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MENTAL FATIGUE: WHAT HAPPENS WHEN YOUR BRAIN IS TIRED?

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Have you ever felt tired after a day at school? That feeling you get from doing tasks that need a lot of attention and focus is called mental fatigue. Scientists created tasks in their laboratories to study this feeling. They observed that when we are mentally tired, both our thinking abilities and physical performance become worse. Scientists are not exactly sure why this happens, but mental fatigue can cause changes in the brain. One small brain region located in the front of the brain, called the anterior cingulate cortex, becomes less active when we are mentally tired. This can make us feel like we do not want to put as much effort into doing things, and that is why our performance declines. The good news is that scientists found ways to reduce mental fatigue. Paying attention to the present moment, listening to music, doing physical exercise, or having caffeine can make people feel better.

WHAT IS FATIGUE?

FATIGUE

Fatigue makes it hard to do engage in activities because it is a feeling of being really tired.

Fatigue is a familiar sensation that everyone has experienced at some point in their lifetime. Symptoms of fatigue include a decrease in some abilities and an increase in the feeling of tiredness. Fatigue is widespread in society. For example, a recent study in Korea estimated that 31% of people suffer from fatigue.

Some illnesses or injuries, such as traumatic brain injuries, can cause fatigue that lasts for a long time. This is called chronic fatigue. But other times fatigue may appear quickly, as after intense physical exercise. Physical activities such as running, cycling, or swimming can cause the body to feel fatigue. But have you ever felt tired after a day of classes or work, even though you barely moved your body at all? The fatigue that comes from completing mental tasks that require concentration and attention is called **mental fatigue**.

MENTAL FATIGUE

Mental fatigue makes it difficult to participate in activities due to feeling exhausted after concentrating and paying attention to a task.

MAKING THE BRAIN TIRED

All activities of daily life that require attention and concentration can cause mental fatigue. However, to better understand what mental fatigue is, researchers need to recreate this sensation using laboratory tasks.

The laboratory tasks involve the ability to pay attention for long periods, the ability to switch from one task to another, and the ability to ignore irrelevant information. A long time ago, researchers used math problems to make people feel mentally tired, but now they have other fun games like the AX-Continuous Performance Task (AX-CPT) or Stroop task. For the AX-CPT, participants are presented with a series of cards and they must respond based on specific rules. If the first card shows the letter "A" and the last card is an "X," the participant must say "Yes." For all other combinations, the participant must say "No." This game challenges participants to pay attention, remember the rules, and respond quickly (Figure 1A). In the Stroop task, participants see words written in colors, but the tricky part is that the color of the ink does not match the word's meaning. For example, the word "blue" might be written in red ink! The challenge is to say the color of the ink as quickly as possible, not the word itself. It can be tricky because the participant's brain may want to say the word instead of the color (Figure 1B).

As these are not tasks that we do in our daily lives, other more realistic tasks have been studied, such as long drives or extended smartphone use. It has recently been shown that using a smartphone, for a long time ($\geq$30 min), especially for social networking, can cause mental fatigue.

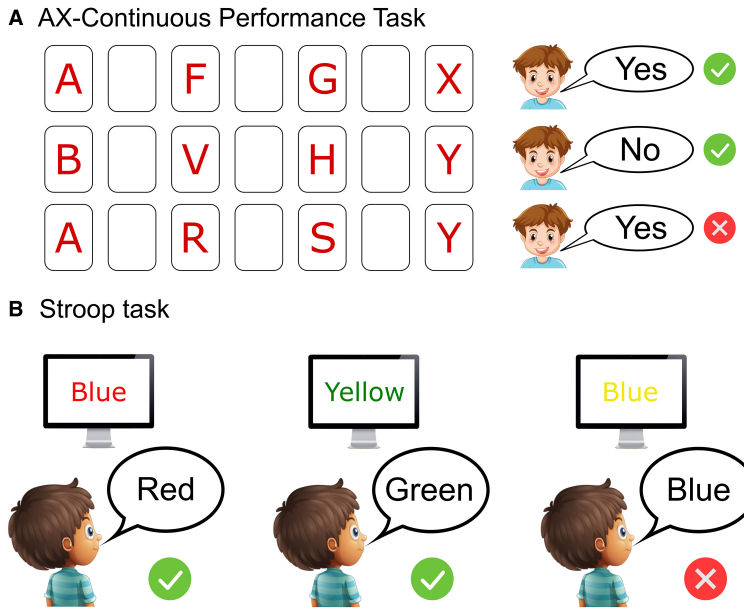

Figure 1

Figure 1

Two laboratory tasks currently used to cause mental fatigue. **(A)** In the AX-Continuous Performance Task, participants must say "Yes" only when the combination begins with the letter "A" and ends with "X." For all other combinations, participants must say "No." **(B)** In the Stroop task, participants must say the color of the ink. The green checks indicate correct responses, and the red crosses indicate wrong responses.

EFFECTS OF MENTAL FATIGUE ON BRAIN PERFORMANCE

Have you ever noticed your attention fading at the end of a day of classes, or that you are making more mistakes? These effects are related to the negative influence of mental fatigue on your **cognitive performance**, which is how well your brain does things like pay attention, solve problems, and make decisions. When we get mentally fatigued, it can affect how well we can focus and concentrate on things that require a lot of thinking. Imagine you are doing a math problem that takes a long time to solve—at least 30 min. As you work on it, your progress might start to slow down or you might make more mistakes. The same thing can happen if someone drives a car for many hours without stopping—their reaction times can become slower, making driving more dangerous and increasing the chance of an accident.

COGNITIVE PERFORMANCE

Cognitive performance is how well your brain does things like pay attention, solve problems, and make decisions.

But decreased performance during cognitive tasks does not always happen. Sometimes people can still do a good job even when they feel mentally tired. One reason for this is motivation. When we strongly desire to do well, we can push ourselves to use more effort and energy, even when we are mentally fatigued—so we can keep performing at our best [1].

When our brains get really tired, it can make it harder for us to do certain things. For example, if you play a video game after a long day at school, you might not do as well as if you played on a Saturday morning after getting a good night's sleep. This happens because when we are mentally fatigued, it can affect our attention. It becomes

more challenging to stay focused and react quickly to the game's unexpected events. Mental fatigue can also make it more difficult to ignore distracting things that do not matter, make decisions, and switch between different tasks. All these effects can make it harder for us to do our best in our daily activities.

EFFECTS OF MENTAL FATIGUE ON PHYSICAL PERFORMANCE

As mentioned earlier, mental fatigue can negatively impact cognitive performance, but can it also affect physical performance? For example, if you go to a sport training session in the evening after a day of school, will you perform less well? To answer this question, let us take the example of soccer. Performance in a soccer game depends on several abilities: the ability to run as fast as possible, the ability to run multiple times during the game, and the accuracy of passing, dribbling, and shooting.

Your ability to run as fast as possible depends on your capacity to produce a lot of force. To examine the effects of mental fatigue on the ability to produce force, we asked participants to squeeze a handle as hard as possible, or jump as high as possible without a running start, before and after a mentally fatiguing task. We showed that participants' strength was the same before and after a mentally demanding task. It seems that mental fatigue does not, therefore, affect the body's ability to produce a lot of force.

Your ability to run fast multiple times during a game depends on **endurance**, which is the capacity to keep exercising for a long time without getting tired. To evaluate endurance, we asked people to run or bike a certain distance as quickly as possible. When people are mentally fatigued, they take longer to cover the given distance. This happens because being mentally fatigued can affect how much endurance people have. Researchers noticed that when people are mentally fatigued, they feel like the task is harder and that it requires more effort. Scientists use a scale from 6–20 to measure the feeling of effort. When a person is mentally fatigued, the same exercise (e.g., running at 12 km/h for 10 min), feels like it takes more effort, so the exercise seems more difficult (Figure 2).

ENDURANCE

Endurance is the capacity to persist in an activity for an extended period, even when it becomes difficult.

Passing, dribbling, tackling, and shooting are important technical skills used when playing soccer. However, when you are mentally fatigued after performing a difficult or long cognitive task, you may make less accurate passes, dribbles, and tackles and weaker shots on goal. Mental fatigue can therefore reduce your technical abilities and make you perform less well in a soccer match.

To summarize, mental fatigue affects some aspects of physical performance, but not all [2]. It seems to decrease endurance and

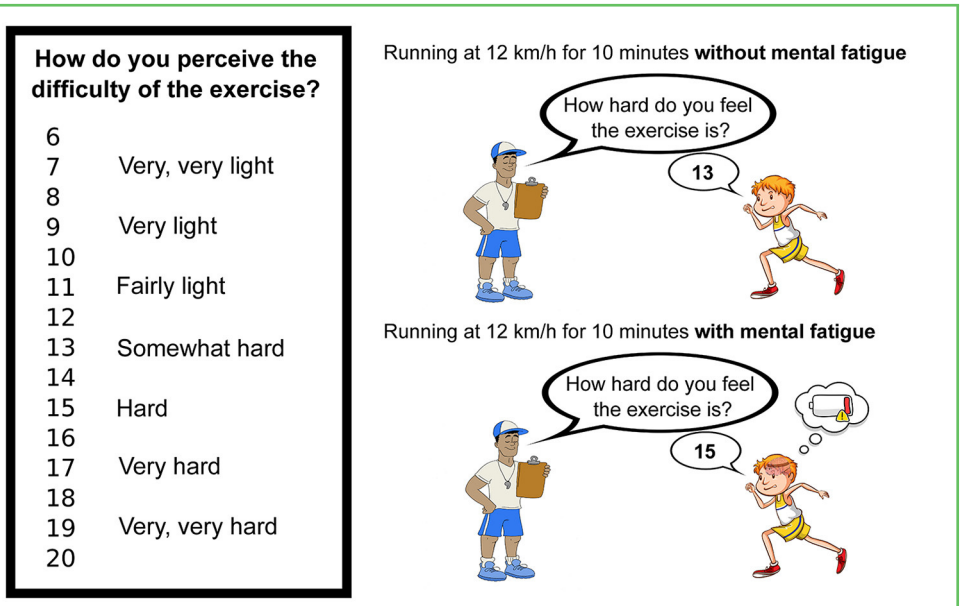

Figure 2

Representation of the subjective scale used to evaluate the perception of effort, and an example of the effect of mental fatigue on the perception of effort. When people are mentally fatigued, they feel like physical tasks are harder. A difficultly scale ranging from 6–20 can be used to assess the amount of effort people feel they are using to complete a physical task, like running at a given pace for 10 min.

technical capacities, but does not affect the ability to produce a strong force (Figure 3). Although soccer was used as an example, mental fatigue will alter performance at all sports involving endurance and/or technical abilities, such as basketball, badminton, or cycling for example.

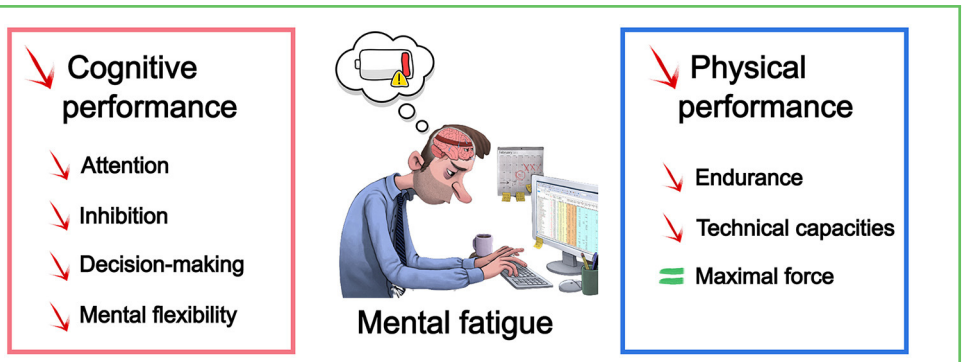

Figure 3

Mental fatigue affects both cognitive and physical performance. Inhibition is the ability to ignore unimportant information. Mental flexibility is the ability to switch from one task to another.

ANTERIOR CINGULATE CORTEX

The anterior cingulate cortex is the part of your brain, located in the front of the brain, that helps you make choices, anticipate positive results, and manage your emotions.

DOPAMINE

Dopamine is like a happy and excited messenger in your brain, called a neurotransmitter, that makes you feel good.

WHY DOES MENTAL FATIGUE ALTER PERFORMANCE?

Scientists have done a lot of research on the brain to understand how being mentally fatigued affects us. They discovered that several parts of the brain work together to make us feel tired. One essential part is called the **anterior cingulate cortex**, which is located in the front of the brain [3]. This region helps us do important things like make decisions, expect good things to happen, and control our feelings. However, when we are mentally fatigued, the anterior cingulate cortex does not work as well, which makes it difficult for us to focus and do well in tasks. One reason for this is that a chemical called **dopamine**, which

helps the body send messages between nerve cells, is reduce when we are mentally fatigued. This reduction in dopamine levels affects how the anterior cingulate cortex works and makes it harder for us to do our best when we are mentally fatigued.

CAN WE BEAT MENTAL FATIGUE?

Now that you understand why mental fatigue reduces cognitive and physical performance, you might be wondering whether we can fight mental fatigue. The good news is that several strategies have been shown to be effective. Caffeine is currently the most studied strategy and appears particularly good at fighting mental fatigue. However, not everyone can consume caffeine (for example, kids), and when consumed in excess, caffeine can cause problems like insomnia, headaches, and anxiety. So researchers have found that other strategies, such as **mindfulness**, listening to music, and physical activity, are also effective in combating mental fatigue [4].

MINDFULNESS

Mindfulness allows us to hit pause in your thoughts, helping you focus completely on the present moment.

The powers of these fatigue-fighting strategies are believed to be due to their positive impact on dopamine production. For example, drinking coffee, practicing mindfulness, listening to music, or engaging in physical activity all stimulate dopamine to be released in the body, which can balance the reduced activity in the anterior cingulate cortex. This can help combat the decline in performance caused by mental fatigue, improving the ability to focus, make decisions, and perform complex tasks.

CONCLUSION

Mental fatigue is when your brain gets tired from doing something that requires much thinking and focusing for a long time, like studying or playing a challenging game. It can make you feel like you have less mental energy and affect how well you pay attention, make decisions, and ignore things that do not matter. Sometimes, mental fatigue can even make it more likely for accidents to happen, like when people get tired while driving. It can also make it harder to do some physical activities, like running or doing sports moves correctly. When you are mentally tired, certain brain parts become less active because of a chemical called dopamine. But do not worry! You can do some things to help your brain feel better when it is tired. Drinking something with caffeine, listening to music, or going for a walk can give your brain a little boost and combat mental fatigue. So, if you ever feel mentally fatigued, try one of these things to help your brain feel refreshed and ready to go again!

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CONFLICT OF INTEREST: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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