COMMENTARY

Expert violinists can't tell old from new

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In PNAS, Fritz et al. (1) follow up their groundbreaking 2012 paper with what will probably be the final nail in the coffin for those who would believe that old musical instruments sound demonstrably better than new instruments. Their study used six prized instruments, Stradivari and Guarneri "del Gesu" violins, and six modern violins. World class violinists who were literally blind to provenance (the violinists wore goggles that dramatically reduced their ability to see) were given two opportunities to play them: in a small salon and in a concert hall. They were allowed to bring a friend to act as a second judge. Their task was to rank order the violins in terms of desirability and to label them as old vs. new. These highly trained and highly discerning musicians utterly failed at detecting old vs. new and showed no consistent preferences.

The study balanced rigor with real-world considerations and represents the most ecologically valid conditions possible while maintaining strict experimental protocols. Yet, intriguingly, the participants themselves remained unconvinced, even after having seen the results with their own eyes (or heard them with their own ears). Said one, "the one thing that you cannot put into a new violin is that it's been played for 300 years—these instruments change and develop." Said another, "I would absolutely buy a new instrument, but for a later generation. They need to be broken in" (2).

Why is it that musicians and scientists reach different conclusions when considering the same data? This arises in part due to different ways of knowing things. Scientists know what they know through systematic observation of the external world, mediated by replicable experiments and objective measurement. Artists know what they know through emotional experience, subjectivity, and intuition. When they disagree, each appeals to his or her own internally stable and coherent system. Scientists embrace rationality; artists cite the ineffability of experience and the limits of scientific knowledge. However, it would be a mistake to say that scientists' way of knowing is superior. Scientists haven't written *Messiah* or *The Rite of Spring*. Artists' intuitions and the meandering, nonlinear path of inspiration yield results that could not have been gotten any other way.

Some musicians espouse decidedly nonscientific views, such as the existence of spirit guides (3) or the idea that certain musical instruments are superior to others based on their age and heritage, who built them, and who played them previously. So famous is one line of old violins that the word Stradivarius has entered the popular lexicon. Students and amateur musicians everywhere, at some point in their lives, have harbored the thought that if only they could get their hands on such a masterpiece instrument, they would sound like their musical heroes. However, Fritz et al. clearly demonstrate that these venerated older instruments are indistinguishable from well-made contemporary ones.

What's going on then? Why does the folk belief that old instruments sound better persist? A cognitive explanation is that this phenomenon represents the influence of top-down processing, that is, expectation-driven perception, as opposed to stimulus-driven perception. Top-down processing was perhaps most compellingly demonstrated by Stroop (4) and later by Biederman et al. (5), and Palmer et al. (6). More recently, top-down processing has been demonstrated in the reading of musical notation (7), emotion regulation (8), and in the restoration of speech intelligibility among cochlear implant users (9). Top-down processing is well known to change perception, as demonstrated in a number of visual illusions, such as Kanizsa's illusory triangles (Fig. 1) (10).

In experiments with illusory boundaries such as these, most people report seeing a white triangle pointing up on top of a black-bordered white triangle pointing down. However, a true bottom-up, stimulus-driven perspective reveals that there are no triangles drawn; the triangle is an illusory perception created by a brain trying to make sense of the apparent coincidence of occlusions and contours. Based on Helmholtz's notion of unconscious inference (11), the brain evolved in a world with certain physical properties and regularities. It is highly unlikely that there exist three disks with notches cut out of them in a Pac Man configuration and three angled line segments positioned just so that they would appear like this. In a 3D world, far more likely is that these are circles partly occluded by something lying on top of them, giving rise to the very strong impression, if not perception, of two triangles.

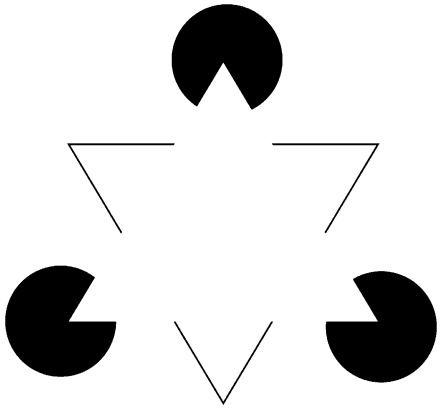

Fig. 1. Kanizsa's illusory triangles, demonstrating top-down or expectation-driven processing. Most observers report seeing two overlapping triangles. Careful inspection of the figure reveals that no triangles are actually drawn, they are only implied.

Top-down processing is not just a convenient fiction in a cognitive box model. Expectations have been shown to retune neural circuits, increase perceptual sensitivity to particular targets, and cause firing patterns consistent with what people report seeing or hearing rather than what they are actually being presented (12–14).

In short, simply knowing that an instrument has a certain pedigree or history could activate expectations for its sound that cause neural circuits—even lower level sensory-perceptual ones—to behave differently than they would without that knowledge. We may really believe that they sound better, even if there is no acoustic difference in the distal world.

The results of Fritz et al. neatly parallel those of investigators studying the inability to discriminate fine wines from cheap ones and even red wine from white. Setting aside some of the methodological problems that exist in many wine competitions (15), wine experts have been shown to be no more accurate in distinguishing wines under blind test conditions than regular wine drinkers (16). In one particularly ambitious study, expert wine assessors were studied over a 15-y period for

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internal consistency, and their test-retest scores accounted for a measly 25% of the variance (17). In another sample of 6,000 blind tastings, the correlation between price and rating was small and negative. That study concluded that the wine recommendations of experts were a poor guide for consumers (18).

If top-down processing is so error-prone, why did it evolve? Probably for reasons of cognitive economy and because most of the time, as a heuristic, it works. Top-down, expectation-driven processing makes sense in a 3D world in which occluders frequently block our view of physical objects. It's evolutionarily advantageous for our sensory systems to fill in such missing information, such as when viewing a crouching tiger whose torso is partly obscured by tree trunks; survival requires that it be perceived as a single entity encompassing those parts that are not visible. Similarly, speech is often encountered in reverberant or noisy environments, with a great deal of the speech stream masked or otherwise occluded. It's important in such situations that we don't waste time. If what you hear someone yell is "Look out there's a #ark near you!" (where # represents a masked phoneme), one's chances for survival are vastly improved by perceiving "shark" rather than asking the speaker to repeat himself, or hearing "lark" or "park" (19).

One of the more interesting aspects of top-down processing is perhaps that we can't shut it off. Knowing the principles at work in the Kanizsa illusion above doesn't mean that they stop working. Certain interventions can tilt the balance, however. Nicotine can increase stimulus-driven detection and vigilance (20). Systematic training can also lead to improvements in bottom-up processing, such as when audio engineers and musicians are taught to hear specific frequency components of an auditory signal (21).

Because artists rely so heavily on their own experience, studies like this have historically fallen on deaf ears—"I know what I know because my senses tell me so" may be the refrain of those who are skeptical of scientific methods. An artist's knowledge comes from his or her own subjective impressions, influenced as they are by labels and expectations, and for many reasons, we want this to be so. Art is not meant to replicate science but to recontextualize the world for us, to show us new perspectives, and to communicate emotional propositions—all things that science is not as good at doing. Although this experiment is unlikely to change many musicians' minds, Fritz et al. accomplish a great deal by meeting artists on their own terms, by conducting a study with maximal ecological validity and a minimum of "laboratory-like" distractions. For those artists who are open-minded enough to allow the scientific method in, the findings are loud and clear and should put an end to speculation and rumor and the outrageously high prices charged for musical instruments that are, even to experts we now know, indistinguishable from their less expensive counterparts.

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