THE SPORTS ISSUE

THE SCIENCE OF F1

In honor of the release of the F1 Movie, let's talk about the science of real-life F1 racing.

Much like airplanes, F1 cars rely on aerodynamics to achieve high performance on the track. Engineers consider lift, drag, downforce, and more when designing these magnificent cars. The vehicles need to counteract lift, a force that pushes the cars upwards. Thus, the front of each car has wings that generate downforce and also guide air underneath the car. With too much lift, it is difficult to ensure that the cars have enough grip and stability, which makes racing less safe; that's why the wings are so important.

The halo is a tubelike structure enclosing the cockpit of an F1 car, which protects drivers in the case of a collision. The halo is made out of titanium, a light material that can withstand thousands of pounds of pressure. The design of the halo allows for flex and deflection, or warping, which helps to absorb impact energy. The halo has saved the lives of numerous drivers, including the F1 movie's producer, Lewis Hamilton, when he crashed

with Max Verstappen in 2021.

Any F1 fan knows that tires are a large part of racing strategy. Teams look to get the maximum grip out of tires, or the maximum friction between the rubber of the tires and the road. Tires need to be at an optimal temperature. Too cold, and the tires are stiff; too hot, and the tires degrade. Teams use tire blankets to heat tires up to around 70 degrees Celsius before races, so they have maximum grip via adhesion.

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Source: F1.com

HOW DO SWIMSUITS REPEL WATER?

By: Lucia Mastroianni

In the summer, one of the most exciting things to do is put on a swimsuit and relax in a pool or the ocean. But why is there a specific fabric that is better for the water?

While normal clothes normally contain a blend of cotton, wool, and linen which has hydrophilic properties, swimsuits are made of synthetic materials such as polyester, and elastane which are all hydrophobic materials. Hydrophilic describes molecules that easily bind with water and hydrophobic describes molecules that repel water. These properties are determined by polarity and intermolecular forces. Water's strong hydrogen bonding causes polar/charged substances to dissolve easily in water (hydrophilic), while nonpolar substances clump together to avoid water (hydrophobic).

Molecules can be polar meaning they have uneven charge distributions. This is often due to electronegative atoms like oxygen or nitrogen bonded to less electronegative atoms like hydrogen, creating partial positive and negative charges called dipoles. These dipoles

can then form strong hydrogen bonds (dipole-dipole interactions) with water molecules, effectively dissolving. But molecules without this polarity are unable to make these dipole-dipole interactions with water molecules.

Polyester is one of the main materials used in swim wear today. Polyester's hydrophobic nature in swimsuits comes from its backbone consisting of carbon and hydrogen atoms, forming long, nonpolar chains. Unlike natural fibers (like cotton) with hydroxyl (-OH) groups that readily form hydrogen bonds with water, polyester does not have many hydroxyl groups preventing significant water absorption. This chemical composition causes swimwear to be quick drying, reduced drag, and lightweight performance in water. Another common material in swim wear is Elastane fibers which are segmented block copolymers made up of flexible polyester chains. This material similarly lacks hydroxyl groups causing it to be less likely to bond with water.
Temperature is also a key component of how repellent a material is to water. After getting out of the pool on a really hot day, it can be observed that a swimsuit will dry much faster than in colder weather. This is not only because of the heat causing water evaporation from the swimsuit but also because of the molecular changes in the swimsuit. Increasing temperature generally strengthens hydrophobic interactions (making nonpolar molecules cluster more) and weakens hydrophilic ones (disrupting H-bonds in water).

So, next time you go swimming, observe how your swimsuit glides in water and think back to the underlying hydrophobic chemistry of the material.

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THE SCIENCE OF HOCKEY

By: Franesca Master

Winter means freezing temperatures and icy conditions. It also means that it is officially hockey season. Hockey has long been one of the hallmarks of winter sports, its fast-paced action giving delight to fans. Most spectators don't realize just how fundamental physics is to the sport, shaping how players skate and how the puck is used. In this article, we will reveal the hidden science of hockey.

One of the most essential parts of the game is the puck. Hockey pucks are made of vulcanized rubber and are frozen between games to reduce their elasticity, helping to keep them on the ice. Puck speeds can go over 100mph in a slapshot. To start a slapshot, the player must raise the stick, which is designed to accelerate the puck from a force created by the player's swing, behind their body (image 1). After the player strikes the ice behind the puck and uses their weight to bend the stick, storing energy like a spring. The face of the blade strikes the puck ,and the player shifts their weight and rotates their wrists to release the stored energy, transferring it into the puck. As a result, the puck's speed

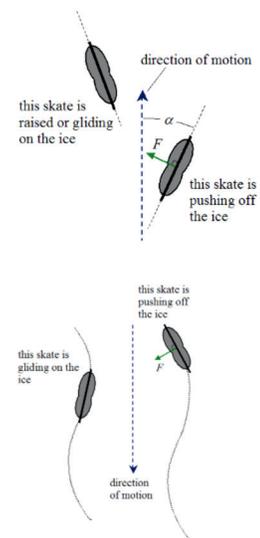Image 1   Image 2   Image 3
Notice the bend in the stick

becomes much faster than it would if the player just hit the puck normally. "The kinetic energy of the puck after impact is equal to the stored energy in the hockey stick." (image 2)

The ice skates on the players' feet help the players to move. The shape of hockey skates, a tip that's two points separated by a slight groove, helps the skaters glide easily across the ice, due to their low friction. The compression from narrow skates melts the ice, helping the player to move without effort.

The physical makeup of the ice makes it easy for players to turn, speed up, and stop. The friction of the ice is almost zero, so the only way to propel yourself forward is by pushing off the ice with a force perpendicular to the skate blade. (image 3)

While smooth surfaces increase speed, friction allows players to accelerate and decelerate quickly and move more laterally. In order to gain speed, the skater must push off with the blades at an angle away from the direction of motion. On the other hand, to slow down, players dig their skates into the ice to oppose the direction of friction. While skating, players must balance while moving quickly and work with friction.

Players skate backwards to avoid turning their backs to

to the opposite team, making a gliding pattern of a lazy 'S". However, this makes it so players can't skate as fast since they can't push off as hard against the ice. (image 3)

Hockey is an exciting and action-packed sport that millions enjoy every winter. Physics shapes nearly all parts of the game, creating the hockey we all know and love. Next time you step on the ice, or just attend a game as a spectator, you'll understand this unique game.

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FSB FUN FACTS: SPORTS

FSB Staff

From the Olympics to the Super Bowl, everyone's minds seem to be on sports. In this issue of FSB Fun Facts, we will pull back the curtain and reveal how science shapes sports. From tennis to frisbee, golf to surfing, physics plays a role in these games.

How does the spin of a tennis ball influence its trajectory?

Spin is one of the most important aspects of tennis because it allows a player to control the flight path of the ball. The spin on a serve can cause a ball to float in the air, curve sideways, or dive. The Magnus effect, which describes the interaction between a moving object's spin and a fluid (air), explains how spin influences a ball's trajectory. When a spinning ball moves through the air, the ball drags some of the air around with it. The drag on the side of the ball turning into the air slows the airflow, while speeding up the airflow on the other side of the ball. The pressure is higher on the side of the ball where airflow is slowed, which forces the ball toward the lower-pressure area on the opposite side. Topspin causes the trailing air to flow upward, which pushes the ball down. Backspin causes the trailing air to flow downward, which pushes the ball up and helps it resist the force of gravity.

Which forces influence the flight of a Frisbee?

Drag, lift, and spin all play a role in a Frisbee's flight. Lift, which is explained by Bernoulli's Principle, allows the Frisbee to stay airborne. The curved shape of the Frisbee causes the airflow above it to travel at a higher velocity than the airflow underneath. This creates lower pressure above and higher pressure below the Frisbee. The pressure difference provides lift. Drag, which is perpendicular to lift, acts against the Frisbee's movement through the air. The angle at which the Frisbee is thrown affects both lift and drag. To fly well, a Frisbee needs enough

lift and not too much drag. Without spin, a Frisbee would flutter to the ground like a leaf. Spinning helps keep the Frisbee stable by supplying angular momentum–the faster the spin, the more stable it is. This phenomenon is known as gyroscopic stability, which refers to the tendency of a rotating object to maintain its orientation and resist changes in its axis of rotation. This is due to the angular momentum generated by the rotation, which creates a force that opposes any external torque attempting to alter its direction.

How do the dimples on a golf ball influence its flight?
The dimple patterns of a golf ball influence trajectory, peak height, angle of descent, and overall distance. Dimples reduce drag while the ball is in the air; this influences airflow and increases lift, helping the ball travel farther with a more stable trajectory. The shape, depth, edge angle, and number of dimples all play a role; shallower dimples result in a higher trajectory, and deeper dimples result in a lower trajectory. Golf balls are designed to achieve specific flight profiles. According to Titleist, when its engineers design balls, they make adjustments as precise as 2/10,000 of an inch—roughly the size of a red blood cell—to maximize a golf ball's aerodynamic performance.

What influences the height and distance of a football punt?

When a punter kicks a football, they control the speed at which the ball leaves their foot, the angle of the kick, and the rotation of the ball. The ball's velocity and kick angle are the primary factors determining how long it remains in the air, how high it goes, and how far it travels. If a ball is kicked at a steep angle, it has more velocity in the vertical direction than in the horizontal direction. As a result, the ball will go high and have a long hang-time, but it will only go a short distance. If the ball is kicked at a shallow angle, it will have more horizontal velocity than vertical velocity—the ball will not go very high and will have short hang time, but it will travel far. The rotation of the ball also plays a role. It impacts air drag, which influences the rate at which the ball slows down in flight. A spiraling kick has less air drag than an end-over-end kick, so it does not slow down as much and can stay in the air longer and travel farther.

What forces influence the movement of a surfboard?

When a surfer is at rest on their board waiting for a wave, the gravitational force pulling the board down and the buoyant force pushing the board up are equal and opposite. As the wave gets near, the surfer paddles to match the wave's speed. As the surfer catches the wave, the surfboard accelerates. The board forms an angle with the water, creating pressure on its underside that forces the surfboard out of the water and causes it to skim the surface. The increased forward momentum makes the surfer more stable, enabling them to stand up and surf the wave. The position of the surfer's body also influences the movement of the board. The fins on the surfboard allow a surfer to alter their speed and direction as they reposition their weight.

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THE EFFECT OF APPARENT MOTION ON PERCEPTION OF FACIAL ORGANIZATION

Cristina Ellis

Abstract:

Motion detection is ancient and essential for survival, sometimes causing us to see motion where it doesn't exist. Apparent motion happens when static images are shown quickly in a sequence, making us perceive movement, like in a flip book. This type of motion perception is processed at a "low level" in the brain, meaning it's fast, automatic, and unconscious. Like motion cues, faces are also processed rapidly and automatically; however, faces are processed holistically (shape and color are important). Humans are born with the capacity for face perception and automatically detect facial organization. This experiment will test the limits of facial organization by attempting to use motion cues to separate elements of the face from each other. We hypothesize that when smiling human faces are flashed in sequential order, participants will perceive the apparent motion of the smiles. We will test this using the object preview benefits. Participants will view eight faces aligned in a grid (seven faces will be neutral, and one will be smiling). A letter will appear on a face, then disappear. Afterwards, the smiles will rotate. Once the rotation is concluded, a second letter will appear over the mouth of a face, which may or may not be the same face that was the last to smile. Participants will be asked, "Was the second letter the same or different from the first letter?" The mean response time for incongruent trials was longer, regardless of whether the letter was the same or different. The P-values indicate statistical significance since they are far smaller than 0.05. Since the means were significantly different, we can conclude that people were tracking the motion of smiles across the faces. If people were tracking the smiles across faces, then participants perceived apparent motion, which substantiates our

hypothesis. Motion cues processed at a low level are able to override facial organization cues processed at a high level.

Introduction:

Motion detection is a very ancient form of vision due to its importance for survival. For this reason, we even perceive motion when it does not occur. One example of this is when stationary objects are viewed in rapid succession, the illusion of motion will occur - this illusion is referred to as "apparent motion" (Antis and Mackay 1980). One such example of apparent motion is a flip book. Although each of the individual images viewed is static, due to the reader's rapid flip through the pages, it appears as one continuous movement. This apparent motion is perceived on a "low level." Low-level perception is the set of neural-based computations building unconscious or self-generated inferences while processing sensory events (Fregnac and Bathellier 2015).

Object files, temporary mental representations that track objects across space and time, are essential to motion perception and tracking (Kahneman, Treisman, and Gibbs 1992). These object files allow us to predict where something will be based on where it was, even if we can no longer see it.

For example, when watching a game of tennis, we unconsciously create an object file for the tennis ball so we can understand that the ball that was hit from one side of the court is the same ball that appeared on the other. When a non-visible object reappears, we will still expect it to be the same ball we saw previously, although it was briefly missing, which is called object persistence (Kahneman, Treisman, and Gibbs 1992). Object files rely more on spatiotemporal information, where something is at a specific time, in space, than surface features such as color and shape. If, in the tennis game, the ball was green when hit but then appeared purple on the other side of the court, humans would still be more likely to mentally represent it as the same ball than if it had remained the same color but

suddenly switched direction mid-air. Whenever object files are violated, humans are surprised by the violation of their expectations and thus need to update their mental representation of the object.

Like motion cues, faces are also processed rapidly and automatically in visual systems. In contrast to motion, however, faces are processed holistically (i.e., face features are all processed simultaneously rather than being processed as distinct parts of the face), and surface features such as shape and color are more important to face perception than spatiotemporal information.

Faces are among humans' most critical social stimuli due to the robust information they provide in social settings. By looking at a face, one can gain crucial information regarding the age, gender, emotional state, intention, and identity of the person with whom they interact (Falk et al. 2001, 463-481). Due to their importance, faces have long been believed to be processed via high-level perception, which processes complex data at an abstract, conceptual level. High-level perception allows humans to view a chaotic environment and organize stimuli into various mental representations (French and Hofstadler 1991).

A large body of literature suggests that humans are born with the capacity for face perception and automatically detect facial organization (i.e., two eyes, a nose, and a mouth) (Longmore et al. 2010). This experiment will test the limits of facial organization by attempting to use motion cues to separate elements of the face from each other.

Since apparent motion has already been tested many times, a lot is known about how various visual factors affect it. The most relevant visual factors to this experiment are the object's size, color, contrast, shape, and topology.

If the proportion of the size between two objects is greater than 0.5, viewers will see the shapes as in phase, and thus perceive motion. If the ratio is less than 0.5, the shapes will be out of phase, and no motion will be seen. The motion will be seen since the faces will all be of

similar size and a ratio greater than 0.5 (Heuer 1987). In this experiment, the faces will be close to each other, so the color will affect perceived motion, but since the lips will be a similar shade, it will strengthen the illusion rather than disrupt it.

There are two different conditions for color and its effect on apparent motion. When the shapes are close together, any color change will disrupt perceived motion (Kolers and von Grünau 1976); color doesn't affect apparent motion when the shapes are further apart (Antis and Mathers 1985). Through various tests, scientists have discovered that the stronger the contrast between the object and the background, the stronger the apparent motion will be (Antis and Mathers 1985). The lips of the smiles will all be pink, which will contrast with the skin tones of the face. People of all races and varying skin tones were used for this experiment, so that may affect the apparent motion seen in individual test runs of the experiment.

Shape has little to no effect on the apparent motion: motion between disparate pairs of shapes is seen just as frequently as between like shapes (Kolers and Pomerantz 1971). Since the shape is unimportant, varying shapes of the stimuli's lips (i.e., heart lips, downturned lips, full lips, thin lips...) will not affect the motion seen by subjects.

Topology is the visual factor with the most potent effect on apparent motion. Apparent motion is more likely to be seen when the initial and final object contains the same number of "holes." When there is an object on the first screen (for example, a black circle with no holes) and two objects on the second screen equally spaced from where the initial object was (a black triangle and a circle with one hole), motion is more likely to be seen between the object with the same topology, even if its shape is changing (i.e., the black circle with no hole will travel and shapeshift to become the black triangle on the second screen). (Zhou et al. 2010). Smiles will all have the same topology, a pink shape (the lips) with one white hole (the teeth).

Visual Factor	Conditions
Size	- Ratio of 0.5 or less → AM Detected - Ratio of greater than 0.5 → No AM detected
Color	- When shapes are close together, a change in color disrupts the AM - When shapes are spaced out, color doesn't affect the AM
Shape	- Minimal effect on AM
Topology	- AM is seen between shapes with the same number of holes. - AM is more likely to be seen between two disparate shapes with the same number of holes than two of the same shape with different numbers of holes.
Contrast	- The contrast between the background increases AM perception

Table 1: A summary of the Visual Factors of AM

If the visual factor list is accurate, then we should be able to use apparent motion as a means to separate the facial elements. We hypothesize that when smiling human faces are flashed in sequential order, participants will perceive the apparent motion of the smiles. All the necessary visual factors needed for the apparent motion to be perceived will occur.

Methods:

We will test this using the object preview benefits. On each screen, participants will view eight faces aligned in a grid (seven faces will be neutral, and one will be smiling). First, a letter, either a "P" or a "Q," will appear over the mouth of the smiling face for 35ms. Then, the smile will rotate clockwise or counterclockwise across the faces. Each smile during the rotation will be shown for exactly 35ms. Once

the rotation is concluded, a second letter, "P" or "Q," will appear over the mouth of a face, which may or may not be the same face that was the last to smile. Participants will be asked, "Was the second letter the same or different from the first letter?" To indicate the same, they will click the "j" key; to indicate different, they will click the "f" key.

There will be eight different conditions for the experiment:

The first case will have the smile rotate clockwise, appear on the same face as the final smile, and use the same letter as the one at the beginning.

Accordingly, the other cases are:
- Clockwise/different face/same letter
- Clockwise/same face/different letter
- Clockwise/different face/different letter.
- Counterclockwise/same face/same letter
- Counterclockwise/different face/same letter
- Counterclockwise/same face/different letter
- Counterclockwise/different face/Different letter.

The experiment will be a full-screen experiment programmed on Psychopy. The faces will be programmed so that the faces appear the same size on all computers, so their size will be standardized across different-sized computers.
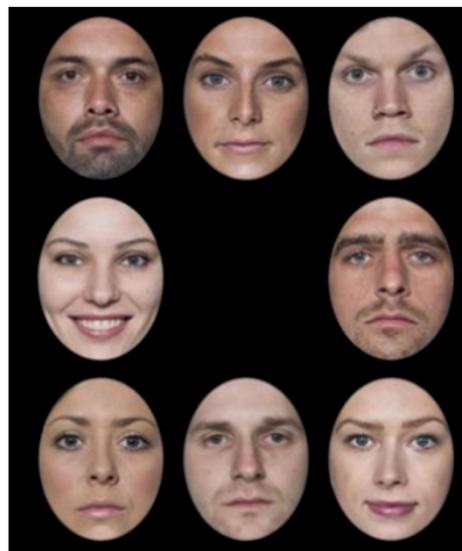
Results:
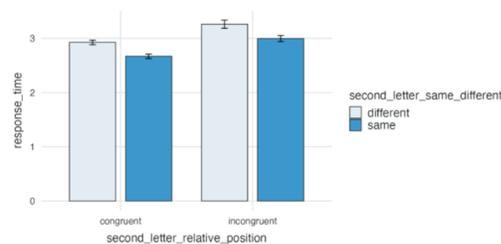
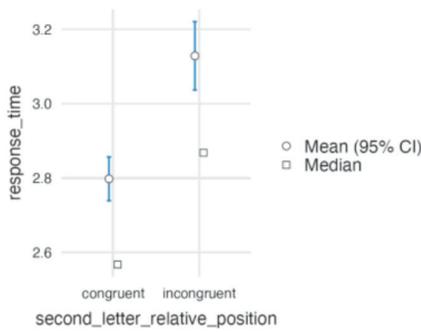*Figure 1: The mean response times for the different conditions*

Figure 2: The mean and median response times for congruent and incongruent trials.
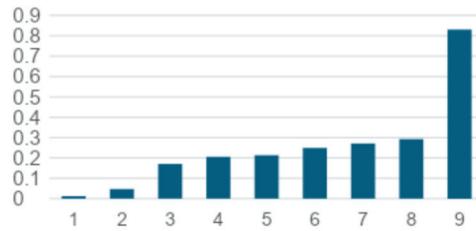

Figure 3: The mean difference in response time (s) between congruent and incongruent trials
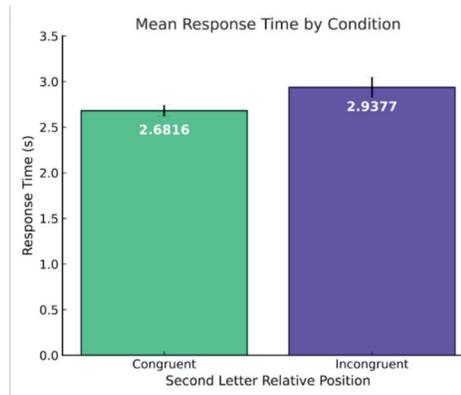

Figure 4: The mean response times by condition

Table 1

Differences in response time between congruent and incongruent second letter positions.

second letter position	M	SD	t	p	Cohen's d	95% CI for d
Congruent	2.68	0.20	-3.23	0.01	-1.07	[-2.95, -0.80]
Incongruent	2.94	0.37				

Note. M and SD represent mean and standard deviation, respectively.

Table 1: T-test comparing the difference in means and Cohen's d comparing the effect size of the differences. The means are significantly different and differ by approximately one standard deviation.

Average of response_time	second_letter_relative_position	
trial_block	congruent	incongruent
block_1	2.752798791	3.092491931
block_2	2.694920912	2.979273759
block_3	2.676190986	2.882117795
block_4	2.612316541	2.842108139
Grand Total	2.683067357	2.949995229
	t.test p-value	0.003011621945

Table 2: A T-test run on the overall average response time for congruent and incongruent conditions. The differences are considered statistically significant when a P value is less than 0.05.

Discussion:

We hypothesized that when smiling human faces are flashed in sequential order, participants will perceive the apparent motion of the smiles; the data we collected supported this hypothesis. The mean response time for participants to accurately identify whether the letters were the same or different was longer for the incongruent trials, indicating that people were subconsciously tracking the motion of the smiles. The mean response time for incongruent trials was longer, regardless of whether the letter was the same or different. When we ran a t-test on the average time to accurately identify the letter during the congruent trial and the average time to identify the letter during the incongruent trial, we received a p-value of 0.003. Since the p-value was below 0.05, statistical significance was indicated. Since the means were significantly different, we can conclude that people were tracking the motion of smiles across the faces. If people were tracking the smiles across faces, then participants perceived apparent motion, substantiating our

hypothesis. Motion cues processed at a low level can override facial organization cues processed at a high level.

One data point of note is that the median response time for all trials was far lower than the mean response time (FIG. 2). This indicates that there were extreme outliers, which is substantiated by FIG. 3. As we can see, it took Participant 9 more than half a second longer on average than other participants to identify incongruent trials. This extreme outlier will drive up the mean time to identify the letter, as seen in Figure 2.

One alternative hypothesis for why motion was perceived is that participants saw a smile not attached to any of the faces, traveling around and covering the neutral mouths. Our hypothesis is that people see the face's lips contouring into a smile. This hypothesis suggests a separate autonomous smile, covering the neutral lips belonging to the face. Still, this would mean that people saw a separate smile, which should not be possible due to facial
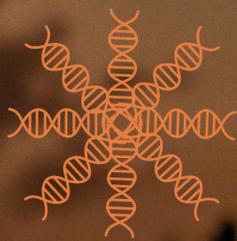
20

organization. This theory also doesn't account for the fact that a smile isn't only relegated to the mouth portion of the face; smiling causes one's eyes to crinkle, cheeks to appear fuller, and dimples to become more prominent. Therefore, the explanation that low-level motion cues overrode the high-level facial organization is still the most logical.

There were several potential sources of experimental error. One such error is the lack of racial diversity in the face pictures used for this experiment. We chose to use all white people so we could ensure that we had the strongest apparent motion effect possible, as color was one of the critical visual factors. This choice could have predisposed participants to seeing motion. Another significant flaw in our experiment design was the fact that we allowed participants to complete as many trials as possible within 20 minutes. Since some participants completed more trials, their results are given more weight than those of other participants. Luckily, it appears like our results were

not severely affected by this; all of our participants completed between 191 and 193 trials. (Participant 1 completed 193, Participant 2 192, Participant 3 192, Participant 4 192, Participant 5 191, Participant 6 193, Participant 7 191, Participant 8 191, Participant 9 193). Still, it is necessary to correct this flaw in future experiments, where participants may not have such a similar number of trials.

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