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## Forum

### Magic for the blind: are auditory tricks impossible?

Gustav Kuhn <sup>1,\*</sup>, Tyler Gibgot<sup>2</sup>, Cyril Thomas<sup>3,4</sup>, and Vebjørn Ekroll<sup>5</sup>

**Many magic tricks rely solely on vision, but there are few, if any, that rely on auditory perception alone. Here, we question why this is so and argue that research focusing on this issue could provide deeper theoretical insights into the similarities and differences between our senses.**

#### Introduction

Magic is an art form that allows us to experience the impossible. At the core of any magic trick lies a conflict between the things that we experience and the things that we believe to be possible [1]. There is an abundance of tricks that rely solely on vision, but there are few, if any, tricks that rely on auditory perception alone (Box 1). Here, we raise the question of why this is so and argue that research focusing on this could not only provide deeper theoretical insights into the similarities and differences between our senses, but also make the art of magic more accessible to people with blindness. (See Box 2.)

#### Distinguishing magic tricks from perceptual illusions

Perceptual illusions occur when our subjective experience differs from reality. In some instances, we can point out this discrepancy and we become aware of the illusory experiences. However, we are often oblivious to such illusory experiences. For example, if you listen to a cyclic sequence of sounds known as the Shepard tones [2], you will experience

the sounds as continually increasing in pitch for as long as you listen to the sequence, although, in reality, the same sequence is being repeated over and over again. Unless you have additional information beyond what you hear, there is no way to know that you are experiencing an illusion. Thus, perceptual illusions do not in themselves imply any conscious awareness of conflict, but magic illusions do. Moreover, you can continue to experience a perceptual illusion even if you understand its true cause. This is not the case for magic.

Magic tricks are characterized by illusory experiences of impossibility that arise from a conflict between what we experience and our beliefs about the world. Since impossible things never actually happen, magicians rely on exploiting perceptual and cognitive illusions to create the illusion of impossibility. Awareness of these cognitive limitations allows people to attribute the phenomena to their own cognitive failures and, thus, eliminates the illusion of impossibility. Therefore, failures of metacognition [3] are central prerequisites for creating magical experiences. Magic tricks often exploit perceptual illusions, but they are underpinned by distinct cognitive mechanisms.

#### Why are auditory magic tricks rare?

There are countless auditory illusions [4], but auditory magic tricks are surprisingly rare. We conducted a thorough review of the magic literature and interviewed eminent magicians about the existence of magic tricks that solely rely on nonverbal auditory perception (Box 1). We also challenged magicians to come up with a magic trick based on non-verbal auditory perception, and we are still waiting for a suitable contender. Why might it be so difficult to come up with a purely auditory trick?

The lack of auditory magic tricks may simply reflect a lack of tradition [5]: since vision provides a perfectly suitable sensory

domain, there may simply be no need to perform magic for the other senses. However, magicians are extremely creative [6], and we do not believe that the lack of auditory magic tricks simply reflects a lack of creativity on the magicians' behalf. Thus, it is more plausible that the lack of auditory tricks points to crucial differences between vision and hearing in their suitability for evoking magical experiences (i.e., illusions of impossibility), but what might these differences be?

One possibility is that although there are plenty of perceptual illusions and failures both in the auditory and the visual domain, we are intuitively more prone to regard failures of vision as impossible compared with analogous failures in hearing. According to this hypothesis, sighted people could rely more on vision than on other senses when navigating the world. This visual dominance may lead us to trust what we see more than what we hear, making us more surprised when our vision deceives us compared with when our hearing does. For example, visual change blindness and inattention blindness took visual scientists and the public by surprise because we do not expect to miss seeing things that are right in front of our eyes. This is probably the reason why Simons and Chabris' gorilla illusion [7] has been viewed more than 45 million times on YouTube. This paradigm was designed to be a direct visual analog of the dichotic listening task, a paradigm frequently used during the 1950s to study auditory attention [8]. In the auditory domain, we also often fail to notice unattended stimuli (e.g., people do not notice when the voice in the ignored channel changes to a different language) [8]. According to our hypothesis, trusting our vision more than our hearing would make us less surprised by inattentional deafness than by inattentional blindness. Thus, when faced with an experience that contradicts our beliefs, we are more likely to attribute it to a perceptual failure rather than to a magical cause in the

### Box 1. Magic tricks that involve hearing

There are many magic tricks that involve hearing, but they are either supported by other senses or rely on language.

- Tricks involving sound: tricks in which surprising things happen to sound. For example, the spectator rings a bell that either emits a sound or is silent. Even though this trick involves sounds, it relies on other sensory signals (visual and haptic) for us to experience it as a magic trick.
- Mentalism/verbal magic: the magician talks to the audience and extracts information or makes predictions about future events. Such tricks are amodal, and do not rely on specific sensory experiences. Other examples involve situations where the listener is instructed to perform the actions that are necessary to create the magic effect themselves.

case of hearing than with vision. False beliefs about the validity of our sensory experiences are central to magic, and the lack of auditory magic tricks may point toward cross-modal differences in meta-cognition. Both our eyes and ears are easily

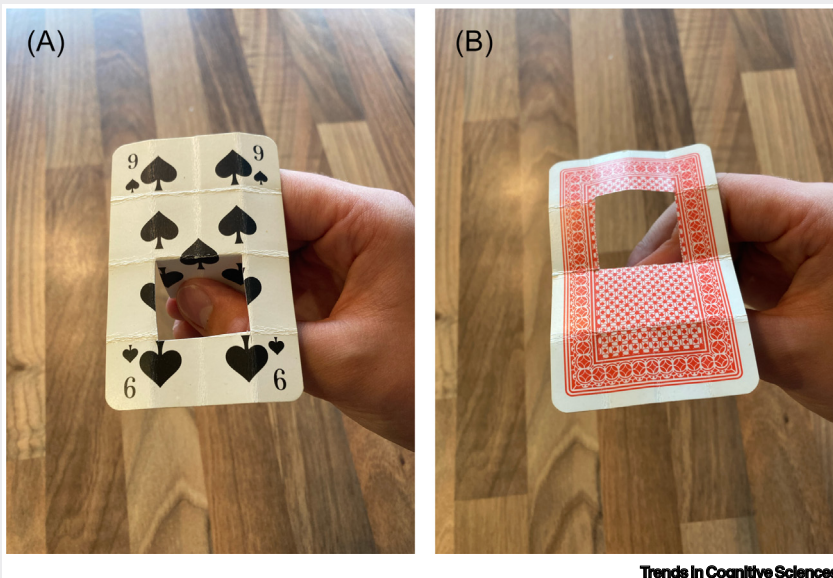
fooled, but we are perhaps more surprised by failures in visual perception than by failures in auditory perception.

It may be more difficult to create a conflict with other strong beliefs about states of

the world by relying on auditory perception rather than on visual perception. Vision and hearing both help us make sense of our environment, but these senses provide different information about the state of the world. Our eyes register light that is reflected from an object, and we use this information to infer about the physical properties as well as changes to the world. Our visual system can access a continuous representation of the physical world, and bats do the same through echolocation. Conversely, human auditory signals generally register auditory happenings, rather than the state of the world. If an object disappears from our visual representation, it appears to disappear from our world. Conversely, sounds are transient, and a sound that ceases to exist simply implies that the object stops vibrating, not that the object disappeared. Many existing magic tricks defy our understanding of object properties (e.g., objects disappear, appear, change color, etc.), and our visual system provides valuable information about such object properties. Visual objects are also perceived as being more solid and tangible, and they should not appear or disappear unexpectedly. By contrast, auditory objects are more ephemeral and can vanish naturally, such as a tone that disappears at the end of a song. Visual information also provides us with more direct representations of the world. For example, we do not say that we see the visual representation of an apple; we simply see the apple. By contrast, with sounds, we are more likely to say that we hear the sound of a trumpet, rather than the trumpet in itself. It is possible that audition simply does not provide sufficient information about the state of the world to elicit the illusion of impossibility we experience when witnessing a visual trick.

### Box 2. Magic based on illusions in the mind's eye

It is rare to adapt a visual trick to another sense. A recent study [5] suggests that some traditional tricks can be adapted for non-visual presentation because they rely on illusions of visual imagery rather than on visual illusions. Thus, while these tricks are traditionally presented relying on the sense of vision, vision has no integral role in creating the magical experiences they evoke, and can be replaced by touch as a vehicle of presentation. As an example, Figure 1 illustrates Robert Neale's classic trapdoor card trick, where a card with a 'door' cut out is magically turned inside-out while a member of the audience holds on to the door. The reason why this trick evokes a magical experience is that the necessary transformation of the card, although physically possible, is difficult or even impossible to visualize in our mind's eye. This trick can be presented to a person with blindness by using a card made of sandpaper (which is rough on one side and smooth on the other, such that the difference between the two sides of the card can be felt instead of seen).



**Figure 1. Robert Neale's trapdoor card trick.** In Robert Neale's trapdoor card trick, a card is magically turned inside out, such that the side that is up in (A) is down in (B) and vice versa, although the spectator never lets go of the door.

### Concluding remarks

Studying cross-modal differences in magic raises intriguing questions about the relationship and limits that our various

senses have with our representation of the state of the world, as well as the role of our meta-beliefs in the interpretation of associated perceptual failures. It also invites us to investigate whether principles that deceive the eye can also fool the ear.

Magical experiences form an important part of learning about the boundaries between the possible and impossible. Since magic is typically visual, it prevents individuals born with blindness from ever witnessing such experiences. Developing nonvisual magic tricks not only fosters inclusivity, but also offers a unique opportunity to explore how such beliefs about the impossible are formed.

In conclusion, the observation that purely auditory tricks are rare or even nonexistent points to potentially fundamental differences between vision and hearing with

regards to their potency in creating the kind of strong conflicting beliefs that are the hallmark of a magical experience.

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#### Declaration of interests

The authors have no interests to declare.

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