Supporting Information

Immordino-Yang et al. 10.1073/pnas.0810363106

SI Text

Participants. The participants were 13 right-handed healthy volunteers (6 women and 7 men; mean age 30.3 years, SD 11.9; range 19–57 years). All were native English speakers born and raised in the United States. All reported normal or corrected-to-normal vision and normal hearing. None had a history of neurological or psychiatric disorder or physical or emotional abuse, and none were using psychotropic medication. None reported a medical condition that would preclude scanning. All participants gave written informed consent in accordance with the requirements of the Institutional Review Board of the University of Southern California, and each received $50 for their participation. Handedness was assessed by using a modified version of the Edinburgh handedness questionnaire (1), which ranges from −14 (strongly left-handed) to +14 (strongly right-handed). All participants scored 11 or higher.

Stimulus Selection Procedures. To develop the set of narratives for the experiment, a large group of potential narratives (>100) were reviewed and rated and then discussed by 7 members of our laboratory research staff. The most effective and compelling narratives were then shared in one-on-one sessions with 8 pilot subjects, to identify participants' responses and time their duration. Finally, 12 stimuli per category (60 total) were piloted in a group setting in which 24 participants listened and watched as an experimenter shared the narratives in pseudorandom order. After each narrative, participants used a questionnaire to rate from 1–10 the strength of their emotional reaction. Participants then ranked their feelings about the person in the narrative, choosing from a series of statements describing the emotional categories corresponding to the experiment conditions (e.g., "I do not feel any strong emotion for this person," "I feel inspired by this person, and I admire his/her virtue"). For a narrative to qualify for inclusion in the imaging experiment, participants must have reported feeling the intended emotion as their primary reaction to that narrative, $\chi^2_{\text{critical}}(6, n = 24) = 16.8, P < 0.01$; emotional narratives had to score 5 or greater for average strength of reaction; control narratives had to score 4.5 or less. Of the 60 potential stimuli subjected to group piloting, 56 qualified; the 50 stimuli used in the experiment came from this group. Clarity, presentation and content of the questionnaire were confirmed with a social psychologist specializing in questionnaire design and analysis before piloting, and group pilot sessions were videotaped.

Experiment Design. ***Visual properties of scanner stimuli.*** Equivalence of the visual properties of the scanner stimuli across conditions was assured by converting the RGB values of each frame into LAB (luminosity and chromaticity) using MATLAB (The Math Works). Based on these results, values for the spatiotemporal contrast for each component (L, A, B) for each stimulus were generated; a MANOVA revealed no overall effect of condition (Wilks λ, $P < 0.41$). Both still and video images were included in the stimuli, with no significant differences among conditions, χ^2 $(4, n = 50) = 5.6, P > 0.2$.

Stimulus preparation and delivery. Stimuli were prepared by using Premiere Pro version 7.0 (Adobe), and burned to DVD by using RoxioDVD Builder 1.2.0.110 (Roxio). During the experiment, the DVD was played by using PowerDVD 5.5 (Cyberlink) running on Windows XP (Microsoft) and synchronized to the start of each scan. A DLV1280-DX 3-chip DLP projector (Christie) displayed the visual stimuli on a rear projection screen situated in the scanner bore. Auditory stimuli were normalized for loudness, and delivered via pneumatic headphones (Avotec) connected to the built-in sound system (Siemens).

Protocol. For the button press, in the scanner, participants' task was to induce in themselves for each story, as strongly as possible, a similar emotional state to the one they had experienced during the preparation session, and to push a button to indicate the strength of the emotion they achieved in the scanner. For this purpose, a button box rested in the participant's right hand. Participants pushed the button under their first (index) finger to indicate that they were finding the narrative interesting and/or engaging, but not particularly emotionally moving. Participants pressed their second (middle) finger to indicate that they were feeling moderately emotional toward the person in the narrative, their third finger to indicate very strong emotion, and their fourth finger to indicate feeling overwhelmed with emotion for the person in the narrative. Button presses and TR timestamps were collected on a Thinkpad computer (IBM) running MATLAB. Stimuli were separated by 2 s of fixation, during which participants were asked to relax and clear their mind in readiness for the next narrative.

Behavioral Data Analysis. To create the best possible contrasts, only data from good exemplars were included in the analysis. However, to ensure equivalence of the experiment across subjects, all subjects were presented with all of the stimuli in the scanner. Therefore, data were sorted for inclusion/exclusion in 3 steps, using: (*i*) the preparation interviews, (*ii*) the button press values, and (*iii*) the debriefing interviews. First, to ensure that participants' emotional responses in the scanner were those expected for each stimulus, data from the preparation interviews were examined. Narratives to which a subject provided a different emotional label than the one established by piloting were excluded from analysis for that subject, e.g., reacting strongly to a control narrative or expressing mixed emotions, especially mixed compassion and admiration. Second, button press data (from the scan session) were examined. Data from control trials in which participants indicated feeling emotional (second- to fourth-finger button presses), and from emotion trials in which participants did not feel emotional (first-finger button press), were discarded. Third, data from the debriefing sessions were examined, and narratives to which a subject provided a different emotional label than that established by piloting were excluded from analysis for that subject. This 3-step process allowed us to include in the analysis only exemplars that a participant had labeled consistently with our established categories, and of those, only trials that had produced the expected amount of emotion in the scanner. In steps *i* and *iii*, to confirm our decisions, the suitability of participants' reactions to the narratives was judged again by an independent rater blind to the experimenters' judgments. Interrater reliability calculations on the whole dataset revealed 96% agreement (Cohen's $\kappa = 0.8$), which is considered outstanding (2). Therefore, the experimenters' original judgments were used.

Table S1 presents tallies of qualified and disqualified trials based on the above behavioral criteria and average reported emotion strength in the scanner by condition for trials qualifying for inclusion in the analysis.

Psychophysiology. Respiration and heart rate data were collected from ten subjects; due to inherent difficulties in collecting quality psychophysiological data inside an fMRI scanner, data were examined by a psychophysiology expert who is part of our research team. Respiration data from ten subjects and heart rate data from 7 subjects were deemed reliable. Inevitably, in collecting heart rate data in an fMRI scanner, there will be cases in which the pulse probe slips; in our experiment, heart rate data from 3 subjects were discarded due to slippage of the pulse probe.

Respiration was sampled at 200 Hz by using an MRI-compatible pneumatic belt placed over the subject's shirt, around the torso (respiratory effort transducer TSD201 connected to RSP100C respiration amplifier; BIOPAC Systems). Pulse was sampled at 200 Hz by using a photo plethysmograph transducer (TSD200 connected to amplifier PPG100C; BIOPAC), placed on the index finger of the left hand. Data were recorded and analyzed on a Macintosh Powerbook laptop (Apple Computers) using Biopac software (AcqKnowledge v.3.9). Heart rate data were filtered to remove scanner-induced noise.

Results from analyses of respiration rate (RR) and heart rate (HR) during scanning were used in conjunction with behavioral pilot data to determine the time window to include in the BOLD contrasts. During scanning, the average time course of RR for all conditions showed a rise at the onset of the trial, with a return to baseline after ≈12 s. HR during scanning showed a similar timing profile; time-to-peak for AV, CSP, AS, and control fell 10–12 s after trial onset. CPP peaked earlier at ≈6 s but sustained a high level through a secondary peak at 12 s. Fig. S1 *A* and *B* present RR and HR time courses. Adjusting for the standard 2-s delay in HR change, RR and HR together suggested that the peak of the response for all conditions could be captured within the first 10 s of the trial; therefore, we included in our contrasts the BOLD data corresponding to this time window.

Image Acquisition and Processing. Images were acquired at the Dana and David Dornsife Neuroimaging Center at the University of Southern California by using a Siemens 3 Tesla MAGNETON TIM Trio scanner with a 12-channel matrix coil. Functional scans were acquired using a T_2*-weighted Echo Planar (EPI) sequence (TR = 2,000 ms, TE = 30 ms, flip angle = 90°) with a voxel resolution of 3 × 3 × 4.5 mm. Thirty-two transverse slices were acquired to cover the whole brain, including the brainstem. Functional data were acquired continuously for the duration of each run, with breaks between runs. Anatomical scans were acquired by using a magnetization prepared rapid acquisition gradient (MPRAGE) sequence (TI = 900 ms, TR = 2,530 ms, TE = 7 ms, flip angle = 7°) with an isotropic voxel resolution of 1 mm.

Data analysis and image processing were conducted by using BrainVoyager QX version 1.8 software (Brain Innovation). T_2*-weighted functional images were preprocessed with motion-correction, linear-trend removal, and high-pass temporal filtering. The preprocessed images were then coregistered with the anatomical scan, and these coregistered data were transformed to Talairach space.

After preprocessing, functional data from each run for each subject were normalized by transformation to *Z* scores. We estimated the BOLD signal for each participant using a general linear model (GLM). We assumed that the neural activity within an 18-s trial was complex and could not be modeled by a single boxcar activation function convolved with a stereotypical hemodynamic response function (HRF). Instead, we modeled the activity within trials of the same type by 9 independent regressors, each a δ-function of 1 TR in duration (2 s). Similarly, a group of 9 regressors were assigned to the discarded trials, and 1 dummy variable was assigned to each run to capture the variation in baseline across runs. To draw general conclusions across the test population, the estimated parameter values and variances of the residuals for all of the participants were subjected to an ANCOVA random-effects analysis in BrainVoyager QX (Brain Innovation) to provide the relevant contrasts.

Results from analyses of respiration rate (RR) and heart rate (HR) during scanning were used in conjunction with behavioral pilot data to determine the time window to include in the contrasts. Behavioral piloting suggested that the time course of the emotional response to our narratives lasted between 10 and 18 s after trial onset (see *Stimulus Selection Procedures* above). RR and HR data, collected during scanning, both suggested that the peak of the response for all conditions could be captured within the first 10 seconds of the trial (see *Psychophysiology* above); therefore, we included in our contrasts the BOLD data corresponding to this time window. Taking into account the standard 6-s time-to-peak of the HRF, voxels were considered differentially activated if the sum of the β-values from the contrast between target condition and control for regressors corresponding to the 4th–8th TRs inclusive (collected 6–16 s after trial onset) was significantly different from zero. Statistical maps were thresholded using the false discovery rate statistic, $q(FDR) < 0.05$, and overlaid on a previously produced average brain (see *Localization of Activations* below).

Localization of Activations. Anatomical localization of maxima and minima from the whole-brain GLM analysis for all participants combined was determined by overlaying the Talairach coordinates for each point on a previously produced averaged brain in Talairach space using Brainvox (3, 4).

Event-Related Averaging and Analysis of Time Course. Voxels included in this analysis were first defined anatomically on the brain of 1 subject; the resulting clusters (left and right) were then displayed sequentially on each of the subject's brains, and the boundaries of the clusters were delimited to fall within the anatomical boundaries of the anterior insula for each subject. This procedure identified the largest cluster of voxels that fell within the anterior insula for all subjects. Next, the clusters were combined into a bilateral volume of interest (VOI).

ERAs of the *z*-transformed signal from these voxels were produced for each emotion condition. The time course of each ERA was then fitted with the difference of gamma-functions to determine the time-to-peak (positive peak) and mean duration (full-width at half-height around the positive peak). The following bootstrap procedure was then implemented in MATLAB to estimate the standard errors of the 2 parameters of interest, time-to-peak and duration, to perform statistical comparisons between the curves: (*i*) Generate a series of normally distributed random values with a standard deviation equal to the standard error of the ERA data. (*ii*) Fit this curve with the difference of gamma-functions. (*iii*) Estimate the time-to-peak and duration from the fitted curve. (*iv*) Repeat steps *i–iii* 1,000 times. (*v*) Compute the standard deviation of bootstrapped values obtained in step *iv*. (See Table S4 for results.) Tests for significance were performed in terms of the *Z* scores of the difference between conditions at a criterion level of 0.05 after Bonferroni correction for multiple comparisons.

Stimuli. In the following section, we provide examples of stimuli for each category, using a variety of media. Stimuli are in the form of narratives about real people's lives. Full narratives are delivered during the one-on-one preparation session; 5-s reminder narratives are delivered in the scanner.

1. Narrative format during preparation session.

Experimenter: "This is the story of a man/woman who…" [Experimenter tells scripted story.]

"…Let's watch/look/listen." [Experimenter reveals additional materials.]

"How does this story make you feel?"

2. Narrative format during scanning:

Visual and verbal components are delivered simultaneously.

Examples of Stimuli. ***Example A, Admiration for Virtue***

1. Preparation session

Experimenter Script: "This is the story of a woman who adopted 10 special needs children. She first had 2 biological sons with her husband, but they wanted a daughter, so they adopted a little girl. Then, a few years later, her marriage began to fall apart, and she and her husband got a divorce. She was left in an emotional crisis, because she felt that her children would not grow up in a real home, with only a single mother. She was also torn because through her daughter's adoption, she realized how many children are waiting for good families. So, because she needed to work, she decided to become a caseworker for the adoption agency to help place children with families. However, as she got more deeply involved in the adoption work, she grew heartbroken over the kids she saw with disabilities, who would often wait for years for a family. Even though she had had a crisis after her divorce that she couldn't single-handedly create a home, she now embraced this as an opportunity. She began adopting the children whom no one wanted, many of whom had serious disabilities and needed lots of special care. She tells how she is raising them to become competent, self-sufficient adults. Let's watch…"

Video Description: A mixed group of adult bystanders are seen talking to a preteen girl in a wheelchair, with a waterfall in the background. ⟨dialogue⟩ The scene then fades to a group of children and their mother (the protagonist), posing for a photograph in front of the waterfall; there are children of various ages, some in wheelchairs and one with bandages on his limbs. The camera then focuses on the children's mother, standing among the children and smiling. The scene then shifts to a home movie, showing 6 disabled children joking and laughing around a table. The scene shifts again, to the children's mother, sitting in front of a window, being interviewed.

Video Transcript:

Bystander: "Are you adopted?"

Girl (in wheelchair): "Yes"

Bystander: Are you?

Girl(in wheelchair): "There's… We're all adopted, adopted, except, uh, 2."

Bystander: "Oh, you must have very, very special parents. That's …."

Girl (in wheelchair): "I only have a mom, but like she's the best parent that you could have."

Bystander: "That's wonderful."

⟨visual shift, to children laughing around a table⟩

⟨visual shift, to the mother being interviewed⟩

Woman: "I think it's hard to explain to people, there was no grand plan. It wasn't like, oh, gee, I think I'll have 13 kids. The kids that I picked were my kids. Whether you've birthed the kids, or adopted the kids, whatever they have is part of who they are, and you accept them for that. I want them to grow up to be caring, responsible, happy adults who can support themselves, and anything that I need to do in order to help them achieve that goal, I'm there for. I, I think that's the job of a parent, and that's what I'm, I want to do. So anything that the kid needs in order to achieve that goal, I'll be there to help them. I won't do it *for* them, you know. That's not my job, but my job is to help them learn the skills so that they can be responsible adults."

Experimenter Script: "How does this story make you feel?"

2. Scanner Stimulus

Visual component: Participants see a 5-s clip from the video shown in the preparation session, which shows the children and their mother posing for a group photograph, then zooms in to a close-up on the face of the mother.

Verbal component:

Woman: "My job is to help them learn the skills so they can be responsible adults."

Example B, Admiration for Virtue

1. Preparation session

Experimenter Script: "This is the story of a woman who is blind, who helps blind Tibetan children learn Tibetan Braille. Actually, this woman invented the Tibetan Braille system. Her story is that she has a degenerative disease that caused her to lose her sight at age 12. Although she had been a very bright student, she was forced to enroll in a school for the blind in her native Germany. After she graduated, she thought she had reached the end of her academic career, because there were no universities for the blind in Germany.

"But then one day she was listening to a documentary and she learned that 30,000 of Tibet's 2.6 million people are blind because of high altitude and poor nutrition and hygiene. Many of these are children, who are denied schooling and are seen as burdens on society. At that point she resolved to go to the University of Bonne, even though she would be the only blind student out of 30,000, to study central Asian studies and work on ways to help these Tibetan children. She wanted to find a way to give them the opportunities that she had had, to learn Braille and become competent and respected citizens.

"Despite the difficulties, she learned the Tibetan language fluently, by sound alone, since there turned out to be no Tibetan Braille system. As her senior thesis project, she used the rhythmic spelling system of Tibetan to invent a Tibetan Braille system, and created a computer program that would translate whole Tibetan texts into this new form of Braille.

"At that point she knew that in order for her Braille system to help the blind children of Tibet, she would need to go there and found a school for the blind. And this is just what she did. Blind and by herself, she first traveled to China, where she spent 6 months learning intensive Mandarin, and then traveled from there into Tibet on horseback using local guides. Her school now has 37 students and 5 teachers, and runs on international donations. The students learn Tibetan Braille, Mandarin Chinese, and various professions, like cheese making. She also teaches them rock and mountain climbing, to build confidence. When they graduate and return home, they are often the only available Chinese translators in their communities, which makes them incredibly valuable. Let's look at this picture of her with a student… and listen to the only interview clip we could find in English…"

Image Description: A smiling blind woman is seen leaning over a young Tibetan boy whose hands are on a paper with Braille markings on it. She appears to be teaching him. A banner with a black and white design is in the background.

Audio Transcript:

Woman: "When they find out that they can climb a mountain, and that they can master a rock like that, then I guess they can even do even better in life! I hope at least."

Experimenter Script: "How does this story make you feel?"

2. Scanner Stimulus

Visual component: Participants see the photo shown during the preparation session for 5 s.

Verbal component:

Woman: "When they find out that they can climb a mountain, they can even do even better in life!"

Example C, Admiration for Skill

1. Preparation session

Experimenter Script: "This is the story of a young woman who can solve a Rubik's cube blindfolded. You are going to see her memorizing the configuration of the cube, and then putting on her blindfold and solving it entirely from memory. The voice you'll hear is of a friend of hers, also an expert cuber, explaining how she does it. She first memorizes the cube by translating the squares into numbers, which she can track using algorithms when she is blindfolded. He explains that she solves it in layers, not by colors. And the whole time she needs to keep track of how solving one layer is changing the configuration of the others, since she can't see what's going on. Let's watch…"

Video Description: A young woman sits at a table, Rubik's Cube in hand. She studies it from a variety of angles, then pulls a blindfold over her eyes and solves it. She then removes the blindfold and smiles at the camera.

Video Transcript:

Man: "Doing it blindfolded, it's not really Braille or anything so you can't feel anything. So what you want to do is to, um, before you even close your eyes and start solving it, you have to memorize the whole cube first. Um, but it's hard doing it in colors, so you, you convert every single information that's on the cube into numbers. That way, it's, uh, it sticks to your memory. It comes out to be about 30 digits of numbers. And then so you memorize that. And then you, you can close your eyes and do, you know, just track the numbers, see where it goes. And then it's just, the rest is, uh, keeping track and using algorithms."

Experimenter Script: "How does this story make you feel?"

2. Scanner Stimulus

Visual component: Participants see a 5-s clip from the video shown in the preparation session, in which the young woman finishes solving the cube, and removes her blindfold.

Verbal component:

Man: "Before you even close your eyes and start solving it, you have to memorize the whole cube first."

Example D, Admiration for Skill

1. Preparation session

Experimenter Script: "This is the story of a high-functioning autistic man who can visually memorize large amounts of detailed spatial information. Here, he is flown in a helicopter over the city of Rome for 45 minutes. He has never been to Rome before. Back on the ground, he spends 3 days recreating from memory a drawing of the entire city on a big sheet of paper wrapped around 3 sides of a room. His drawing is complete with all of the side streets and squares. Not only that, but close examination of his drawing reveals that he has included all of the details correctly. Each building, no matter how insignificant, has the correct number and configuration of windows. The arches on the buildings are drawn perfectly to scale, and you'll see him reproduce a view of the Coliseum. Let's watch…"

Video Description: A man (the protagonist) climbs into the back seat in a helicopter, fastens his seatbelt, and puts on his headset. The helicopter is then shown taking off. The man and the helicopter pilot are shown looking out the window at a city, Rome. The camera then shows views of the city's landmarks from the helicopter. ⟨visual shift⟩ The man is shown walking into a large, well-lit room (much like an art gallery), with a large curved white paper hanging. The man sits on a stool in front of the paper and begins drawing in ink pen. Time-lapse videography then shows the man drawing a detailed panorama of the city. ⟨visual shift⟩ Side-by-side images contrast views of individual Roman buildings as seen from the helicopter with the man's drawings of those buildings, highlighting the accuracy of his illustration. Finally, the camera pans across the completed drawing of Rome.

Experimenter Script: "How does this story make you feel?"

2. Scanner Stimulus

Visual component: Participants see, for 5 s, a still image of the man drawing the panoramic view of Rome. His face is clearly visible as he draws.

Verbal component:

Woman [experimenter]: "Even the number and shape of windows on the side streets were completely accurate."

Example E, Compassion for Social Pain

1. Preparation session

Experimenter Script: "This is the story of a woman who has cerebral palsy. She tells of how she has never been kissed or had a romantic relationship, because her wheelchair forms a barrier between her and the rest of the world. She recalls how as a child in elementary school she had been popular and had had lots of friends. She loved to joke around and had a good sense of humor, and she loved to play over at her friends' houses. But once she got to junior high, her friends started to drift away, since she wasn't pretty or cool. The boys were never interested in her. She longs to have friends now, but she has resigned herself to being alone. In this interview, she is talking with her cardiologist, whom she has been seeing for many years and whom she trusts. Let's listen…"

Image Description: A middle-aged woman sits in a wheelchair, looking toward the camera. The setting appears to be an office, such as could be found at a hospital.

Audio Transcript: Woman: "I had a few friends who I formed tight relationships with who all of a sudden wouldn't sit next to me anymore at the lunch table, uh, decided I wasn't cool enough, uh, would stop calling me after I called them, uh, wouldn't speak to me when I spoke to them. I, I was kind of on my own. And then as far as intimate relationships, being in, being in a wheelchair, you're always protected by, by this chair. There's armor between you and the opposite sex. So, uh, intimacy's a difficult thing."

Man: "Even now?"

Woman: "Even now. You know, I've never been kissed. So I have no idea what the, what the rules are, and what the norms are of a relationship. And I, I have to be honest, I don't see myself in a romantic relationship at all. I think that I'm, I've gotten to this place where a wall is up so much that I don't even want to go in that direction 'cause when I do I get sad."

Experimenter Script: "How does this story make you feel?"

2. Scanner Stimulus

Visual component:

Participants see the photo shown during the preparation session for 5 s.

Verbal component: Woman: "I don't see myself in a romantic relationship at all."

Example F, Compassion for Social Pain

1. Preparation session

Experimenter Script: "This is the story of a 9-year-old South African girl whose mother is dying of AIDS from a blood transfusion. She is an only child and has no father. Her mother was worried she'd be mistreated if people knew that she was dying of AIDS, so she swore the little girl to secrecy. The girl tells how she is afraid to go to school, in case her mother dies while she is away. She also tells about how she writes a letter each day to her mother, who is in the clinic, telling her how much she loves her and how she wants her to return home. She sleeps on a tiny cot to leave her mother's bed fresh for her. Let's watch…"

Video Description: From behind, we see a girl combing her hair while looking into a hand-held shard of mirror. ⟨visual shift⟩ Then we see the same girl sitting, as if being interviewed, outside an African-style building, likely a school, with dirt and an oil drum behind her. ⟨visual shift⟩ The scene then shifts to inside a sparsely furnished, brightly colored house, as the girl is walking out. ⟨visual shift⟩ The scene shifts again to a more distant view of the building, which is surrounded by a chain link fence and some chicken wire; the girl is walking out of the gate. ⟨visual shift⟩The scene then returns to the earlier view of the girl sitting outside the building, being interviewed.

Audio Transcript:

Girl: "I asked my mother, I said 'Do you have AIDS?' Then my mother said 'Yes, I do have AIDS.' I cry [sic], and then they come [sic] and take my mother to hospital. My mother tell [sic] me I must not tell anyone what, what she have [sic]. And I said 'Yes, I'll not tell anyone.' ⟨pause⟩ I miss my mother very much. Every day I write, I write a letter to my mother. I said [sic], 'I love you, mother, and I want you to not die."

Experimenter Script: "How does this story make you feel?"

2. Scanner Stimulus

Participants see a 5-s clip from the video shown in the preparation session, in which the protagonist says

Verbal component:

Girl: "Every day I write, I write a letter to my mother."

Example G, Compassion for Physical Pain

1. Preparation session

Experimenter Script: "This is the story of a man who is a competitive weightlifter. He had been attempting to lift 350 lbs. But, as you will see, his arm was unable to support the weight and the ligaments that hold together his upper and lower arm ripped as his lower arm was dislocated from his upper arm. While this injury was clearly painful, though, he later had surgery to reconstruct his arm, and he recovered fully. His sports career was not affected in the long term. Let's look…"

Image Description: A young adult man crouches in front of a set of barbells, his left arm bent backwards (with his elbow hyperextended) and a grimace of pain on his face.

Experimenter Script: "How does this story make you feel?"

2. Scanner Stimulus

Visual component: Participants see the photo shown during the preparation session for 5 s.

Verbal component:

Woman [experimenter]: "He ripped the ligaments that hold together the upper and lower arm."

Example H, Compassion for Physical Pain

1. Preparation session

Experimenter Script: "This is the story of a soccer player who breaks his leg during a game. He is running down the field and trying to get the ball from the opposing team when the 2 men's legs become entangled. As he tries to steal the ball from the other player, his leg gets caught and breaks. While this is a painful injury, though, the player's leg did eventually heal completely, and he was able to continue playing for the team the following year. Let's look at the video… Watch his left leg…"

Video Description: Two male soccer players, one in a light-colored jersey and one in a dark-colored jersey, are running toward the ball. Their legs and arms get entangled as they run, and the lower left leg of the player in the light-colored jersey visibly bends around the lower right leg of the other player. As the players fall down, the mid-calf break is clearly visible. A close-up of the moment of injury is then shown.

Experimenter Script: "How does this story make you feel?"

2. Scanner Stimulus

Visual component: Participants see a 5-s clip from the video shown in the preparation session, in which the soccer player's leg breaks.

Verbal component:

Woman [experimenter]: "Watch his left leg."

Example I, Control

1. Preparation session

Experimenter Script: "This is the story of a man who is now a successful businessman, telling about his first paying job. He recalls how as a young man he worked for a dry cleaner delivering suits and laundry around the neighborhood on his bike. He talks about how once he fell off his bike during the route. He dropped a package of folded laundry and it split open, but he gathered up the clothes as quickly as he could, and to his surprise, none of the customers complained. However, usually nothing like that happened and he was able to do his job efficiently. Let's watch…"

Video Description: A middle-aged man in a suit sits, as if being interviewed. He appears to be in a living room or similar setting. The man gestures in a naturalistic way while talking.

Video Transcript:

Man: "What happened was, is that at about, uh, I guess my parents at the time must have decided that I better get to work, you know. So they got this job after school. Now, my father used to have his suits made, an Armenian tailor called Drasian, and later on, this, this tailor needed somebody to deliver clothes after they were cleaned and dry-cleaned. So, I got the job, and he'd line up maybe 4, 5, or 6 stacks of clothes, and I'd go up apartments or I'd ride a bicycle one hand like this, I got these clothes. And I'd deliver the clothes and all that. And sometimes they would tip me. Wow. I mean, this was unbelievable. So, I remember one time, I had this wonderful assortment of clothes, and I'm going down Buckingham Road, and something happened and I take a fall. All of these dry-cleaned and pressed things, scattered on the ground. So, I'm picking them up, and trying to fold them, and trying to put them back over my arm. And I kept going, then I go up and I deliver the clothes to the people. ⟨pause⟩ I never heard a word about it. No one ever complained."

Experimenter Script: "How does this story make you feel?"

2. Scanner Stimulus

Visual component: Participants see a 5-s clip from the video shown in the preparation session, in which the protagonist says

Verbal component:

Man: "Then I'd go up, and I'd deliver the clothes to the people."

Example J, Control

1. Preparation session

Experimenter Script: "This is the story of a woman who is a trapeze artist. She is a performer, and has enjoyed working on the trapeze since she first tried it as a teenager. In this interview, she is telling about what it feels like, and what goes through her mind, when she is performing in an act. She describes how she knows how the act is going not by feeling her actions directly as much as by noticing how the trapeze responds to her. On good days, she says she feels at one with the trapeze and like she is in control, but on bad days she says she can feel the trapeze wobbling and not fully under her control. Let's listen…"

Image Description: A young woman, wearing street clothes, sits casually on a trapeze, smiling at the camera. Behind her are a tree and the sky.

Audio Transcript:

Woman: "And, in fact, most of what I notice is sort of the way the trapeze is behaving in relation to the way I'm behaving. And if I'm tired—I may not even be aware of it—but I'll be just a little bit trembling, a little bit shaky, and the trapeze absorbs that, and will, um, accentuate that. And so I'll notice it from the trapeze instead of from my own body. So, yeah, that's, that's a lot of the dialogue that's going on in my head during the act."

Experimenter Script: "How does this story make you feel?"

2. Scanner Stimulus

Visual component: Participants see the photo shown during the preparation session for 5 s.

Verbal component:

Woman: "If I'm tired—I may not even be aware of it—but I'll be just a little bit trembling, a little bit shaky."

1. Oldfield RC (1971) The assessment and analysis of handedness: The Edinburgh inventory. *Neuropsychologia* 9(1):97–113.
2. Landis JR, Koch GG (1977) Measurement of observer agreement for categorical data. *Biometrics* 33(1):159–174.
3. Frank RJ, Damasio H, Grabowski TJ (1997) Brainvox: An interactive, multimodal visualization and analysis system for neuroanatomical imaging. *NeuroImage* 5(1):13–30.
4. Damasio H (2005) *Human Brain Anatomy in Computerized Images* (Oxford Univ Press, New York), 2nd Ed.

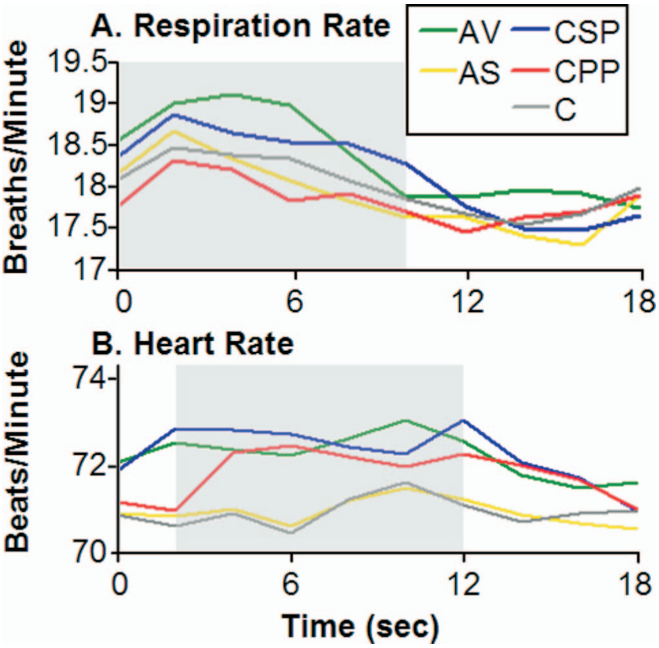

Fig. S1. Respiration rate (*A*, $n = 10$) and heart rate (*B*, $n = 7$) data averaged to 2-s intervals (corresponding to TR length). The shaded boxes cover the portion of the trial that corresponds to the window used for the BOLD contrasts. (*A*) Note rise and return to baseline over the first 10 s of the trial. Emotion curves are not significantly different from control. (*B*) Note higher levels associated with AV, CSP, and CPP than with C (statistically significant for AV and CSP); AS and C are indistinguishable.

Table S1. Summary of behavioral results

Condition	Included Trials			Excluded Trials		
	Tally		Strength (1–4)	Tally		
	Total	Mean per subject (SD)	Mean (SD)	Button press	Interview	Other
AV	226	17.4 (2.5)	2.66 (0.70)	16	14	4
AS	176	13.5 (5.4)	2.40 (0.68)	72	3	9
CSP	226	17.4 (2.8)	2.86 (0.73)	12	18	4
CPP	227	17.5 (2.9)	2.79 (0.77)	29	0	4
C	218	16.8 (3.4)	1.00 (0.00)	30	10	2

Included trials tallies the total number of trials included in the BOLD analysis for each condition as well as the mean number of trials included for each subject. Strength is the average button press value by condition (included trials only). Excluded trials tallies the number of trials discarded due to button press (reflecting emotional strength during the scan session), pre- or post-interview (reflecting emotional label given by the participant) and other reasons (including failure of the subject to press a button and technical failure). Tallies of included and excluded trials are from 260 total trials for each condition. One subject had no valid AS trials, resulting in fewer exemplars and more excluded trials for this category. AV, admiration for virtue; AS, admiration for skill; CSP, compassion for social pain; CPP, compassion for physical pain; C, control.

Table S2. BOLD maxima for emotions versus control in hypothesized areas of interest

	AV				AS				CSP				CPP			
Region	X	Y	Z	Sig	X	Y	Z	Sig	X	Y	Z	Sig	X	Y	Z	Sig
Anterior insula	−27	20	7	+++	−27	17	7	+++	−42	8	4	+++	−27	20	13	+++
	39	5	4	+++	30	14	7	+++	39	5	4	+++	39	11	4	+++
Posterior insula					39	−1	−2	+					−39	−7	−2	+++
													36	−13	1	+++
Anterior cingulate	−3	20	25	+++	−3	26	22	+++	0	29	22	+++	−6	11	40	+++
	6	17	31	+++												
Posterior cingulate	−3	−43	25	+++	−3	−37	22	++	−3	−46	28	+++	−6	−34	22	+++
Sup/ant precuneus					0	−55	46	+++					−3	−64	49	+++
Inf/post precuneus	0	−61	31	+++					−6	−52	31	+++				
Supramarginal G	−51	−61	28	++	−51	−37	31	+	−45	−49	31	++	−51	−37	31	+++
					54	−37	28	+++	60	−46	19	++	54	−34	31	+++
Hypothalamus	0	−4	1	++	−3	−10	7	+	0	−7	7	+++	3	−7	1	+
Mesencephalon	0	−19	−8	+++	0	−19	−8	++	0	−19	−8	+++	0	−19	−8	++
					0	−22	−17	+	9	−22	−11	+++	−9	−25	−8	++
Medulla	−3	−31	−38	++					0	−31	−42	+++				

Coordinates are given in Talairach space. Activation thresholds (significance levels, Sig) were determined by the false discovery rate statistic, q(FDR), according to the following scale: +++, q(FDR) < 0.001, *t*-statistic ≥ 4.65 (AV), ≥ 4.72 (AS), ≥ 4.56 (CSP), and ≥ 4.24 (CPP); ++, q(FDR) < 0.01, *t*-statistic ≥ 3.80 (AV), ≥ 3.84 (AS), ≥ 3.70 (CSP), and ≥ 3.41 (CPP); +, q(FDR) < 0.05, *t*-statistic ≥ 3.04 (AV), ≥ 3.09 (AS), ≥ 2.92 (CSP), and ≥ 2.69 (CPP). AV, admiration for virtue; AS, admiration for skill; CSP, compassion for social pain; CPP, compassion for physical pain. G, gyrus. Note activation in the anterosuperior sector of the PMC in AS and CPP, versus in the posteroinferior sector in AV and CSP. Note that posterior insula was activated only in AS and CPP and that the medulla was activated only in AV and CSP.

Table S3. BOLD maxima and minima from a contrast of AV/CSP together (negative) versus AS/CPP together (positive)

Region	X	Y	Z	Sig
Anterior Insula	−33	2	13	−−−
	30	14	−5	−
Posterior Insula	−39	−7	1	++
	36	−10	2	+++
Anterior Cingulate	−6	29	10	−−
	3	26	19	−−−
Posterior Cingulate	−15	−30	38	+++
	−4	−4	34	+++
	14	−28	37	+++
Sup./Ant. Precuneus	0	−46	49	+++
Inf./Post. Precuneus	0	−61	31	−−−
Supramarginal G	−51	−34	31	+++
	54	−28	28	+++
Hypothalamus	−3	−4	4	−−−
Mesencephalon	9	−19	−11	−−−
Pons	0	−25	−29	−−
Medulla	6	−37	−38	−−−

BOLD maxima and minima from a contrast of AV/CSP together versus AS/CPP together, for hypothesized areas of interest. Positive significance values (Sig) indicate positive *t*-statistics and greater activation for AS/CPP; negative significance values indicate negative *t*-statistics and greater activation for AV/CSP. Coordinates are given in Talairach space. Activation thresholds were determined by the q(FDR) according to the following scale. +++/−−: q(FDR) $<$ 0.001, AS/CPP $>$ AV/CSP |**t**-statistics| $\geq$ 4.19; ++/−−: q(FDR) $<$ 0.01, AS/CPP $>$ AV/CSP |**t**-statistics| $\geq$ 3.43; +/−: q(FDR) $<$ 0.05, AS/CPP $>$ AV/CSP |**t**-statistics| $\geq$ 2.73. Note activation in anterior insula, posteroinferior sector of the posteromedial cortices (PMC), hypothalamus and brainstem for AV/CSP; activation in posterior insula, anterosuperior sector of the PMC, and supramarginal gyrus for AS/CPP.

Table S4. Mean time-to-peak and duration for activation in the anterior insula by condition, calculated by bootstrapping

Condition	Time-to-peak, s		Duration, s	
	Mean	SE	Mean	SE
AV	9.81	0.25	8.79	0.54
AS	10.60	0.32	7.76	1.01
CSP	8.73	0.24	11.89	0.96
CPP	7.07	0.46	7.21	0.58

Mean time-to-peak and duration for activation in the anterior insula by condition, in seconds with standard errors. Values were calculated from the event-related averaging (ERA) time courses of the BOLD effects for each of the conditions by fitting with difference of gamma-functions. All differences are significant at the level of $P < 0.05$, after Bonferroni correction for multiple comparisons.