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Table of Contents

Introduction

Letter from the journal Page 3

Contributors Page 4

Articles

Multitasking: the solution for keeping up with the modern world speed? Psychology Radwa Al-Ashwal Page 5

Lucid Dreams: modifying dream content Neuroscience Ahmed Farrag Page 8

Quantum Computers & Networks: An Overview Computer Science Saif Taher Page 11

Prion Diseases: A Journey Through Therapeutic Strategies Neuroscience Roaa El-fishawy Page 15

Quantum Teleportation: Applications and Challenges Computer Science Hamdy Amin Page 19

Industrial Scrubbers and Air pollution Control Mechanical Engineering Omar Ayman Page 23

Letter from the journal

Dear readers,

Welcome to the biggest issue this journal has ever witnessed! With 6 articles covering topics across various fields, we are proud to release our April 2021 issue. We've had a lot of fun assembling this one, so we hope you have a fruitful time reading it!

These past months were really busy as most of us were testing but our workflow went through smoothly, thanks to the cooperation of our many writers and their hard work, so a round of applause to Omar Ayman, Hamdy Amin, Roaa Elfishawy, Saif Taher, and Radwaa El-Ashwal for keeping up with the workload! Furthermore, to increase our audience across social media platforms, we have created an Instagram account for students to follow us: @ysciencejournal if you have not followed us yet, make sure to take a second of your time to do so!

Without further ado, we hope again you have an enjoyable time reading this, and do not hesitate to reach out to us for constructive feedback!

Best Regards,
Youth Science Journal Community

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Multitasking: the solution for keeping up with the modern world speed?



Radwa Al-Ashwal, Maadi STEM High School for Girls

Abstract

In the rush of the technology age, where most people are part of a 24/7 community, it might seem appropriate to perform more than one job at a time. Multitasking is the idea of having multiple tasks competing for your attention. The fact that attention is a very limited resource is skipped and the overall impression is that you are saving time, energy, and space for later rest. Unfortunately, the study shows otherwise. While in the heat of the work you might feel like the output is efficient, the actual outcome - in most cases- is not as good as if you were not “multitasking”

I. Introduction

When you start an activity, it takes time to get fully focused. After some time, you will probably be doing it with higher efficiency and less effort. That is, the regions responsible for this specific action are activated and the neurons are already fired up.

In case you want to switch tasks, there are two stages: “the Goal Shifting” which is just deciding you want to do task 2 now instead of task 1. And stage two: “rule activation” you are turning off the rules for task 1 and turning on the rules for task 2 [1].

Depending on the type and familiarity of the tasks, this process could either be flawless that you would not even be aware of or it could be not. Problems arise when switching causes conflict between the current physical and mental states. The operations required to make these changes take time and resources and thereby affect performance. Although switch costs may be relatively small, sometimes just a few tenths of a second per switch, they can add up to large amounts when people switch repeatedly back and forth between tasks. Thus, multitasking may seem efficient on the surface but may take more time in the end and involve more error.

II. Like a clown box, but scarier

When focused on a single task, our attentional resources are well directed and uninterrupted [9]. Information is neatly processed, encoded, and stored. When a secondary task is added, attention must be divided, and the processing of incoming information becomes fragmented. As a result, encoding is disrupted [2], leading to the reduction of the quantity and quality of stored information.

How focused you are during the task determines how detailed you are likely to remember it. Information processed without interruptions is way less prone to errors than information perceived during multitasking. Performance declination is more likely to happen when attention is divided.

When interruptions are attention-consuming, they can increase feelings of stress and anxiety by subjective and physiological measures. For instance, when you have 18 tabs open in one window and a deadline in 47 minutes, having a mail notification pop out of your screen or hearing Microsoft Team’s ringer is not really calming.

III. Multitasking is contagious

Laptops are being more common in classrooms. The dependence on technological methods to facilitate the learning process and make it more interactive is increasing. However, students are more commonly found engaged with their laptops or smartphones with irrelevant actions to the learning process. In an experiment conducted at York University [2], participants who multitasked during the lecture scored significantly lower than participants who did not multitask.

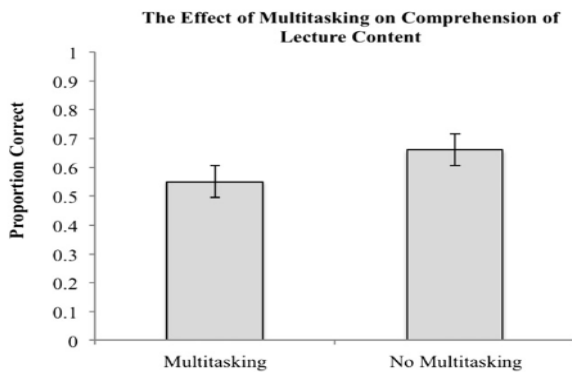


Figure #1: The effect of multitasking on comprehension of lecture content

You could predict that referring to the fact that there are limitations to how well multiple tasks can be carried out concurrently. But could viewing a multitasking peer affect performance? Another experiment by (McMaster University, Department of Psychology, Neuroscience, & Behavior) [2] investigated whether being in direct view of a multitasking peer would negatively influence learning as measured by performance on a comprehension test. A group of participants was asked to take notes using paper and pencil while attending the lecture. Some participants were strategically seated throughout the classroom so that they were in view of multitasking confederates on laptops, while others had a distraction-free view of the lecture. Confederates were typing notes on the lecture and performing other concurrent, irrelevant online tasks. The results were as follows: Participants in view of multitasking peers scored significantly lower on the test than participants, not in view of multitasking peers. Conclusion: Peer

multitasking distracted participants who were attempting to pay some attention to the lecture. Those in view of a multitasking peer scored 17% lower on a post-lecture comprehension test.

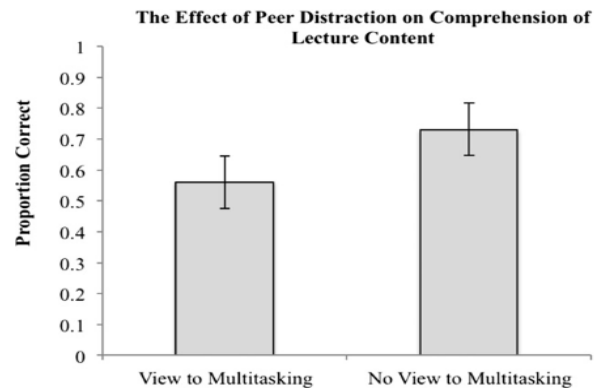


Figure #2: The Effect of Peer Distraction on Comprehension of Lecture Content

IV. Drawbacks of Multitasking

It is hard to quit multitasking, scary, and might seem unrealistic in some cases. Just to realize the true impact, this is a thorough review of multitasking dangers.

A study published in Plos-One journal [4] demonstrates that multitasking can cause physical damage to the brain. Gray matter, which plays a vital role in attention, consciousness, and memory [5] can have less density in the case of heavy media multitaskers.

A paper published in NCBI [6] studies the relation between working memory, long-term memory, and media multitaskers. Results show that media multitasking negatively affects both types of memories. The frequent attention division between multiple tasks weakens the ability to recall information over long -or short- periods.

A study published in the journal Neuroimage [7] studied the effect of distractive stimuli on performance. Results show clear performance declination when exposed to irrelevant sources of attention-capturing stimuli.

A study of college students [8] found that as students multitasked more while using their computers, their stress levels elevated. The constant exposure to new information that needs to be processed escalated the stress responses.

V. Conclusion

To sum up, where multitasking might appear as a perfect solution for sparing time, zooming in a little reveal that under the name of getting a variety of duties done, time is lost, efficiency is lost, and mental health is lost. Multitasking does not only affect you but those around you as well. Instead of starting all due tasks at the same time, take them one by one. Limit distractions to increase efficiency.

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Lucid Dreams: Modifying Dream Content



Ahmed Farrag, STEM High School for Boys – 6th of October

Abstract

Scientists have been recently investigating lucid dreams and their side effects because of their potential as therapeutic tools, where it is being claimed that they have positive impacts on immediate waking mood. This paper discusses several techniques of lucid dream induction, like WBTB, MILD, and reality testing. It also goes over several concepts related to lucidity, such as the REM stage, and different methods of dream content modification, such as altering the dream environment through mimicking a real-world scene. It turned out that lucidity does have promising results when being used as a therapeutic tool, except that it might increase negative psychopathologies on frequent use. It was also obvious that there is a partial dissociation between lucid dreams and the memories of the person experiencing them.

I. Introduction

Lucidity is a state of consciousness during sleep that enables dreamers to modify their dream content. However, it has got its limitations according to various internal and external factors. For instance, it depends on the place at which the participant sleeps and to what extent he is accustomed to it. It also depends on how much light is being leaked and the noise the participant is experiencing. Though they limit the ability of lucid dreaming, external factors can be altered according to needs, but when it comes to internal ones, it becomes a bit hindering. Recent studies show that controlling dream content was hard for PTSD patients to achieve, even when lucid [1]. Sleep generally consists of two phases: non-REM and REM sleep, and it is widely agreed that lucidity only occurs in the latter stage [1]. For further needs of study and research, several lucidity-inducing methods were developed. These involve MILD, WBTB, and reality testing techniques [1]. They have been used in a multi-case study to prove whether lucid dreams are associated with a positive waking mood or not. A dreamer's ability to mimic a real-world scene was also in question, so similar methods were used and experimented with to check the existence of an association between lucid dreams and partial memory [2].

II. REM Stage

Though the study of lucid dreams has many inconsistencies and disagreements, it is unanimously agreed that lucid dreams occur within the Rapid Eye Movement stage of sleep [1]. The Rapid Eye Movement phase, also known as the REM stage, occurs after being in sleep for 90 minutes [3]. It is the last stage of sleep, and it's associated with the eye being rapidly moving right and left with other phenomena such as increased heart rate, increased blood pressure, and faster breathing [3]. Muscles also become temporarily paralyzed to prevent the dreamer from acting out of his dream [3]. Mixed frequency brain wave activity becomes very similar to those seen while awake as well. It has also been hypothesized that the recognition of being in a dream occurs in the dorsolateral prefrontal cortex, which is one of the few areas that have no activity during REM sleep and is associated with working memory [4]. However, when it happens that this part of the brain becomes activated, one recognizes he is dreaming, enabling him to act as he likes. Electroencephalography is a method of monitoring the electrical activity of the brain. It has been proved that lucidity occurs within REM through this method, where it proposes that there is increased beta

1 frequency band brain wave activity during this phase (13-19hz) [6]. This indicates an increased amount of activity in the parietal lobes, which makes the brain conscious.

III. Inducing Lucidity

Most of the lucid dreams studies were just theoretical, with no actual evidence for their authenticity. So, several lucidity-inducing techniques were developed for the sake of experimentations. One of the methods, known as reality testing, involves genuinely checking whether you are in a dream or not throughout the day by searching for any glitches or inaccuracies in the surrounding environment. Having patients do this technique will increase the likelihood that they do it when in a dream, and therefore realize they are dreaming. Two other methods, Mnemonic Induction of Lucid Dreams (MILD) and Wake Back to Bed (WBTB), are used simultaneously. They involve waking a patient up after a certain period of time to increase his mental alertness (WBTB) and having him rehearse a phrase repeatedly, such as “I’ll remember I’m dreaming” while falling back into sleep. However, recent studies showed that lucidity induction techniques may be associated with sleep disruption [1].

IV. Effect of lucidity on waking mood

A recent multi-case study proved that there is a link between lucidity and positive waking mood, which means it can be used as a therapeutic tool. [1]. These experiments were done in a within-subjects comparison instead of a between-subject. Because the between-subject method could be explained by individual differences, that may be certain participants were naturally more positive and of a higher ability to achieve lucidity. However, using within-subject comparisons gave the advantage of fading such a problem, indicating that lucidity itself is related to a more positive waking mood, and it actually makes sense. Because, through lucid dreams, you can face something that was previously regarded as beyond your capabilities or meet someone you miss and so. In contrast, other researchers claimed that frequent lucidity induction

may cause negative psychopathologies in the long term. For instance, a symptom known as dissociation, where one distances himself from surrounding people in order to fade emotional pain, is shown to increase with increased lucidity [1]. It’s also worth mentioning that these experiments only measured the immediate waking mood. So, determining whether lucid dreams have lasting effects on mood or not remains an important area for future research.

V. Accessing Episodic Memories

An experimental study of dreamers’ capability of accessing episodic memories turned out to be partially true. This will be elaborated later on. The methodology used in this case study involved exposing participants to a certain experimental scene, where specific objects were put in a certain order, and participants were asked to memorize and learn them all by heart in order for them to try and mimic it in their dream environment. Figure #1 illustrates the process of interest.

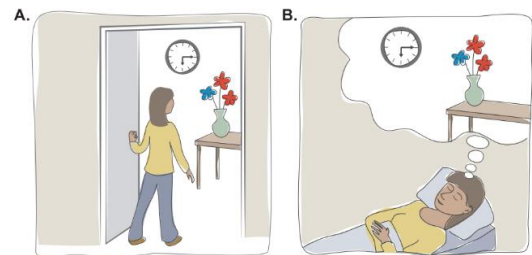


Figure #1: Mimicking a real world scene

Table 1 illustrates the list of objects used with a brief description for each of them:

There is more to the story, the procedures followed by participants to get to the point of altering dream scenery differed greatly. For instance, some participants changed their dream environment only by wishing it so. Others needed to get through a door or a portal to do so. A portal might be a glass surface, a mirror for example. These techniques are still being studied up to this moment and remain an important field of study for future research. Unfortunately,

Table 1
Experimental items placed in scene/room.

Item	Brief description
Snake	Rubber rattlesnake in a coiled striking position
Fruit	Plastic fruit setup (pear, banana, etc.)
Picture of family	Mother, father, and son sitting around a chess board
Picture of individual	Headshot of female with striped (orange/blue) earrings and blue eyes
Artwork	Abstract digital painting made of many shapes
Clock	Round analog clock with Roman numerals set to 6:15
Flowers	Six individual fake roses of different colors
Blocks	Set of small toy blocks and shapes (one letter M), all red, blue, yellow, or green

Table #1: Objects used at the experimental scene

many inconsistencies appeared in dream scene reinstatements, indicating a dissociation between the dream environment and the scenery formed during waking [2]. However, dreamers were aware of these inconsistencies while dreaming, and they actually tried altering them. Table (2) contains several dream reports for more details.

VI. Conclusion

Lucid dreams are being studied on a wide range because of their positive impact on waking mood, which means they could be used as a therapeutic tool. WBTB, MILD, and reality testing have proved their potential as lucidity induction techniques and are currently being used on larger scales than before. It was also proved that there are some inconsistencies in dream scene reinstatements.

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Participant	Dream report
sub-005	<i>... I used the car to fly to the university crashing into a window. I made my way into the correct area after navigating a maze of hallways. I entered the [experimental] room to find it mostly empty. I recalled the items I was looking for and noted missing elements, shelves, digital painting, desk gone, no end table. There is a picture where the blonde one should be. It's blurry and watery ...</i>
sub-007	<i>... I was wandering the halls of the building where the study took place ... this time they were full of ... shadowy figures ... I made it my mission to get to the room, but the closer I got the more crowded the hallways got ... but I reached my hand to the door ... the door was locked again ... so I imagined just passing through the door ... I opened the door and the room was empty ... I closed the door and tried to make things appear as they were in the room ... I would close my eyes, think of an object that I could remember and open my eyes and it would appear. First it was the wooden desk with the fruit ... I kept closing my eyes and trying to make it perfect, but then things got out of control. The clock above the switch spun to midnight ... the snake moved off the metal desk to the fruit and wrapped around them ...</i>
sub-009	<i>... I caught myself in hypnagogia and set the intent to go to the [experimental] room. I then saw myself going up the northeast flight of stairs at [the university] ... turned left past the coffee mugs ... Went ahead into the [experimental] room. I saw the picture of the girl with green turquoise eyes and rainbow earrings, then moved forward to the desk. Looked down and around, walls were clean and table next to desk was not there. Also the big painting was not there, it was a plain white wall. I saw the rattlesnake, it was mostly orange and black. The first time I saw the tail it had three black bands but when I looked again there were five, then seven and finally thirteen ...</i>

Table #2: Dream Reports

Quantum Computers & Networks: An Overview



Saif Taher, STEM High School for Boys – 6th of October

Abstract

Today's classical computers are headed to a plateau regarding performance/power increases and size decreases. Many companies are investing in quantum computers as the next generation of computers due to their vast potential. Said potential stems from their ability to exploit bizarre quantum phenomena, such as superposition and entanglement. However, the road is still long to achieve quantum computers capable of doing anything that today's supercomputers cannot. The road is riddled with design challenges that heavily limit the extent of problems quantum computers can solve. Those challenges include error correction, increasing the number of qubits, and finding more efficient ways to create the super-cooled ultra-vacuum environments necessary for the operation of supercomputers.

I. Introduction

The integrated circuit present in most of today's modern computers was first introduced in 1959. Since then, computers have been following a trend termed "Moore's Law": In 1965, computer engineer Gordon Moore observed that the number of components on integrated circuits had been roughly doubling every 1-2 years since circuits were invented. This allowed circuits to run at higher speeds and efficiencies per unit area for the same amount of power. Consequently, computers have both been shrinking in size and growing in computing power over the decades. However, the end to Moore's law is looming on the horizon as the size of components on circuits is approaching the atomic scale, which means that further increases in classical computers' power are going to be quite difficult. It's time to start developing entirely new technology that will succeed today's computers as our tool for moving forward, and quantum computers seem to be the perfect candidate [4].

Quantum computers have the potential to revolutionize science, medicine, commerce, space exploration, and countless other industries and markets. That potential lies in their ability to easily solve problems that even the most powerful of

today's supercomputers struggle to tackle, such as chemical/biological simulations, machine learning, financial modeling, cybersecurity, and optimizing manufacturing and supply chains [1].

In fact, many companies are starting to heavily invest in R&D efforts towards quantum computers: Google and IBM built and tested two quantum processors in 2017 and 2018, the European Commission devoted 1 €-billion to quantum technology research and a team in China under the lead of Professor Pan Jianwei successfully established a 1200-km-long quantum connection between ground stations and satellite Micius. Furthermore, Volkswagen and Daimler are using quantum computers for simulations of the electrochemical processes in their cars' batteries in an attempt to improve their performance. Pharmaceutical companies are also using quantum computers to accelerate the development of novel drugs. Finally, airbus calculated the most fuel-efficient ascent/descent flight paths with the help of quantum computers. These were just a few examples of how quantum computers are being used today and why so many industries are interested in them. Let's take a look at the scientific principles behind the workings of these machines [1] [5].

II. How Quantum Computers Work

All “classical” computers and devices rely on the concept of 0’s and 1’s to represent data: The state of 0 means “off” and the state of 1 means “on”. Bits can only be 0 or 1 at a time, and the number of combinations that can be produced by a string of bits of length n is equal to 2^n . On the other hand, quantum computers utilize the phenomenon of superposition to massively outclass classical bits: Superposition is the ability of particles to be in two states simultaneously. Quantum computers use Qubits instead of bits to represent data. Unlike bits which can only represent one out of the 2^n possible combinations, qubits can be in a superposition of all of them. In other words, a qubit of length n represents all of the 2^n combinations at the same time, which enables solving certain classes of problems, such as optimization and search problems, at exponentially faster rates than normal computers can achieve [1] [6].

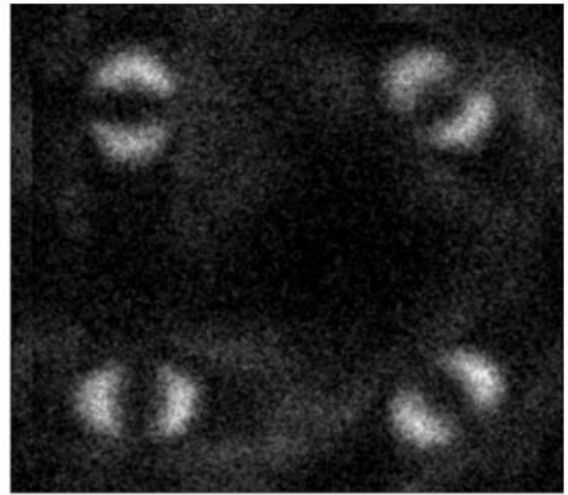


Figure #2: Photo of the first case of successful quantum entanglement between photons of light. The photo was captured in the University of Glasgow, 2019. [2]

Quantum computers make use of another phenomenon known as quantum entanglement, shown in figure #2. A pair of entangled qubits is known as an EPR pair, and they exhibit some very interesting properties. Once one of them is measured

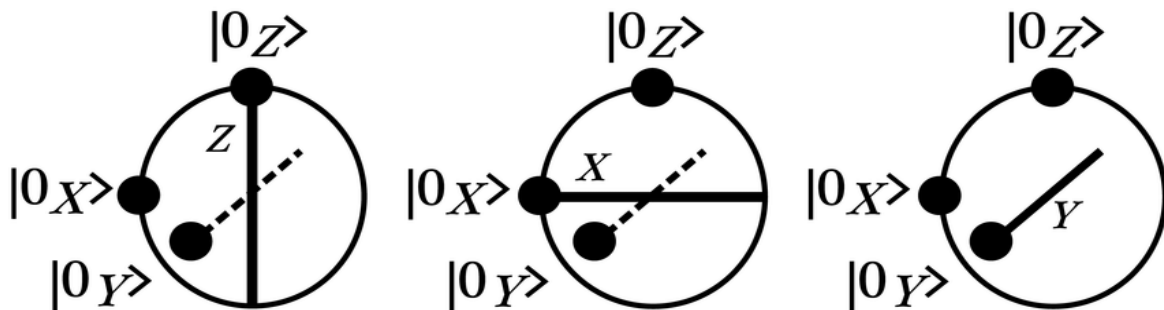


Figure #3: Three vectors representing three qubits corresponding to 0, 1, and a vector at 45° with equal amounts of both, respectively. [8]

After performing all calculations, measuring qubits will yield a probabilistic result of either 0 or 1 depending on “how much” they had of each component. In other words, 0 and 1 could be represented as two orthogonal vectors, and a qubit could be anything between them. For example, a vector at 45° represents a qubit with an equal amount of 0 and 1, as shown in figure #1. Therefore, upon measuring there is a 50/50 probability that the outcome will be 0/1. It is also worth noting that a qubit’s quantum state collapses after measuring it and that every subsequent measurement will result in the same outcome regardless of how much 0 and 1 the qubit initially had. [1]

the other one collapses to the opposite quantum state of the first one, no matter how long the distance between the two qubits is (i.e., if the first qubit collapses to 0 the other one will collapse to 1, and vice versa). This non-classical behavior could be used as the first building block of a quantum internet; a network of interconnected quantum computers. Qubits could be transferred across these networks using technologies such as Quantum Key Distribution (QKD) and SuperDense Coding.

These technologies enable exchanging secret encryption keys via photons. This allows for ultra-secure connections that are impossible to hack due to

something known as decoherence (discussed in the next section). In a nutshell, quantum connections cannot be hacked because any attempt by a third party to access the qubits will alter their delicate quantum state which causes them to lose their data. [1] [3] [7]

While quantum computers may seem like a revolutionary breakthrough in informatics, the road is still very long for them to actually achieve any tangible results due to the numerous challenges facing them. We discuss some of those challenges in the next section.

III. Challenges Facing Quantum Computers

There are two main obstacles in the road to achieving quantum supremacy; that is, successfully designing and implementing a quantum computer superior to any classical supercomputer. Namely, those obstacles are noise and errors.

The quantum state of qubits is extremely fragile, which inhibits quantum computers from operating in normal environments or communicating cubits at long distances due to something known as noise. Even the slightest of changes in environmental conditions, such as temperature or pressure, is considered as noise, and interaction with noise causes errors/decoherence; i.e., qubits tend to lose their special quantum state and subsequently lose the data they carry. Therefore, although the size of quantum chips and circuits is not too large compared with their classical counterparts, it is the equipment required for preserving the qubits that take up large space and funds. This equipment includes super-cooled fridges and ultra-vacuum chambers, and it ensures qubits retain their superposition to achieve their purpose. [1]

The number of calculations that can be performed using classical bits scales linearly with the number of bits. On the other hand, the computing power of quantum computers increases exponentially with the number of qubits, which gives quantum computers their vast potential. However, at the moment it takes hundreds of thousands or

millions of qubits to solve even a fundamental chemistry problem to correct all the errors arising from noise. To help with this, error-correction techniques and algorithms have been developed. However, further research is required to improve them. Not to mention that creating qubits is already quite a challenging engineering task. [1] [6]

IV. Conclusion

Quantum computers are the most promising tools at our hands if we are to explore the next frontiers of science and technology. Nevertheless, they are still very early in development, and we have barely scratched the surface of their power. More work is needed to decrease the size and costs of the equipment needed to shield qubits from noise and to find efficient ways of achieving superposition and entanglement. Current quantum computers haven't exceeded double digits in terms of qubits, and there's still a long way to go before we can accomplish anything useful with them.

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Prion Diseases: A Journey Through Therapeutic Strategies



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Abstract

Prions are unconventional infectious agents that cause lethal transmissible neurodegenerative diseases in humans and animals. They were the main cause of a number of diseases including Creutzfeldt-Jakob Disease (CJD), Variant Creutzfeldt-Jakob Disease (vCJD), Gerstmann-Straussler-Scheinker Syndrome, Fatal Familial Insomnia and Kuru. Prions can be distinguished from other pathogens by their lack of nucleic acids. The most important process for prion propagation is the conversion from normal cellular prion protein on the cell membrane to insoluble, limited protease digestion-resistant, pathogenic scrapie prion protein. For several years, many pharmacological and biological tools have been targeting different stages of disease progression. A very few numbers of them have been upgraded to clinical trials. Despite all these treatments being tested, none has been approved as a therapeutic drug for prion diseases in general. In this review, some of these treatments will be discussed to get a basic knowledge of different possible therapies.

I. Introduction

Prion diseases, or transmissible spongiform encephalopathies, are fatal neurodegenerative diseases in the central nervous system [1] which include Creutzfeldt - Jakob disease (CJD), Variant Creutzfeldt-Jakob Disease (vCJD), Gerstmann-Straussler-Scheinker Syndrome, Fatal Familial Insomnia, and Kuru.

Prions are the main infectious agents of these diseases. They behave like any other infectious pathogens, except the fact they lack the most fundamental features of any organism, in particular, genetic material (DNA, RNA). But it turns out that they are caused by the misfolding of a host-encoded prion protein (PrP). Prion Protein is a 253 amino acid AA protein. After its transport to the endoplasmic reticulum in the process of synthesizing proteins, the first 22 N-terminal AA are removed from PrP, while the last 23 C-terminal AA are cleaved off after the addition of glycosylphosphatidylinositol (GPI) anchor. GPI helps the proteins attach to the outer surface of the cell membrane.

PrP could be found in two forms: a normal cellular prion protein (PrPC) and a pathogenic misfolded conformer (PrPSc), both of which are encoded from the same sequence from base pairs 4,666,796-4,682,233. The abnormal PrPSc and the normal PrPC differ in secondary and tertiary structure, but not in primary amino acids sequence. [2] [3].

According to the seeding-nucleation model*, the preexisting or acquired PrPSc oligomers catalyze the conversion of PrPC molecules into PrPSc fibrils. This breakage provides more PrPSc templates for the conversion process [4]. This process of conversion is self-propagating, with PrP SC acting as a conformational template forcing more PrP C to convert. The conversion reaction itself is crucial to neurotoxicity in prion diseases. Nonetheless, the exact identity of the neurotoxic prion species and the mechanism of neurotoxicity are still unknown. Figure #1 illustrates the process of conversion from

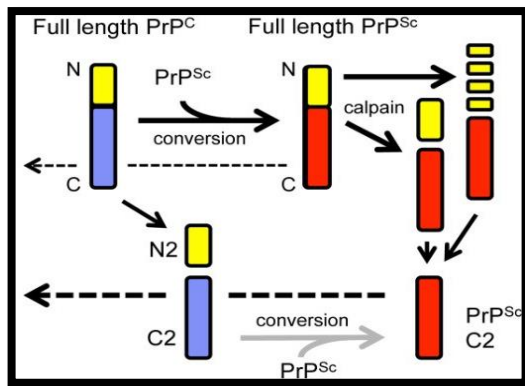


Figure #4: pathogenic signaling

the cellular protein PrPc to pathogenic misfolded conformer (PrPSc).

Prion diseases are rare in humans, but they indeed have a unique biology that had caused them to be the focus of the scientific world for several years. There is currently no effective treatment for prion diseases or clear evidence of how they are transmitted, but mostly they are transmitted through contaminated blood products [5].

II. Treatments for prion diseases: Do they exist?

A short answer is that there is no effective disease-modifying treatment for prion diseases until now. None has string preclinical evidence from experiments on animals. A good understanding of the agent's structure and mechanism is essential for discovering a decent treatment, which is improving every day.

The most frequent targets are PrPc, PrPSc, and the conversion process between PrPc to PrPSc. The main goal of targeting PrPc is to enable knocking down or completely remove substrates for prion propagation, which can be applied for all types of prion diseases.

Targeting PrPSc may be the most logical approach; however, such therapies could not influence disease progression, and they may even enhance or prolong the disease. Conversely, targeting the process of conversion from PrPc to PrPSc includes various pathways. Inhibition of PrPc trafficking to the plasma membrane, stabilization of

the PrPc structure with chemical chaperones, and interference of the interaction between PrPc and PrPSc are examples of such therapies [6] [7].

Any successful therapy for prions would either prevent the formation or block the action of the neurotoxic species. Pathological changes and infectivity are associated with (PrPSc), but there is no evidence for in vivo toxicity caused by PrPSc [8] [9].

Another reason for arguing about the toxicity of PrPSc is the existence of the subclinical disease, in which high levels of PrPSc are present, but with no clinical symptoms [10]. As well as several inherited prion diseases in which PrPSc is not detected in any significant amounts, the level of PrPSc accumulation in certain brain regions has nothing to do with any clinical features [11]. But despite all of the previous, expression of PrPSc is essential for both prion propagation and pathogenesis.

III. Timing of treatment: Does it make a difference?

Before any neural loss in mouse scrapie, spongiform change and synapse loss occur [12] and before the end stage motor symptoms, some changes in the species' typical behaviors take place [13] [14] and they are associated with the early loss of presynaptic terminals in the dorsal hippocampus [15]. In other neurodegenerative disorders, such as Alzheimer's and Huntington's diseases, the loss of synapses precedes neuronal loss.

The early spongiform change had some kind of relation with cognitive and behavioral deficits and synaptic transmission in the hippocampus in prion-infected mice with PrP depletion; these mice recovered just one week after depletion has occurred [16].

Although the link between spongiosis and synaptic loss is not completely clear, it may give some information like reflecting a stage of functional impairment of synapses before they are physically lost. The recovery of early spongiform change bears with the idea of the early stage of the disease being a key for prion diseased neurons to be rescued.

IV. Using RNAi for Therapeutic Gene Knockdown

“Transgene-mediated reduction of PrPC” is an expression that opens a new door when it comes to possible therapeutic strategies regarding prion diseases in general. It has been discussed before how the prevention of PrPsc formation may be a possible cure for prion diseases; a way to do so is by disabling or “silencing” the gene responsible for the formation of PrPsc. Nevertheless, that expression does not contain any direct therapeutic possibilities in human patients. Recent developments in the field of RNA interference (RNAi) constitute a new opportunity to achieve such therapeutic gene silencing in vivo.

RNAi is a naturally occurring highly-conserved sequence-specific mechanism for post-transcriptional gene silencing in eukaryotes. It is associated with the presence of double-stranded RNA (dsRNA), which is exogenously introduced as viral RNA to the cell and endogenously encoded as microRNAs (miRNAs), which is an RNA responsible for regulating gene expression. Exogenously introduced dsRNA is recognized as a cytoplasmic ribonuclease known as Dicer. Its function is to cleave dsRNA into 21–23 nt sequences called short interfering RNAs (siRNAs) [17]. Both siRNAs and miRNAs interact with a multi-protein RNA-induced silencing complex (RISC) that unwinds the RNA duplex and destroys one of the strands [18]. This type is also known as passenger RNA.

We can call the remaining “guide” strand a template, which is used to locate cellular mRNAs containing a homologous sequence. The degree of homology between the guide strand and the mRNA determines whether RISC initiates endonucleolytic cleavage or translational arrest of the target mRNA and, consequently, silences the expression of that gene. Generally, siRNAs mediate the destruction of target mRNAs whereas miRNAs silence gene expression through translational repression due to their imperfect complementarity to the target mRNA [19] [20]. Interfering RNA sequences can be designed to enter the RNAi pathway at various points. siRNA duplexes can be synthesized for direct

loading into RISC without requiring further processing [21]

Targeting of brain structures has been achieved successfully with an infusion of naked siRNA duplexes in conjunction with transfection reagents and conjugated to a peptide derived from the rabies virus glycoprotein [22] [23]. Because of the promising results being attained, current technologies mean clinical translation for the treatment of many neurodegenerative diseases. The previous process will require the continuous or repeated long-term infusion of the interfering RNA directly to the CNS.

Alternatively, stable, long-term expression of interfering RNA sequences can be achieved through the use of recombinant viral vectors (see schematic in Fig. 2).

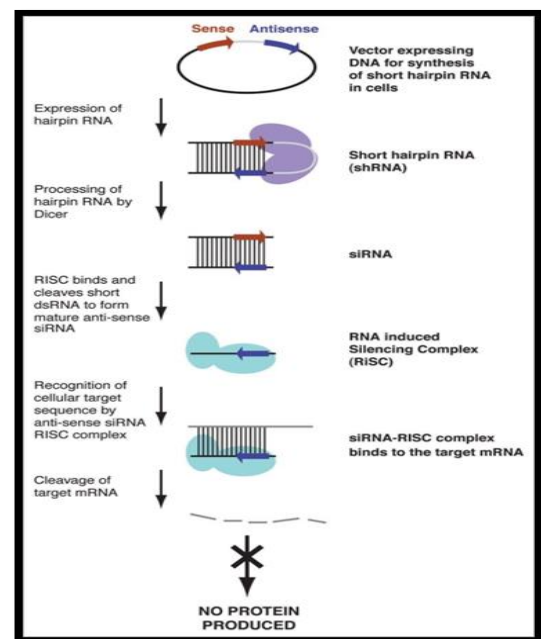


Figure #5: Schematic representing virally mediated RNAi

V. Chemotherapeutic Approach

Treatments targeting early or preclinical acquired prion diseases may find success by targeting peripheral replication and blocking neuroinvasion. However, effective therapies for symptomatic disease will most likely require a combination of approaches, such as inhibiting pathogenic PrP formation, destabilizing or

enhancing the clearance of existing pathogenic PrP, blocking neurotoxic effects of the infection, or promoting the recovery of lost functions in the central nervous system. There is a long list of chemical classes of compounds that have been screened and tested in vitro, and some even in vivo.

The majority of anti-prion compounds were examined to stop the conversion of PrPC to PrPSc. This may happen through direct binding of PrPC and/or PrPSc, causing prevention of interaction or block polymerization. Hence, a compound may redistribute PrPC to a location where conversion cannot occur. Others affect conversion by interfering with important accessory molecules or by suppressing PrPC expression altogether.

VI. Conclusion

Our vision and knowledge about Prion diseases and PrPsc especially are in constant progress each day. While increasing our understanding of their structure & formation, various methods of treatment have emerged on the scene, perhaps not all of them have proven remarkable progress in vivo, but this increased knowledge will help in the future to open other doors for various biological and pharmacological tools.

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Quantum Teleportation: Applications and Challenges



Hamdy Amin, STEM High School for Boys, 6th of October

Abstract

Quantum teleportation plays a crucial role in information science for its property of completely secure transmission. It was first demonstrated as a means of transferring the quantum state. Later, it has been extended greatly in the field of quantum computing, quantum network, and quantum communication, and other fields. The first part of this article will talk briefly about the basic theory of quantum teleportation and the applications that have been achieved in recent years for both commercial and scientific purposes. Next, the results of current experiments and the challenges that should be overcome in the future will be presented. The final section will be a discussion about the development of quantum teleportation and its future implementations.

I. Introduction

Numerous questions about information transfer have been raised from the quantum entanglement now between EPR pairs. It is impossible to deliver information simultaneously over a long range, but it is feasible to take quantum entanglement as a protocol to encrypt information. In 1993, physicists Asher Peres and William Wootters first proposed the concept of quantum teleportation. In their paper, the way to achieve quantum teleportation could be generally explained as measuring an unknown quantum state of a system then reconstructing it at a remote location. But the teleportation is only meaningful in the perspective of quantum information for the reason that the original particle does not move physically, and the state is changed. More importantly, the process of teleportation requires two channels, a traditional one and a quantum one. The traditional channel is used to transport the result yielded from the Bell measurement. And the quantum protocol is used in the unitary transformation to retrieve the original state and information.

The 1997 quantum teleportation was first verified by Dik Bouwmeester experimentally through pairs of entangled photons. Later, it

suddenly became a hot spot in information science. Not only does quantum teleportation provide a complete secure information transmission but also it boosts the development of quantum technologies. From the perspective of traditional communication protocol, it is a revolutionary watershed. In the point of quantum technologies, it serves as an indispensable foundation. Lots of technologies like quantum gate teleportation, computing, port-based teleportation, and quantum networks are derived from the basis of quantum teleportation. Quantum teleportation has been achieved in many laboratories with different approaches. With the great progress of the experiment, some extensions of quantum teleportation have been brought to the real world for commercial and scientific purposes.

II. Theory of quantum teleportation

For simplicity, the sender and receiver will be called Alice and Bob. In the preparation process, Alice prepares an EPR pair (particle A, particle B) and particle C that carries the information which needs to be transferred. Then, Alice performs a joint measurement which is also known as Bell measurement with particle A and particle C, and gets a result that is used to transport. Since the state of particle C is changed, the technique survives the no-

cloning principle of quantum mechanics. After Bob gets the outcome of the Bell measurement from Alice through the traditional protocol, Bob can apply the unitary transformation to the result with his particle B to retrieve the state of particle A and the information contained in particle C.

What is presented in figure #1 is a basic approach to teleportation. Some components like the Bell measurement and unitary transmission are compulsory for it but the approach to achieve teleportation may be various when different setups are adopted.

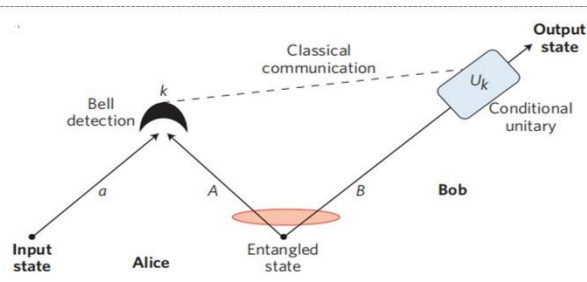


Figure #1: Theory of quantum teleportation

III. Applications

i. Quantum network

In 2016, a scientific team in China successfully achieved quantum teleportation in relatively long-range communication using the existing fiber network. Almost at the same time, the Canadian scientific team also achieved quantum teleportation independently for several kilometers using a slightly different from the previous one.

And China's 'first commercial quantum private communication network' was built for national defense, finance, and other aspects in 2017. Their success may serve as an important milestone in building an international quantum network in the real world.

ii. Quantum computing system

In 2019, IBM revealed a quantum computing system named 'IBM Q' which is the first industrial-grade system built with integrated commercial universal quantum systems for business and science applications. It is a critical step towards the quantum computing system to break off from the lab.

IV. Experimental status

i. Teleportation between light and matter

A scalable quantum network requires numerous nodes and those nodes may be far away from each other; thus, long-range teleportation is of importance.

One study demonstrates the teleportation between light and matter. In this experiment, shown in figure #2, an entangled pair is generated from the interaction between pulse and coherent atoms. In the transmitting section, the entangled light transmitted by atoms and pulse is mixed with a 50/50 beam splitter. The outcome of a Bell measurement in the form of homodyne measurements of the optical fields in the two output ports of the beam splitter is sent to the receiver through the classical channel. Results of this experiment show that the fidelity of 0.58 when $n=20$ and fidelity of 0.60 when $n=5$ is achieved, where n is the photon number.

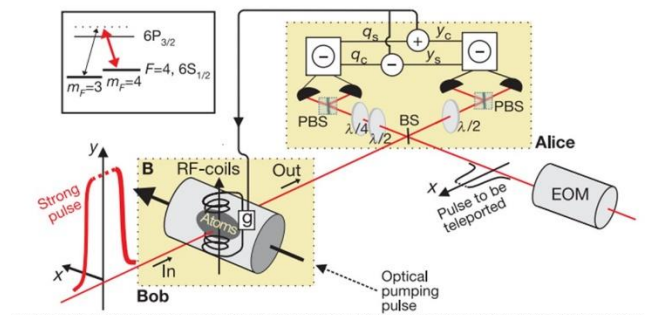


Figure #2: Setup of teleportation between light and matter

Another study focuses on diamonds. In this experiment, each node of teleportation is diamond with a nitrogen-vacancy center surrounded by carbon nuclei. And the nitrogen impurity provides a magnetic field to the electron enabling the entanglement between the hyperfine coupled electron and carbon spins under a zero magnetic field. In this study, the quantum state encoded in the emitted photon is transferred into carbon through the absorption of the electron which is entangled with the carbon nucleus on another node.

The teleportation works between a photon and the diamond serves as a bridge that connects microscopic particles and the macroscopic world.

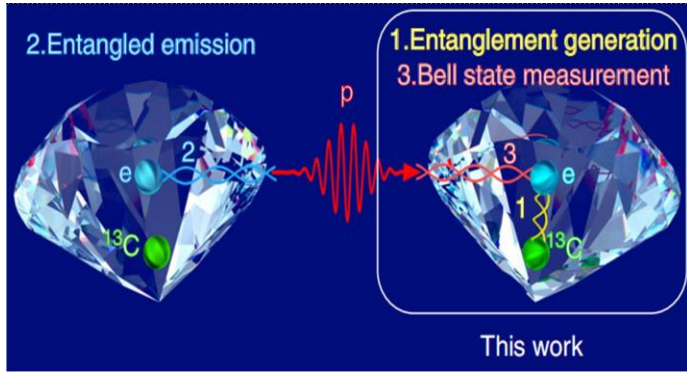


Figure #3: Process of teleportation between light and diamond

More applications could be realized in the field of quantum information technologies with the increasing size of teleportation.

ii. High dimension teleportation

As previous experiments established, most of the experiments are limited to two-dimensional teleportation. This has been a stumbling block for the development of quantum technologies. For instance, a large number of small gates are required for simple computation, which badly influences the development of multiple qubit computers. And each particle can only carry a few pieces of information, which lowers the efficiency of communication. There is one solution that can improve the performance of the communication system and reduce the number of gates in quantum circuits, and that is to improve the dimensions of quantum states.

One study reports the experimental teleportation of a qutrit seen in figure #4 and proposes a scheme for high-dimensional quantum states. In three-dimensional teleportation, the first step is producing three-dimensional entangled pair and an ancillary photon using the nonlinear crystal. And the input qutrit states used to teleport and the ancilla photon is prepared by using the polarization-dependent beam displacers manipulated by half and quarter-waveplates. Then, Alice can transmit to Bob. And Bob implements the unitary transformation to recover the original state of Alice's teleported photon and the original information that Alice wishes to

teleport. Average fidelity of 0.75 is achieved under this condition.

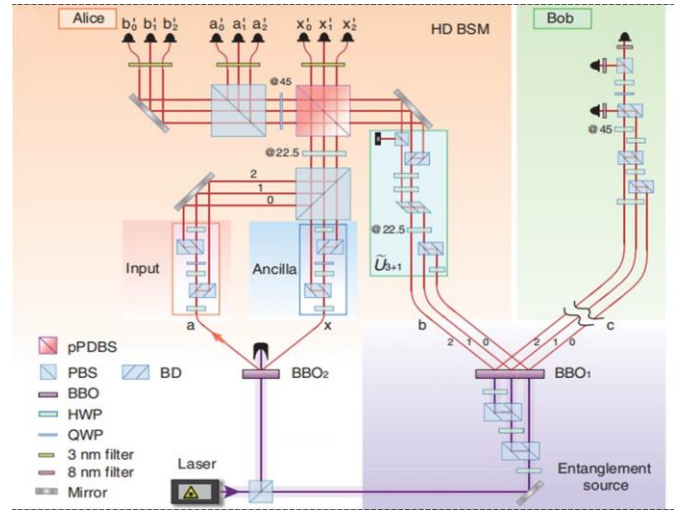


Figure #4: Experimental setup of high-dimensional teleportation

By using the scheme proposed in this paper, the quantum technologies could be extended to a higher dimension so that the efficiency of simulation and computation will be improved. The high-dimensional quantum states also mean large information contained in single-particle more capacity and noise resilience of the quantum communication system.

V. Challenges

For optimal quantum teleportation, many conditions should be satisfied.

- There is no limitation to the input information.
- The input information and output can be supplied and verified by the third party except for the sender and receiver.
- A complete Bell measurement is achieved.
- Conditional unitary transmission could be performed before the verification from the third party.
- The fidelity of teleportation should be higher than the appropriate threshold of the classical protocol.

In many cases, only a few subsets of the Bell measurement are feasible and the feed-forward is either unaccomplished or simulated in post-

processing, thus the conditions (3) and (4) are not satisfied generally.

When it comes to reality, the problem that emerged in teleportation may be slightly different. While scaling up the dimension from 2 to N, for instance, one thing that should be considered carefully is whether all N dimensions still can form a coherent superposition to maintain the teleportation intact. For genuine N-dimensional teleportation, the scheme may need to combine some hypotheses that only fit in N dimensions with some basic hypotheses that can be applied to all dimensional teleportation. There are other issues to consider like the propagation losses of light and the atomic coherence lifetime raised from the classical protocol.

VI. Conclusion

More than two decades have passed since the concept of quantum teleportation was proposed and verified. Now branches of it like quantum gate teleportation, quantum computing, port-based teleportation, photonic qubits, photonic qubits, optical modes, nuclear magnetic resonance, atomic ensembles, and trapped atomic qubits are achievable both theoretically and experimentally. The technologies mentioned above performed well in some aspects and failed in others, therefore certain technologies only correspond to a certain kind of practical situation. For example, trapped atomic qubits are appreciated in the quantum circuit for their short-term interaction, high fidelity, and relatively long quantum memory. While constructing a scalable quantum network, the atomic assembly is the preferred candidate for its long-range interactions.

Those technologies are imperfect more or less in some aspects, which raises lots of engineering questions as most of them are expected to be solved when more experiments are devised. Future aspects of quantum teleportation might focus on long-range

quantum teleportation between light and macroscopic matter or even quantum energy teleportation proposed in recent years.

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Industrial Scrubbers and Air pollution Control



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Abstract

Air pollution appears as a more straightforward problem which is facing the whole world, where it affects the ecosystem; it harms animals in general and humans in particular. As a result, scrubbers were used in industries to remove harmful chemicals and acids from polluted gas [1]. Scrubber is a waste gas treatment installation as it uses liquid to remove particulate substance or gases from an industrial use or flue gas stream [2]. In other words, scrubber is an air pollution device control, where an atomized liquid, typically water, drags particles and pollutant gases in order to successfully wash them out of the gas stream. Scrubbers can be used as an emission-limiting technique for many gaseous emissions. The two types of scrubbers, which are wet and dry scrubbers, mainly approach the same aim: achieving air pollution reduction.

I. Introduction

Every problem has its own solution and every situation must be analyzed wisely to reach a proper solution. Air pollution occurs when harmful gases enter into the atmosphere and make it difficult for plants, animals and humans to survive. Scrubbers met the technical performance standards and was used in the last decades to control the pollutant gases that emit from industries and cause air pollution. Scrubbers mainly work on transporting the components from the gas phase to the liquid phase. It was noticed that the level of gaseous particles that can reach the liquid phase is determined by the ability of these gaseous particles to dissolve in the liquid. There are distinct types of scrubbers: Wet and dry scrubbers. Wet scrubber's process forces the polluted components to pass through a wet limestone slurry which traps sulfur particles. In contrast, dry scrubbers do not utilize any liquid to absorb inlet particles. Scrubbers prove that they are an ideal solution for industries' emissions, but they also have some disadvantages. Apparently, corrosion is one of the biggest problems of the scrubber's system. Corrosion takes place in microscopic cells whenever conditions are suitable, reacts with oxygen and hydroxyl ions, and then it leads the metal to corrode.

General gas scrubbing

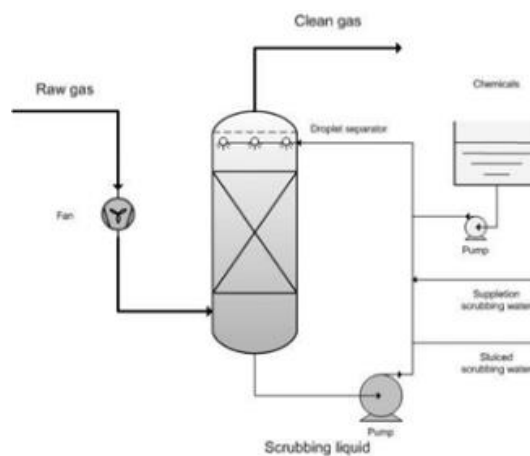


Figure #6: The structure of the gas scrubber

However, it was found that stainless steel that is used in scrubbers can cause distinct types of corrosion.

II. Mechanism

During this process, components are transferred from a gas to a liquid phase. The level of gaseous components that can permit to the liquid phase is determined by the ability of these components to dissolve in the liquid as shown in figure #1. As a result, Henry's Law was used as it is applicable to low concentrations and components with a partial pressure less than 1atm. The partial

pressure was calculated using the equation shown in figure #2 [3], where:

p = partial pressure
 x = mole fraction
 H = Henry constant

$$p = H \cdot x$$

Figure #2: Henry's Law

The importance of scrubbers lies in its ability to remove contaminants and chemicals from the process. However, scrubbers have two different mechanisms to rely on. The first mechanism involves particles wetting. This can be achieved by using the scrubbing liquid. The efficiency gets higher with smaller droplets. The smaller the droplets, the bigger the surface area for the weight of the liquid; as a result, this gives a greater chance for the particles to get wetting [4]. The second mechanism is basically the removal of the modified (wetted) particles to the collecting surface. Then, the separation of wetted particles from the carrying gas stream occurs in the inertial collector. Increasing the gas velocity or even the liquid droplets velocity in Venturi Scrubbers - a type of wet scrubbers - will ultimately increase the number of collisions per unit time. Thus, the efficiency will be increased to a greater extent. This makes venturi scrubbers operate at a very high gas

and liquid velocities with an extreme pressure drop.

III. Types of Scrubbers

There are two main types of scrubbers: Wet scrubbers and dry scrubbers. Their main use is protecting the environment by removing harmful chemicals and acids from polluted gases. Furthermore, there are multiple types of scrubbers that aim to support the process, including wet and dry scrubbers [5]. Concisely, with high efficiency and well-maintained industrial scrubbers, a facility can complete production and keep the environment and its workers protected. There are two main types of wet scrubbers: Venturi and Packed Tower scrubbers. The operating system of wet scrubbers differs from the other types of industrial scrubbers as demonstrated in figure #3, because of the liquid-gas association that increases the moisture level of the gas that is being excluded from the scrubber. The increased moisture in the gas will create a visible cloud exiting the scrubber. A venturi scrubber is a type of wet scrubbers and it designed to effectively use the energy from the entered gas stream to spray the liquid being used in order to purify the gas stream [6]. This type of devices is a part of the air pollution controls, and this together referred to as wet scrubbers.

IV. Advantages and Disadvantages

Advantages of Scrubbers can be determined by describing their uses, which are removing the contaminants from an industrial use or flue gas stream with high efficiency. Scrubbers is an ideal solution for industries' emissions, but they also have some disadvantages that are discussed below:

Advantages

1- One of the effective advantages of using scrubbers is the positive environmental impact. Actually, the removal of harmful substances from exhaust gas is important as it prevents a large number of pollutants from escaping into the air.

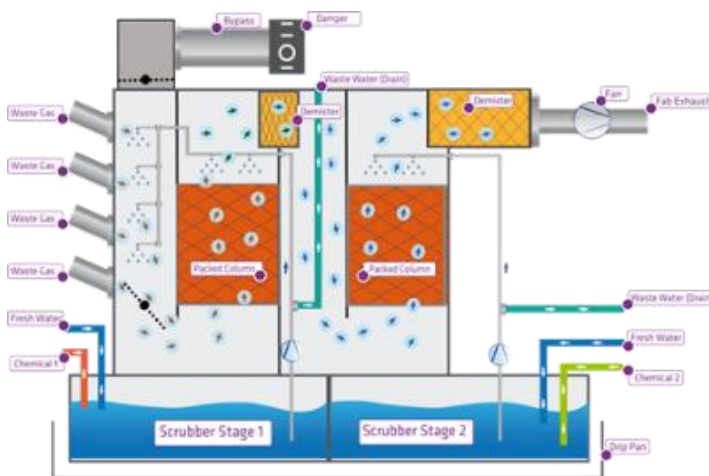


Figure #3: The operating system of wet scrubbers.

2- Developments in wet scrubbers have allowed it to increase the efficiency in pollutant removal. One of the major developments has been to take full advantage of the total surface of the liquid with which the polluted gas associates, as more surface area means that more of the particles can be singled out of the gas.

3- Dry scrubbers produce relatively little wastes. Actually, most of these materials that are sprayed into the exhaust are burned off in the heat of the stream or caught in a filter.

4- The use of dry scrubbers is not expensive as there is no linked cost with removing, transferring, and storing waste water from wet scrubbers

5- The design of the dry scrubber allows it to remove sulfur dioxide with high efficiency that can reach 98%.

Disadvantages

1- The residual waste powder that used in scrubbing must be disposed of because it is a risky material. This waste must be handled by specialists because of its chemical makeup.

2- Using scrubbers causes a high potential for corrosion problems which will cause a significant deterioration of natural and historic monuments along with increasing the risk of terrible equipment failures [7].

3- Scrubbers have a high potential to cause corrosion; as the selected materials of construction for scrubber system can be low corrosion resistant metals. As highly corrosion resistant metals can be expensive, choosing between the higher performing metals and the cost may have some consequences that lead to an economic analysis and demonstrate mainly what is gained from the both scenarios.

V. Corrosion

Corrosion has been one of the biggest problems that scrubbers cause. When metal reacts with another substance such as oxygen, it corrodes. Furthermore, it can also happen when metals are put under stress. Thus, it cracks.

Stainless steel that is used in scrubbers can cause diverse types of corrosion depending upon the nature of the agent. Corrosion actually takes place in microscopic cells wherever conditions are suitable. The typical conditions for corrosion are imperfections in metal surfaces, metal exposed to electrolytic solutions, and obviously, the presence of chemicals in solution that can react with the oxygen and hydroxyl ions.

VI. Conclusion

As a matter of fact, the effects of air pollution are alarming. They are known to create several respiratory and heart conditions along with cancer and other threats to the human body.

Scrubbers have two main types: Wet and dry scrubbers. Those two types of scrubbers approach achieving air pollution reduction through different mechanisms. Using scrubbers to remove harmful chemicals and acids from polluted air made it much easier to reduce air pollution. Scrubbers appear as an ideal solution for industries' emissions. However, it causes corrosion which is one of the biggest problems of the scrubbers as in most cases, they use stainless steel.

VII. References

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