Sight over sound in the judgment of music performance

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Edited by Dale Purves, Duke-National University of Singapore Graduate Medical School, Singapore, Singapore, and approved July 12, 2013 (received for review December 21, 2012)

Social judgments are made on the basis of both visual and auditory information, with consequential implications for our decisions. To examine the impact of visual information on expert judgment and its predictive validity for performance outcomes, this set of seven experiments in the domain of music offers a conservative test of the relative influence of vision versus audition. People consistently report that sound is the most important source of information in evaluating performance in music. However, the findings demonstrate that people actually depend primarily on visual information when making judgments about music performance. People reliably select the actual winners of live music competitions based on silent video recordings, but neither musical novices nor professional musicians were able to identify the winners based on sound recordings or recordings with both video and sound. The results highlight our natural, automatic, and nonconscious dependence on visual cues. The dominance of visual information emerges to the degree that it is overweighted relative to auditory information, even when sound is consciously valued as the core domain content.

social perception | cognition | decision making | evaluation | communication

We do judge books by their covers. We prefer the nicely wrapped holiday gifts (1), fall in love at first sight (2), and vote for the politician who looks most competent (3). Daily life is littered with examples of how visual information can have a powerful effect on social cognition, ranging from interpersonal perception to consumer judgment (4–7).

In music, however, it is auditory information that defines the domain. Hiring committees have embraced "blind" screenings (8) not only out of the pursuit of fairness, but also in response to critics who disparage those who prioritize visually stimulating choreography over the composer's intended sound (9, 10). Professional musicians consistently report that sound is the most important information in the evaluation of music (11). After all, the foundation of the field was built upon the creation of a better sound; ear-training classes are part of the core curriculum at major conservatories, and performance is evaluated during auditions.

Given the wide consensus that sound is central to judgment about performance in music (12), our judgments should be limited if we are denied access to sound. Although people often make evaluations quickly on the basis of visual cues (4–7, 13, 14), these cues have traditionally been neglected (15) and discounted as peripheral to the meaning of music (16). However, people can lack insight into their own preferences and cognitive processes (17–19), or be unable or unwilling to report their beliefs (20, 21). These findings suggest that there may be gaps between what we say we use to evaluate performance and what we actually use. People may be unlikely to recognize or admit that visual displays can affect their judgment about music performance, particularly in a domain in which other signals are deemed to be more indicative of quality.

Using real competition outcomes, this series of experiments empirically tests the impact of visual information on expert judgment. In highly competitive arenas such as music, competitions emerge as one launching pad for establishing careers. With these important decisions at stake, professionals are sought for their expertise to identify the best. Indeed, no matter what domain, the judgment of performance occupies a key area of investment. Experts are trained and societal institutions are constructed to identify, develop, and reward the highest levels of achievement. We trust that professionals can judge performance through their specialized knowledge; these are the leaders who are responsible for shaping the landscape of the future of their fields. In music, we expect that professionals would critique the sound of music.

However, research points to the influence of visual information on the perception and processing of sound (22, 23), extending even to the domain of music (16, 24). Given that the literature suggests that either audition (25–27) or vision (28–30) may dominate, and that the two modalities can be complementary (31–35) and share many similarities in their cognitive processing (36, 37), these experiments offer a direct comparison of the extent to which auditory versus visual cues affect our evaluations and decision making. It may be that, regardless of training, knowledge, and theories about the meaning of music, experts are just as vulnerable as novices to certain heuristics—ones that may be at odds with what is valued by the field.

Honing in more specifically on the music psychology literature, there has been great interest in investigating performance evaluation and expert evaluators with more precision (38). As a host of factors that contribute to performance assessment have not been well understood or considered (19), a fuller understanding of the evaluation process holds great promise. The role that auditory versus visual information plays in performance evaluation is of particular interest to researchers, practitioners, and educators. It thus becomes more surprising that, with some exception (39), there has been relatively insufficient empirical research to justify definitive conclusions (38). An understanding that is grounded in empirical research lends itself not only to the possibility of more objective evaluation processes, but also to the crafting of more effective performance.

With the general consensus on the importance of sound in the domain of music, as "an art of sound" (40), it follows that experts and key decision makers would privilege auditory-related rating in professional evaluation and assessment, even when such items show insufficient reliability (41–45). However, despite all that is invested in the auditory domain, low interrater correlations suggest that such basis of evaluation is an unreliable process. The increasing interest in investigations of the role of visual information in evaluation (24, 39) dovetails well with recent calls for the need to include the visual component in music performance

Author contributions : C.T. designed research, performed research, analyzed data, and wrote the paper.

The author declares no conflict of interest.

This article is a PNAS Direct Submission.

Freely available online through the PNAS open access option.

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This article contains supporting information online at www.pnas.org/lookup/suppl/doi:10.1073/pnas.1221454110/-/DCSupplemental.

(46) and the authenticity that this modality specifically communicates through expressive behavior (47).

The current research uses a two-pronged approach: (*i*) the experimental design offers high test power and tight control over variables of interest, allowing for better substantiated conclusions, and (*ii*) the use of field data with real decision processes and outcomes addresses external validity and relevance for a broad range of contexts that involve performance evaluation. Given the questionable reliability of expert ratings based on audio-only information, and the recent works demonstrating the substantial role of visual information (8, 22, 24), it may be that a visual dominance would emerge above and beyond the impact of auditory information.

In this set of experiments, participant responses were used to extrapolate the evaluation processes of the original expert judges and determine which cues—visual or auditory—were most influential for their decisions in arriving at the real-time results of live music competitions. Given different versions of competition performances, 1,164 participants in total were asked to identify the actual competition winners. These choices were then compared against the established outcomes, previously decided by panels of expert judges (*SI Text*). As a domain in which sound is central to what experts and novices alike value about performance, music offers a strong test of the impact of visual information on the judgment of performance.

Results

Experiment 1: Core Beliefs About Music. Suppose that you have the chance to win cash bonuses if you can guess who won a live music competition. You may choose the type of recording you think would give you the best chance at winning the prize. You can select sound recordings, video recordings, or recordings with both video and sound. Which recordings do you choose? In experiment 1, participants were asked to make exactly that decision and bet their study earnings on their choices.

As expected, 58.5% chose the sound recordings, significantly more so than the 14.2% who chose video recordings, $\chi^2(1, n = 77) = 28.89$, $P < 0.001$. Despite a "tax" levied on selecting the recordings with both video and sound, 27.4% still chose those recordings, a significantly larger proportion than those who chose the video recordings, $\chi^2(1, n = 44) = 4.46$, $P = 0.035$. People have the intuition that sound is a more revealing channel of information in the domain of music and that recordings with both visual and auditory output offer additional and more relevant information that better approximates the conditions under which the original expert decisions were made (*SI Text*).

Experiments 2–5. In experiments 2–5, the top three finalists in each of 10 prestigious international classical music competitions were presented to participants. Given such difficult decisions (*SI Text*), untrained participants should fare no better than chance (33%) in identifying the winners of these competitions. In fact, even expert interrater agreement tends to be moderate, hovering at an average of 67%; consensus is notoriously absent (48).

Novice participants. In experiment 2, novice participants were presented with both video-only and sound-only versions of 6-s clips of the top performances from international competitions. Although 83.3% of participants reported that the sound mattered most for their evaluation of music performance, these same participants were significantly more likely to identify the winners when they were presented with only the visual components of the performances, $t_1(105) = 12.07$, $P < 0.001$; Cohen's d = 1.18 (Fig. 1). The item analysis indicated that the effect held across all 10 competitions, $t_2(9) = 4.37$, $P = 0.002$. Indeed, with silent video-only recordings, participants were significantly above chance (52.5%), $t(105) = 10.90$, $P < 0.001$. With sound-only recordings, they were significantly below chance (25.5%) at identifying the winners, $t(105) = -5.23$, $P < 0.001$.

As seen in experiment 1, participants believed that recordings with both video and sound would allow them to best approximate the original expert judgments. Is it the case that more information necessarily leads to better judgment? Experiment 3 tested judgment when more information was available, and presented participants with video-only, sound-only, or video-plus-sound versions of the performance clips included in experiment 2. Participants performed below chance with sound-only recordings (28.8%), $t(66) = -2.09$, $P = 0.040$, and at chance with video-plus-sound recordings (35.4%), $t(67) = 0.94$, P = not significant (n.s.). However, with silent video-only recordings, 46.4% of novices were able to identify the winners, $t(49) = 4.04$, $P < 0.001$.

These findings suggest that novices are able to approximate expert judgments, originally made after hours of live performances, with brief, silent video recordings. However, when novices were also given the sound of the performances through the video-plus-sound recordings, they did no better than picking a winner at random (*SI Text*). As surprising as these findings are, they may be

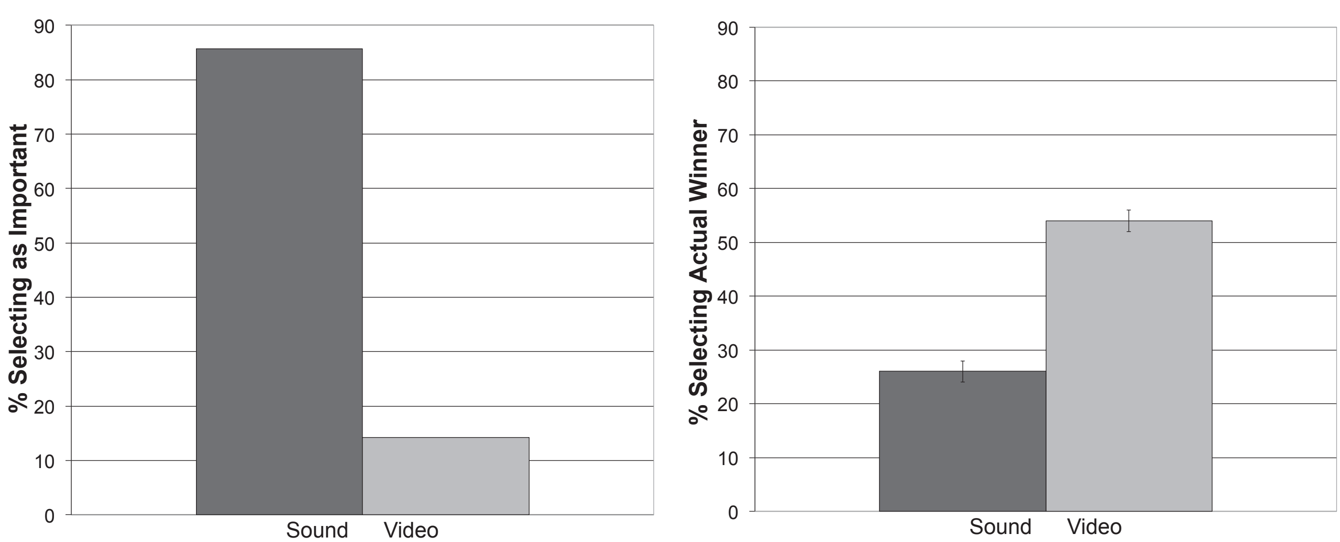

Fig. 1. A comparison of the reported importance of sound vs. visuals for evaluation (*Left*), with the % novices identifying actual competition outcomes when given sound-only vs. video-only stimuli (*Right*), in experiment 2 ($n = 106$).

due to novices' lack of music training, which forces them to rely on visual cues.

Expert participants. Using the same sets of competition clips and paralleling the design in experiments 2 and 3, experiments 4 and 5 explored whether the dominance of visual cues remains in domain experts. Professional musicians have the knowledge and training to discern the quality of performance through sound; they should be able to outperform novices in identifying the actual winners. Although the assumed superior judgment of experts is dependent on domain and context (49, 50), these musicians had participated in and judged competitions and are familiar with how professional judgment is determined.

In experiment 4, 96.3% of domain-expert participants reported that the sound mattered more for their evaluations, $\chi^2(1, n = 27) = 23.15, P < 0.001$. Despite musicians' training to use and value sound in their evaluations, only 20.5% of experts identified the winners when they heard sound-only versions of the recordings, $t(34) = -6.11, P < 0.001$. However, 46.6% did so upon viewing silent video clips, $t(34) = 4.05, P < 0.001$. Those with video-only stimuli performed significantly better, compared with those who heard sound-only stimuli, $t_1(34) = 5.89, P < 0.001$; Cohen's d = 1.01 (Fig. S1). An item analysis indicates that this effect held across all 10 competitions, $t_2(9) = 3.74, P = 0.005$.

In experiment 5, 82.3% of professional musicians cited sound as the most important information for judgment, $\chi^2(2, n = 96) = 103.56, P < 0.001$. However, when provided sound, only 25.7% of experts were able to identify the actual winners (Fig. 2), a rate worse than chance, $t(29) = -3.34, P = 0.002$. With video-only stimuli, musicians performed significantly better than chance (47.0%) at identifying the actual winners, $t(32) = 3.40, P = 0.002$. Experts were significantly better with video-only stimuli than with sound-only stimuli, $t_1(61) = 4.48, P < 0.001$; Cohen's d = 1.20. An item analysis indicates that these effects were robust across all 10 competitions, $t_2(9) = -2.36, P = 0.04$.

In the third condition in this experiment, when provided with stimuli with both video and sound, experts were again at chance (*SI Text*) at 29.5%, $t(39) = -1.43$, P = n.s. They were not significantly better than those who received sound-only stimuli, $t(48) = 1.33$, P = n.s. Those who received video-only stimuli, even compared with those who received both video and sound, were still significantly more likely to approach the actual outcomes, $t(71) = 3.72, P < 0.001$.

Experts were not significantly different from novices in their judgments of music performance. Novices and experts are similarly below chance with sound recordings and at chance with recordings with both video and sound. Novices and experts also paralleled each other in their use of different cues to arrive at the competition outcomes made by the original judges, with no significant differences through the sound-only recordings, $t(95) = 0.85$, P = n.s.; the video-plus-sound recordings, $t(106) = 1.68$, P = n.s.; nor the video-only recordings, $t(81) = -0.12$, P = n.s.

In supplemental tests of the primacy of visual cues, additional studies featuring the same between-subjects design as experiments 3 and 5 replicate the findings outlined in this paper with 3-s and 1-s recordings. The at-chance findings with sound-only and video-plus-sound recordings remain even with longer time intervals ranging up to 60-s recordings. These results suggest that the findings outlined in the current experiments remain meaningful for more extended periods of evaluation.

These results demonstrate how visual information, the information generally deemed as peripheral in the domain of music, can be overweighted when such inclination is neither valued nor recognized. Ironically, this tendency results in our neglect of the most relevant information: the sound of music. What then are novices and experts paying attention to when making their judgments? The next two experiments examine the mechanisms that account for the primacy of visual cues and our dependence on visual information. The studies explore the types of visual information that are used in judgment and how motion, emotion, and apparent motivation contribute to professional inferences about the quality of music performance (*SI Text*).

Experiments 6 and 7: Mechanism. Movement and gesture are elements of performance that are primarily visual. Experiment 6 examined whether motion impacts the professional judgment of music performance. In this study, recordings were distilled to their most basic representation as outlines of motion (Fig. S2). After seeing these 6-s silent clips of the three finalists, participants were asked to identify the actual winners. Participants were significantly better than chance (48.8%) at identifying the outcomes, $t(88) = 6.49, P < 0.001$. Viewing brief motion alone allowed an approximation of professional judgment made after hours of live performance with both visual and auditory information.

The importance of dynamic visual information to professional judgment was further established through two supplementary experiments (*SI Text*). Although demographic cues such as race and sex have been associated with various capabilities (51, 52), such as the quality of musicianship (8)—and although the many advantages of physical attractiveness have been documented (53), from hiring (54) to income (55)—these static visual cues did not significantly impact professional judgment in these competitions.

Visual information may be powerful through its associations with expressive behavior (16, 56) and through its emotional impact. Professional musicians may value novelty (57), involvement

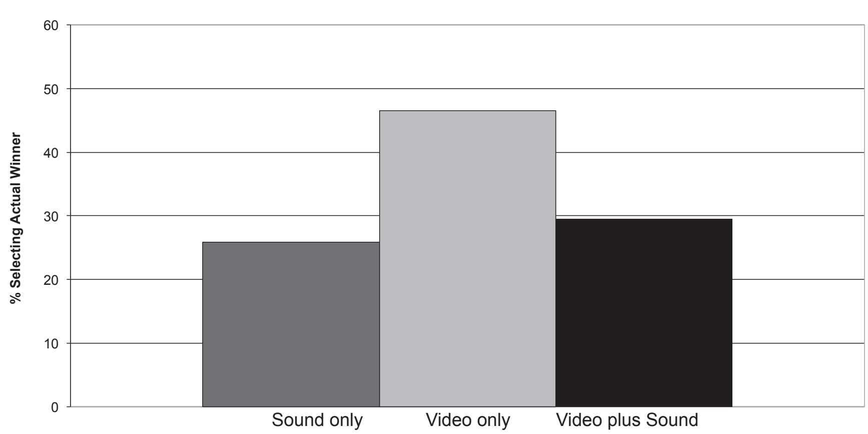

Fig. 2. The % professional musicians identifying actual competition outcomes given sound-only, video-only, or video-plus-sound stimuli, in experiment 5 (n = 103). Thirty-three percent indicates an identification rate at chance.

(58), motivation, and passion (59) as essential to the quality of creative performance. These attributes may be more visible than they are audible. Furthermore, observers not only may perceive nonverbal cues, but also may experience more intense emotional changes and foster greater interpersonal understanding through these nonverbal cues through emotional contagion (60, 61). In the domain of music, however, sound is often assumed to be the primary medium through which creative and affective expression is conveyed and understood (62, 63).

In experiment 7, 262 participants were presented with either video-only or sound-only 6-s recordings of the competition performances. They were then asked to identify the most confident, creative, involved, motivated, passionate, and unique performer in each set of three finalists in the competitions. These evaluations were then compared against the original competition outcomes. Creativity, involvement, motivation, passion, and uniqueness were significantly more salient through visual cues rather than through sound.

Passion had considerable impact on the professional judgment of quality when it was visible; through silent videos, those selecting "the most passionate contestant" identified the actual winners at rates significantly higher than chance (59.6%). They also fared better than those making the same judgments through audio recordings (38.7%), $t(196) = 7.01$, $P < 0.001$. Involvement (53.1%), motivation (52.8%), creativity (44.6%), and uniqueness (43.6%) also contributed to the visual information that signaled quality of performance in a way that auditory information did not allow either novice or expert participants to perceive (all P's < 0.001). Confidence was not a factor that allowed participants to distinguish among the performers through either visuals or sound, $t(193) = -0.68$, P = n.s.

The final experiments explored the visual elements that contribute to the professional judgment of music. Motion, motivation, creativity, and passion are perceived as hallmarks of great performance (*SI Text*). As those facets of performance are visually accessible and readily so, they may be universally understood throughout levels of expertise. Thus, even novices are able to quickly identify the actual winners among world-class performers, without being encumbered by the sound of music that professional musicians unintentionally and nonconsciously discard.

These additional experiments suggest that performers' movements may contribute substantially toward inferences about the quality of performance. Our movements facilitate aspects of cognitive abilities (64, 65) such as coordination and the appreciation of rhythm (66). The sight of others' gestures may also influence our understanding about music. Our responsiveness to movement (67–69) and emotional expression (62, 63, 70) may underlie the intuition that musicians' motions and emotions represent exceptional performance. Future work will be needed to test not only our perceptions of performers, but also the emotions evoked in audiences, to better understand the affective contributions to the primacy of visual cues in the judgment of performance.

Discussion

This set of seven experiments (Table S1) suggests that novices' judgment mirrors that of professionals; both novices and experts make judgments about music performance quickly and automatically on the basis of visual information. Given the relative lack of consensus about competition outcomes noted among even expert judges, the fact that novices are able to quickly identify the actual competition winners at such high rates through silent videos alone is of both statistical and practical significance. These findings point to a powerful effect of vision-biased preferences on selection processes even at the highest levels of performance.

Experts and novices alike privilege visuals above sound, the very information that is explicitly valued and reported as core to decision making in the domain of music. Moreover, when sound is made available along with the video, it led people away from the actual (visually based) competition outcomes. This finding complements those of a recent landmark meta-analysis, which argues for an influence of the visual component on music performance evaluation in a multiplicative cross-modal model of perception (24). When both sound and visuals were available in the current work, judgments appear to be impacted by both modalities.

Ongoing research suggests that pressures that constrain our cognitive resources may lead to a visual dependence. As the current work focuses on choices made during competitive settings, more information would not necessarily lead to better approximations of expert judgment, even if it increases confidence in judgment (71). People are limited by attention to certain cues, with inconsistency (72, 73) and at times detriments to judgment (74).

Professional musicians and competition judges consciously value sound as central to this domain of performance, yet they arrive at different winners depending on whether visual information is available or not. This finding suggests that visual cues are indeed persuasive and sway judges away from recognizing the best performance that they themselves have, by consensus, defined as dependent on sound. Professional judgment appears to be made with little conscious awareness that visual cues factor so heavily into preferences and decisions.

Both musical novices and professional musicians reported attempting to identify the highest quality performances. These self-reports are further supported by the studies that implemented incentives and bonuses for participant performance in identifying the actual winners. However, both experts and novices appear to be surprised by their own data, and experts in particular reported a severe lack of confidence in their judgment when they were assigned to the video-only recordings, not knowing that their approximations of the actual outcomes would be superior under such constrained conditions. The notion that our experience of music (75) depends so much on visual information—at a nonconscious level and to a degree that interferes with what people actually value—points to consequential implications (*SI Text*).

Against broad consensus that auditory information is core to the domain of music, these experiments offer strong tests of the primacy of visual information. The implications of these findings thus extend to any context that calls for the professional judgment of performance. Ongoing research suggests that the effects are generalizable to multiple domains, such as management and entrepreneurship—as well as to multiple levels, from individuals to groups.

The dominance of visual information in our decision circuitry may have evolved as adaptive (76, 77) and reliable, evocative of how visual circuitry itself is molded by accumulated experience and successfully guided behavior (78, 79). However, when these decisions involve other information more predictive of performance, whether it concerns hiring employees, interviewing physicians, or selecting political leaders, we must be more mindful of our inclination to depend on visual information at the expense of the content that we actually value as more relevant to our decisions. Given the dominance of visual cues in our decision making, it would be valuable to determine the contexts in which a visual dependence may not be one that leads to wise decisions and good long-term investments in selecting, promoting, and rewarding talent.

Professional training may hone musicians' technical prowess and cultivate their expressive range, but in this last bastion of the realm of sound, it does little to shift our natural and automatic overweighting of visual cues. After all, sound can be neglected while trained "ears" focus on the more salient visual cues. It is unsettling to find—and for musicians not to know—that they themselves relegate the sound of music to the role of noise.

Materials and Methods

The Harvard University Institutional Review Board approved all procedures. Informed consent was obtained from all participants.

Experiment 1. One hundred six participants ($M_{age} = 20.73$, SD = 2.46; 49.5% male*) volunteered.[†] Participants were instructed about 10 live classical music competitions that they would judge, based on excerpts of the three finalists in each competition. They had the chance to receive an additional $8 if their selections matched the actual competition outcomes. They had the choice of sound or video recordings; or, if they chose the recordings with both video and sound, $2 would be deducted from any bonuses won.

Experiment 2. One hundred six participants ($M_{age} = 22.26$, SD = 1.79; 41.1% male*) with little to no experience in classical music volunteered.[†] Through a within-subjects design, each participant received both the video-only set and the sound-only set of the same performances (*SI Text*). Participants were then asked to identify the winner of each competition. Finally, they were asked to identify whether sound, visuals, or other cues were more important for them in judging a music competition.

Experiment 3. One hundred eighty-five participants ($M_{age} = 24.18$, SD = 9.64; 46.1% male*) with little to no experience in classical music volunteered.[†] Through a between-subjects design, participants were randomly assigned to one of three conditions: video-only, sound-only, or video-plus-sound versions of the experiment 2 stimuli. They were then asked to identify the winners and report whether sound, visuals, or other cues were more important for them in judging a music competition (*SI Text*).

Experiment 4. Thirty-five professional musicians ($M_{age} = 27.00$, SD = 9.69; 31.6% male) volunteered. They were recruited from music conservatories, symphony orchestras, and professional music organizations. The design paralleled the within-subjects format used in experiment 2 and implemented the same stimuli (*SI Text*).

Experiment 5. One hundred six professional musicians ($M_{age} = 27.25$, SD = 12.55; 41.5% male) volunteered. The design paralleled the between-subjects format used in experiment 3 and implemented the same stimuli. Analyses on effects of demographic variables revealed no significant patterns (*SI Text*).

Experiment 6. Eighty-nine participants ($M_{age} = 27.38$, SD = 10.68; 50.0% male*) volunteered.[†] Participants received silent videos from the experiment 2–5 stimuli that had been reduced to black-and-white moving outlines (Fig. S2). Participants were then asked to identify the winners of each competition.

Experiment 7. Two hundred sixty-two participants ($M_{age} = 21.52$, SD = 3.36; 52.3% male) volunteered.[†] Participants were assigned to either the silent videos or the audio recordings from the experiment 2–5 stimuli. They were then asked to identify the most confident, creative, involved, motivated, passionate, and unique performer in each set of finalists. Repeat choices were allowed.

*Participants who did not report their sex were not included in the calculation.

[†]Participants were recruited from a community sample in the northeastern United States and were paid $20 for their participation in an hour-long set of unrelated studies that included the current experiment.

ACKNOWLEDGMENTS. I thank M. Bazerman for his insights and invaluable support throughout the development of this work; T. Amabile, S. Barsade, and B. Groysberg for generous feedback and guidance; N. Ambady and K. Nakayama for the forum that sparked the initial studies; J. Abraham, R. Cheong, S. Dobrow, P. Fili, A. Galinsky, J. Golann, M. Morgan, O. Obodaru, D. Parno, K. Shonk, and the University College London MSI reading group for input on earlier drafts; and M. Banaji, K. Hida, R. Jean, J. Lee, J. Polzer, C. Silva, B. Simpson, B. Tang, A. Williams, D. Wollenstein, and members of non-lab and the HBS OB lab for research help. Many thanks also to the dedicated musicians who shared their art and minds. This research was supported by Harvard University and the Wyss Foundation.

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