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Do you ever feel like time is flashing past you, or perhaps that it is crawling by so slowly that it may have stopped? Think back to your university days, I'm sure that you can recall an instance in which you were amazed that it was already last orders in the pub, or, in a somewhat tedious lecture, the disappointment at realising that you had only been there for 20 minutes and there were still a further 40 to go! If so, fear not, you are not alone. Experiences of distortions to the passage of time are a common occurrence for most of us.

Although real "clock measured" time is passing at a constant rate, experience tells us that our subjective sense of the amount of time which has occurred, or the speed at which time is passing, can vary, leading to distortions in the passage of time. Such distortions result from the subjective sensation of more or less time occurring than has in reality. When we feel like less time has occurred than actually has, time feels like it has speeded up. When we feel like more has occurred than actually has, time feels like it has slowed down.

Despite being commonly experienced, the mechanisms behind distortions to the passage of time are under researched and, as a result, poorly understood. Anecdotal accounts imply that our experience of time is influenced by our emotions and activities. The commonly heard adage "*time flies when you're having fun",* coupled with the sensation of dull events dragging by, suggests that our level of enjoyment influences our perception of time. Fear also appears to slow time down, a sensation that Ruth experienced herself during a car crash in her early twenties; as the oncoming car hurtled towards her, she had the distinct feeling that time was slowing down around her.

It is not only enjoyment and fear which affect how quickly time appears to be passing, other alterations in subjective consciousness have similar effects. The consumption of drugs and alcohol has long been known to warp time experiences. In his, much quoted, book *Confessions of an English Opium Eater*, Thomas De Quincey noted that opium intoxication resulted in distortions to the passage of time to the extent that he "*Sometimes seemed to have lived for 70 or 100 years in one night; nay, sometimes had feelings representative of a millennium passed in that time".* Similar experiences were also reported by Aldous Huxley in *Doors of Perception* after consuming mescaline and LSD. Drug induced distortions to time are not only experienced by renowned literary figures, a quick search of an internet drug forum will reveal that many drug users report similar experiences to De Quincey and Huxley following marijuana, cocaine and alcohol use. The frequency of such reports has led to a recent revival of interest in the way in which recreational drug and alcohol use affect time perception.

A recent study at Liverpool John Moores University explored the prevalence of drug- and alcohol-induced distortions to the passage of time in a student population (Wearden et al., *in press*). 201 students reported occasions in which time had distorted during everyday life. Participants were encouraged to discuss an occasion in which drugs or alcohol had been consumed. They then rated how frequently they experienced time distortions and the extent to which the distortions were troublesome. The results confirmed that distortions are commonly

experienced during and in the absence of drug and alcohol use. Distortions were more common amongst people who took drugs than those who did not, and, of those who took drugs, 66% agreed that distortions occurred more frequently when they were under the influence of drugs than when they were not. There were no reports of distortions to time causing distress; indeed, many people said they were pleasurable. However, it seemed that the nature of distortions varied greatly under the influence of different drugs and during different social situations.

The most widely reported sensation was that of time passing more quickly than normal after the consumption of alcohol: *"when drinking alcohol on a night out…enjoying myself time passed a lot quicker."* The same was also true of cocaine use*; "When taking cocaine time always goes very very quickly. It seems you start taking the drug and then all of a sudden several hours have passed and it is about 7am".* Cannabis, on the other hand, appeared to have different effects on people's perceptions of time depending on the circumstances in which it was consumed. When consumed in stimulating environments or with other drugs or alcohol, cannabis consumption led to the feeling that time was passing more quickly than normal; "*…after a night out and alcohol consumption coming back to my flat sitting down watching TV with my friends and drinking more alcohol, smoking cigarettes and cannabis, when this happens times seems to pass much quicker."* On the other hand, when consumed alone, cannabis was associated with a slowing of the passage of time "*on cannabis, time goes slow, you think that an hour has passed when it was only 10 minutes*".

So, how do drugs and alcohol affect our perception of time? One possibility is that the drugs themselves affect the way in which the brain monitors time, possibly by altering the speed of some "internal clock" (Meck, 1983). Another possibility is that the activities that we perform whilst intoxicated influence how we perceive time, perhaps by distracting our attention away from time. One way to tease apart these influences is to examine whether drugs still affect temporal perception when they are consumed outside of their normal social surroundings in the laboratory.

Early studies into the effects of drugs on timing were conducted on animals. In the 1980's, Warren Meck published a seminal study in which he explored the effects of methamphetamine and haloperidol on animal timing (Meck, 1983). Meck trained rats to respond to a signal after a set duration of 12 seconds, by pressing on a lever which released a pellet of food. Instances in which the lever was pressed too early or too late were not rewarded. When the rats received methamphetamine (which increased dopamine levels) after training, they pressed the lever too soon suggesting that they thought that more time had occurred than actually had. The opposite occurred when haloperidol (which decreases dopamine levels) was administered: the rats responded too late indicating that they thought less time had occurred than actually had. Meck suggested the rats' perception of time was altered because the administration of methamphetamine and haloperidol led to dopamine-modulated increases and decreases in internal clock speed. Similar effects to those induced by methamphetamine have been reported following cocaine but not ketamine administration (Cheng et al., 2006; 2007). It would, therefore, seem that, in animals at least, some drugs which affect dopamine levels influence temporal perception.

The effect of recreational drug use on human timing is less well understood, in part because of ethical constraints on administering illegal drugs to human participants. A number of studies have, however, explored the effects of alcohol and marijuana on timing. These studies have typically employed *prospective timing* paradigms in which participants are required to make judgements about the durations of forthcoming events, typically the sounding of a tone. Because prospective timing is thought to be accomplished through the use of an internal clock, these studies can inform us about the way in which drug administration affects our timing system. Alcohol and marijuana are two of the most commonly consumed recreational drugs in the UK (Smith & Flatley 2011), such that the pharmacological and cognitive effects of alcohol and marijuana intoxication are well documented (see Stahl, 2008). Both alcohol (Schweizer & Vogel-Sprott, 2008) and cannabis (Solowij & Battisti 2008) are known to impair memory function and attentional processing. In addition, the consumption of both alcohol and marijuana leads to indirect increases in dopamine levels (Bossong et al. 2008; Stahl, 2008). It is therefore likely that both substances may affect the way in which we perceive time.

Marijuana consumption has been shown to affect timing when people estimate the duration of events (Chait & Pierre, 1992), produce durations (Tinklenberg et al., 1976) and compare durations with one another (Lieving et al., 2006). Generally speaking, marijuana consumption results in participants overestimating the amount of time which has passed. This pattern of behaviour is consistent with an increase in internal clock speed. Laboratory studies exploring the effect of alcohol on timing have produced mixed results. When participants have been asked to produce durations after the consumption of alcohol e.g. hold down this button for 30 seconds, some studies have reported that durations were overproduced (Tinklenberg et al., 1976). Other studies have reported that durations were underproduced (Lapp et al., 1994), and some studies have reported no effect of alcohol on timing at all (Heishman et al., 1997). The disparity in findings is, perhaps, due to the differing doses of alcohol and the differing duration ranges employed in the different experiments.

In an attempt to clarify the effect of alcohol on human temporal perception and to bridge the gap between the distortions that people report in the real world, and the findings from the laboratory, we recently undertook a study exploring how alcohol consumption affected a range of timing judgements (Ogden et al., 2011). In particular, we wanted to see whether we could replicate the alcohol induced sensation of time 'flying,' that people reported in Wearden et al. (*in press*), even when the social interactions usually surrounding alcohol consumption were removed. To do this we wanted to create a laboratory based task which reflected the way in which people make judgements about time in the real world. In the laboratory, we typically make it clear to participants that their ability to judge time is being tested, which, presumably, motivates participants to concentrate on time. In the real world, however, we often make judgements about the duration of previous events, even when we are not concentrating on their duration. To replicate this type of judgement in the lab, we asked people to complete a short word classification task without telling them that they would later be asked how long the task lasted. Because participants were unaware that timing was the focus of interest, they would be unlikely to consciously monitor time. Once the word

classification task was complete people were asked to estimate the task's duration (retrospective timing) and to indicate whether they thought that time was passing at the same speed as normal, or faster or slower than normal during the task (a "passage of time" judgement). They then performed a series of prospective timing tasks in which they made judgements about the duration of short tones.

People's ability to estimate the duration of the word classification task in minutes and seconds (retrospective timing) was unaffected by alcohol consumption, but a high dose of alcohol did result in the sensation of time passing more quickly than normal). The fact that even in the laboratory the sensation of time speeding up after alcohol consumption was reported suggests that the psychopharmacological effects of alcohol consumption alone are sufficient to affect our perception of time. It is of course likely though, that when these effects are coupled with pleasurable activities which detract our attention away from time, any speeding effect would be more pronounced. Alcohol also made people overestimate the duration of short tones in one of the timing tasks used, and this overestimation is consistent with a dopamine-induced increase in internal clock speed.

Having experienced distortions to the passage of time whilst under the influence of drugs and alcohol, there is some concern amongst users about whether any effects could be permanent. Heavy drug and alcohol use can result in long-term neurological damage (Harper, 2009) and impaired cognitive function (Fisk & Montgomery, 2009), both of which may alter timing ability even when drug use has ceased. Chronic cocaine and amphetamine use reduces Dopamine D_2 receptor availability (Volkow et al., 2001). As animal studies have demonstrated that dopamine levels influence duration perception, it is possible that chronic users of cocaine or methamphetamine may display impaired timing ability even after drug use had stopped. Wittman et al. (2007) explored this by comparing the timing abilities of currently abstinent cocaine and/or methamphetamine users with control participants. Timing ability was impaired in the abstinent drug user group relative to the controls on most measures. Typically, the abstinent users were less able to discriminate between different durations and appeared to overestimate the duration of longer events. Wittman et al. (2007) also suggested that the tendency to overestimate the duration of long delays may lead to increased drug taking amongst users as the time elapsed since the last drug administration appears longer.

In the real world and the laboratory alike, it would seem that drug and alcohol use has the ability to affect our perception of duration. Reassuringly for those of us who may be affected by such distortions, research tells us that they are commonly experienced and that most people find them to be harmless. Having said this, there is some preliminary evidence to suggest that some negative effects appear to be long-lasting in chronic drug users. Further research in this area is clearly warranted; not only to enable better understanding of how drugs and alcohol may affect our ability to time, but also to explore whether impairments to timing may influence our ability to perform time-dependant tasks such as driving, and affect drug seeking and drug taking behaviours.

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