interpreted as scopolamine impairing both verbatim and gist memory, but not elevating response bias.

### 4.6. Antipsychotics

Antipsychotics do not fall under any of the previous major drug classifications but rather constitute a class in itself. Although not drugs of abuse, their effect on false memory formation might contribute to understanding mechanisms behind drugs and false memory. They tend to produce profound sedation and disrupt cognitive function, including memory (Ramaekers, 1998). One placebo-controlled study (N = 24, between-subjects) investigated effects of sulpiride, a dopamine D2-receptor antagonist and atypical antipsychotic, on true and false memory in a verbal and a visual DRM task, using both emotional and neutral stimuli (Guarnieri et al., 2016). Sulpiride (400 mg) was administered prior to encoding with memory tested shortly after; Guarnieri et al., 2016. The substance did not affect true memory but increased false recognition of related lures in both tasks and also increased false recognition of unrelated lures on the verbal DRM task. However, increased false recognition was only found for emotionally charged items (positive and negative) and not neutral ones. Similar results were found in a study with a different antipsychotic and D2 antagonist – haloperidol (4 mg, N = 24, between-subjects, administration prior to encoding with memory tested shortly after; Guarnieri et al., 2017). True recognition was not affected by haloperidol but false recognition of related lures was increased, although in this study the DRM visual task only was employed, and the analyses did not distinguish between emotional and neutral content. These results suggest that a fully functional, D2-mediated, dopaminergic system is important to enable correct discrimination between truly experienced events from similar, but novel, ones (Guarnieri et al., 2019); an effect that seems to go beyond simple elevation of a response bias. It should be noted that acute low doses of D2 antagonists (e.g., as in Guarnieri et al., 2017) are assumed to preferably block presynaptic D2-autoreceptors, leading to an increase in phasic dopamine release [see also relevant work by Clo et al. (2019a, 2019b) on low-dose haloperidol and episodic memory and meta-cognition in non-false memory tasks].

### 5. Discussion

The reviewed studies indicate that in general, psychoactive drugs may influence false memory formation and suggestibility, but these effects vary with the studied substance and depend on which memory stage is in focus. The best-studied substances appear to be alcohol and cannabis, which seems promising because they are also the most widespread on a global scale (e.g., United Nations Office on Drugs and Crime, 2018). Using multiple false memory and suggestibility paradigms, the reviewed studies demonstrated that under certain circumstances, both alcohol and cannabis can impact the susceptibility to spontaneous and suggestion-based false memory or suggestibility, often exerting effects of medium or large size (see Table 2 for an overview). An important caveat here however is that often substances, especially cannabis, were also found to elevate response bias, which can result in inflated false memory rates, even though memory processes might not underlie these effects. For alcohol, moderate levels of intoxication during an event were not associated with increased spontaneous and suggestion-based false memory or suggestibility during an immediate memory test, but suggestibility was increased at higher levels (studies by van Oorsouw et al., 2015, 2019) and sometimes after a delay (Evans et al., 2019). In contrast, cannabis was most detrimental when memory was tested under intoxicated conditions, with cannabis during retrieval robustly increasing response bias (yes-saying, Doss et al., 2018c; Kloft et al., 2019, 2020). However, the evidence reviewed here on how specifically different substances affect false memory is characterized by substantial inconsistencies. This is most certainly due to the fact that in the vast majority of reviewed studies, participants were intoxicated during both encoding and retrieval, whereas some studies that separated these memory phases have shown that they might be differentially affected. Given that individuals involved in crime can be intoxicated either during the encoding of an event (e.g., witnessing a crime), retrieval (being questioned about the event), or both, the importance of studies investigating all of these possibilities is highlighted.

As for the theories introduced in this paper to account for false memory production, there is evidence that particularly the discrepancy-detection principle can help explain vulnerability to suggestion in response to alcohol (Evans et al., 2019; Oorsouw et al., 2019). A poorer memory for an event experienced while alcohol-intoxicated, combined with a delay before questioning, elicits difficulties in detecting discrepancies between one’s memory and suggested information, making an individual more vulnerable to yield to suggestive cues. Apart from this, the presented studies do sometimes refer to but have not always explicitly tested these theoretical accounts (e.g., Ballard et al., 2012; Guarnieri et al., 2016; Kloft et al., 2019).

Interestingly, while cannabis and alcohol’s effects were found to differ in terms of suggestion-based false memory/suggestibility, effects on DRM false memories were more comparable: in those studies where encoding took place while intoxicated but retrieval was sober, both alcohol and cannabis resulted in reduced false memory rates for critical lures (Ballard et al., 2012; Garfinkel et al., 2006; Kloft et al., 2020). This is in line with our prediction that amnesia-producing drugs might indirectly reduce associative activation or gist extraction during encoding, resulting in reduced associative/gist false memory later, thus providing partial support for AAT and FTT. An important point here is that alcohol appears to have no effect on automatic semantic activation (measured via a semantic priming task, Ray et al., 2004), and cannabis enhances semantic activation and fluency (Morgan et al., 2010; Schafer et al., 2012), thus perhaps leaving associative activation mechanisms intact (or even over-activated in case of cannabis). However, encoding of individual words is impaired by these substances and therefore also the conscious encoding of words they activate. In this respect it is also noteworthy that while alcohol has been observed as inducing a conservative response bias (Mintzer, 2007; Mintzer and Griffiths, 2001b), both acute and residual cannabis use has been linked to liberal responding perhaps stemming from loosened or irrelevant associations (Kloft et al., 2019, 2020; Riba et al., 2015). The fact that cannabis during retrieval induced the highest rates of false memories is difficult to reconcile by the main tenets of AAT and FTT, since both assume that false memories are primarily caused at encoding (e.g., Gallo, 2010). Although it is possible that during retrieval being confronted with targets might cause, for example, associative (re)activation of the lists, a framework with an explicit monitoring component such as the Activation/Monitoring Theory (AMT) might be better suited to account for the findings (e.g., Roediger et al., 2001b). Monitoring refers to the decision process that helps to determine the source of the activated information to discriminate studied from unstudied material, a process that is a direct reflection of conservative or liberal retrieval criteria, or in other words response bias. Furthermore from a theoretical perspective, as discussed above additional theories relating specifically to alcohol and memory have been developed; thus, it could be worth exploring whether State-Dependent Retrieval, substance Myopia or Hypervigilance accounts can inform understanding of the mechanisms behind any memory effects for other substances. Exploring mechanisms and theoretical explanations thus is an important future direction for how drugs might impact memory errors.

Overall, substance effects on false memory have not been studied in sufficient depth. More sufficiently powered studies separating encoding
and retrieval phases are needed, both on the substances reviewed here but also on other popular substances where false memory studies are entirely lacking (e.g., cocaine, hallucinogens, opioids). In addition, the types of information (e.g., scene, object, conceptual, perceptual) presented at both encoding and retrieval (and in between) matter if we are to further our understanding about the mechanisms underlying false memories, as well as which mechanisms drugs can affect. To move the field forward, tasks which carefully manipulate these types of information should be developed. Future research also needs to monitor societal drug trends, for example drug-drug combinations or microdosing psychedelics, which are prevalent (e.g., Hutten et al., 2019; Morley et al., 2015) but no false memory studies have investigated these trends and often, true memory has not been well-elicited either. In light of recent advancements regarding therapeutic applications of hallucinogens (e.g., ketamine and classic psychedelics for treatment-resistant depression, addiction, end of life anxiety, MDMA for post-traumatic stress disorder, Johnson et al., 2019; Reiff et al., 2020), we stress that the potential to affect false memory and suggestibility is also a research topic worth pursuing from a clinical point of view.

Apart from alcohol and cannabis, the other substances were mostly studied using the DRM (verbal or visual) or other word list tasks. Though frequently criticized for its limited ecological validity, increased false memories on DRM measures have been linked to false childhood memories (Qin et al., 2008), memories of alien abductions (Clancy et al., 2002), and memories of past lives (Meyersburg et al., 2009) indicating that the task does bear some applied relevance. Nevertheless, it would be interesting to examine these substances with applied eyewitness and perpetrator memory tasks as well, particularly since DRM false memories are only weakly related to false memories on other tasks (e.g., Bernstein et al., 2018). A suggestion for a new direction to increase ecological validity of studies is to pursue virtual reality applications (e.g., Kloft et al., 2020). Virtual reality (VR) is a simulated environment that can be highly similar to the real world, incorporating auditory and visual feedback, but may also allow other types of sensory feedback through haptic technology. Benefits include a maximum of experimental control and thus internal validity, combined with high degrees of realism (see also van Gelder et al., 2014). Moreover, participants report high degrees of telepresence, feeling fully immersed in the simulation. Technological advances in the VR field make this a fast-developing and attractive alternative to more traditional research methods such as case-vignettes or videos.

Another important factor to consider in terms of ecological validity is the fact that most crimes are distressing in nature, and memory for emotional events tends to be generally superior compared to neutral events (Hamann, 2001). Drugs can influence and selectively interact with mood and emotion (e.g., de Sousa Fernandes Perna et al., 2014), and emotion interacts with false memory (e.g., Chang et al., 2020), therefore drugs that affect emotion can modulate both true and false memory for emotional events (e.g., Ballard et al., 2013; Kamboj and Curran, 2006). Although not the main focus of this review, some of the described studies reported notable findings in this regard: for example, THC, dextroamphetamine, and MDMA all tended to disproportionately increase positive false memories (Ballard et al., 2014; Doss et al., 2018a, 2018b). There may also be interactions between the substance consumed and the physiological stress response (e.g., norepinephrine, cortisol, heart rate variability) that could impact encoding and retrieval. How interactions between drug, emotional arousal, and stress might affect memory and suggestibility in context should be explored further in future studies. Finally, with the exception of three perpetrator memory studies (Kloft et al., 2020; Kloft et al., submitted; van Oorsouw et al., 2015), applied research has focused on eyewitness memory perspectives. Knowing that psychoactive drugs can affect false memory and suggestibility, it appears pertinent to explore if this might also translate to increasing vulnerability to false confessions, a leading contributing cause to wrongful convictions (Leo, 2009).

Moreover, in the current review it was established through a combination of different sources of evidence that intoxication on part of the victim, witness or suspect is common. Whereas overall prevalence of legal cases involving substance use were found to range between 1.2–4.3%, the incidence in violent crime cases tended to be much higher. The prevalence of intoxicated suspects was found to range from 25 to 78% for alcohol and from 10 to 83% for illicit drugs, and for victims from 24 to 72% for alcohol and 3–66% for other drugs. Intoxicated eyewitnesses were also frequently reported by police officers, but specific numbers were mostly lacking (with the exception of Palmer et al., 2013a). The fact that intoxication in criminal cases is frequent entails several legal repercussions. As highlighted in this review, the validity and reliability of the intoxicated person might be at stake, due to potentially higher risk of memory distortion. To what extent this is the case still remains to be elucidated for multiple substances. An issue preceding the obtaining of a statement, however, is the initial detection of an intoxicated individual: while suspects of crime are regularly alcohol and/or drug tested (especially in situations involving driving), witnesses and victims of crime generally are not. As a consequence, unless this information is volunteered by the witness or victim, their intoxication status may not be known or recorded. The current research available suggests that in the absence of this admission, police may not always be able to accurately detect intoxication (see Monds et al., 2019 for a review). Therefore, further research is also required into improving police ability to determine whether a substance has been recently consumed that may impair the ability to provide an accurate testimony.

Second, although police officers might be aware of the risks of interviewing intoxicated witnesses, in many countries (e.g., UK, United States, Netherlands) there is no clear protocol on how to handle such situations, and when to interview an intoxicated witness (Crossland et al., 2018; Evans et al., 2019, 2009; van Oorsouw and Merckelbach, 2012). Evidence-based policies are required to inform and reform such practices. Research up to this point has already provided some preliminary indication that substances can distort memory, and that differences exist between substances in terms of how memory is specifically affected. Important to point out here is the difference between alcohol and cannabis with regard to timing of the interview: alcohol-intoxicated individuals might not provide less accurate information when interviewed in intoxicated state, but if someone is intoxicated with cannabis they might be more prone to false reporting in an immediate interview (Evans et al., 2019; Kloft et al., 2020; Oorsouw et al., 2019). Therefore, a nuanced approach is clearly needed in how to deal with intoxicated witnesses, victims, and suspects, taking into account factors such as the used substance, dose, and which memory phase was affected. Intoxicated individuals should be recognized and treated as a vulnerable group, for which extra caution should be taken, but they should not be lumped together.

Another important aspect is that of perceptions about the reliability of intoxicated individuals on the part of potential legal jurors and police officers. One study found that ninety percent of psychology and law experts agree that alcohol impairs eyewitness memory (Kassin et al., 2001). Other studies have found that potential jurors also agree with expert witness views regarding alcohol and memory (Benton et al., 2006), and that they perceive intoxicated witnesses and suspects to be more cognitively impaired than sober ones (Evans and Schreiber Compo, 2010; Mindszenty et al., 2019). While these views are certainly correct with regard to alcohol’s robust impairing effects of true memory when present during encoding, the literature reviewed here showed that these patterns are highly nuanced and complicated when it comes to false memory and suggestibility. It is crucial to inform legal professionals about different substances’ potential memory effects and to consult appropriate expert witnesses to aid during the legal decision-making process.

Some limitations should be mentioned. For the first part of our review, countries were selected for practical reasons, such as that their legal databases were relatively easily accessible. A drawback of the numbers obtained from official legal databases is that while substance
use played a role in the offense, this might refer simply to the type of offense (e.g., drug possession), and does not mean that an involved person was actually intoxicated during the crime. However, it still provides an indication of the link between intoxication and crime. Relatedly, some of the numbers were based on estimates by police or witnesses. While an important first step in determining the prevalence of intoxicated victims and witnesses, the self-report nature of these estimates may be influenced by memory errors and biases. Finally, both review parts in this article are not meant to be exhaustive, but to provide a starting point. Thus, it is possible that other relevant data exists but has not been reported here.

To recap, the current paper aimed at a) establishing an overview of the prevalence of intoxicated individuals involved in legal cases, and b) providing a review of the current state of literature with regard to psychoactive substances and their effects on false memory production and suggestibility. Overall, intoxication and legal cases were found to frequently co-occur. Given the high prevalence identified in the first review part of this paper, it is evident that intoxication needs to be taken into account when considering the role of memory for events and faces under elevated levels of intoxication. However, it still remains to be seen whether intoxication can affect false memory and suggestibility in some circumstances, however the research is still in its infancy regarding the specific circumstances, especially for less commonly used substances.

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Declaration of Competing Interest

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Appendix A. Supplementary data

Supplementary material related to this article can be found in the online version, at https://doi.org/10.1016/j.neubiorev.2021.02.012.

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