

Visioning in the brain: An fMRI study of inspirational coaching and mentoring

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Effective coaching and mentoring is crucial to the success of individuals and organizations, yet relatively little is known about its neural underpinnings. Coaching and mentoring to the Positive Emotional Attractor (PEA) emphasizes compassion for the individual's hopes and dreams and has been shown to enhance a behavioral change. In contrast, coaching to the Negative Emotional Attractor (NEA), by focusing on externally defined criteria for success and the individual's weaknesses in relation to them, does not show sustained change. We used fMRI to measure BOLD responses associated with these two coaching styles. We hypothesized that PEA coaching would be associated with increased global visual processing and with engagement of the parasympathetic nervous system (PNS), while the NEA coaching would involve greater engagement of the sympathetic nervous system (SNS). Regions showing more activity in PEA conditions included the lateral occipital cortex, superior temporal cortex, medial parietal, subgenual cingulate, nucleus accumbens, and left lateral prefrontal cortex. We relate these activations to visioning, PNS activity, and positive affect. Regions showing more activity in NEA conditions included medial prefrontal regions and right lateral prefrontal cortex. We relate these activations to SNS activity, self-trait attribution and negative affect.

Keywords: fMRI; Visioning; Mentoring; Coaching; Compassion.

Coaching and mentoring can be seen in every facet of daily life, in one's personal affairs, work or school whether by a doctor, a teacher, a parent, or manager. Two approaches typically occur: one that focuses on performance targets and individual weaknesses, and one that seeks to inspire stronger performance by focusing on the mentee's strengths, aspirations, and personal development. In the last

15 years, coaching has refocused toward strength-based approaches, orienting individuals to focus on things they do well (Fredrickson, 2009). A number of approaches to coaching have adopted this broad framework, including Fredrickson's flourishing (Fredrickson, 2009), Higgins' promotion versus prevention (Higgins, 1997), and Deci & Ryan's self-determination theory (Gagné & Deci, 2005).

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AIJ wrote the paper, designed the experiment, analyzed the data, and supervised all aspects of the study. REB wrote the paper, designed the experiment, and supervised the coaching. MSK and AMP were the coaches and assisted in logistics and paradigm development. RLL wrote the paper, developed the paradigm, collected the data, and analyzed the data.

The authors would like to thank Katelyn Begany for assistance with paradigm development and Kevin Barry for assistance with data analysis. This work was supported by funding to AIJ from the Leonard Krieger Fund and the University Hospitals Case Medical Center Spitz Brain Health fund, and funding to REB from the H.R. Horvitz Family Business Chair Fund.

Intentional Change Theory (Boyatzis, 2008; Boyatzis, Smith, & Beveridge, 2013) distinguishes between coaching or mentoring toward the Positive Emotional Attractor (PEA) versus the Negative Emotional Attractor (NEA). Although the Intentional Change Theory overlaps with the other theories on several points, it differs in that it places a clear emphasis on psycho-physiological processes associated with parasympathetic (PNS) and sympathetic (SNS) autonomic responses.

Research has shown that a positive approach leads to more behavioral changes (Boyatzis, 2008; Boyatzis et al., 2013). A series of longitudinal studies have shown that coaching on the basis of the PEA in intentional change theory results in a dramatic improvement in social and emotional competencies in MBA students, which result in more effective management performance (Boyatzis, Stubbs, & Taylor, 2002). Subsequent work provides evidence that PEA coaching improves outcomes in other contexts. For example, in medicine, research has attempted to improve the degree to which patients listen to their doctor's advice and take their medicine—"do what they are told." Meanwhile, treatment adherence is low at 50% for diagnosed Type II diabetics worldwide and 50% for orthopedic surgery patients (Khawaja, 2010). In a recent study, Khawaja (2010) showed that treatment adherence was enhanced when the patient experienced the relationship with the doctor as having more shared vision and positive mood—key aspects of a PEA mentoring relationship. Other work has looked at medical student-standardized patient interactions (Dyck, 2010), father-daughter relationships in family businesses (Overbeke, 2010), Information Technology (IT) manager-subordinate relationships (Pittenger, 2012), and physician leadership effectiveness (Quinn, 2013). In each of these studies, the perception of shared vision was the statistically strongest factor in predicting an effective outcome on the dependent variable. Sharing a vision for the desired future is mutually exciting and motivating. Intentional Change theory posits that it involves stimulation of the PNS, and results in both people being more cognitively, emotionally, and perceptually open to learning and change.

Performance reviews and formal coaching approaches often involve all four of the conditions that typically invoke stress-related responding of the SNS. Segerstrom and Miller (2004) characterize the conditions that cause humans to activate the SNS as: (1) something is important and has high valence to the person; (2) something is uncertain; (3) others are watching or observing the person; and (4) the individual is in a state of anticipation of (1–3). Hence, NEA coaching is hypothesized to activate

the Sympathetic Nervous System (SNS), releasing regulatory hormones such as epinephrine and norepinephrine, which increase blood pressure, heart rate, and the body's response to stress (Sapolsky, 2004). NEA coaching creates a situation where the mentor (often unintentionally) increases stress, causing the mentee to view the situation as hostile, and provoking a defensive response that results in cognitive impairment, perceptual and emotional closing down, and poor health (Boyatzis, Smith, & Blaize, 2006; Sapolsky, 2004).

While anticipating an uncertain future may always induce a degree of stress-related arousal, the counterproductive effects of this arousal may be ameliorated by the perception of a supportive mentoring relationship. Conditions similar to the PEA coaching with compassion approach are known to activate the Parasympathetic Nervous System (PNS), resulting in activation of reward systems and modulation of SNS arousal (Janig & Habler, 2000). Matsunaga et al. (2008) have also shown that showing a participant an image of an individual who they are fond of increases activity in the PNS, endocrine, and immune systems. Eisenberger et al. (2011) show that neural activation in the ventromedial prefrontal cortex (VMPFC) mediates the tendency for attachment figures to reduce the perceived distress caused by a painful stimulation. The VMPFC and neighboring subgenual (or ventral) anterior cingulate cortex appear to be part of a safety-signal system associated with parasympathetic arousal and reductions in perceived distress, whereas dorsal anterior cingulate (dACC) activity tracks stress and SNS responses (Eisenberger & Cole, 2012; Matthews, Paulus, Simmons, Nelesen, & Dimsdale, 2004). Hence the PEA method, through activation of the PNS, is thought to modulate stress and result in increased cognitive function and openness to one's own emotions as well as those of others. This mechanism is thought to be critical to the sustained change associated with PEA coaching, and over the longer term better overall health and well-being due to improved self-regulatory function (Boyatzis & McKee, 2005; Boyatzis et al., 2013).

The neuroscience of visioning

Visioning differs from vision both in definition and in neural activation. Vision, the literal act of seeing, engages the primary visual cortex (Hubel & Wiesel, 1962). Visioning is defined as "[a] mental process in which images of the desired future (goals, objectives, outcomes) are made intensely real and compelling to act as motivators for the present

action" (BusinessDictionary.com). While the exact neural basis of visioning can only be guessed at, it plausibly involves activity associated with visual imagery combined with activity in emotion and reward systems.

Visual perception of an external stimulus and visual imagery recruit largely overlapping neural networks in frontal and parietal cortices. However, in occipital and temporal regions, visual imagery tends to preferentially recruit regions further along the sensory processing stream, rather than the primary visual cortex (Ganis, Thompson, & Kosslyn, 2004). Similarly, vivid remembering of a stimulus recruits higher perceptual regions (superior temporal and fusiform gyri) rather than early visual areas (Wheeler, Petersen, & Buckner, 2000), and more vivid visual imagery of felt objects is associated with activity in the right lateral occipital cortex (Zhang, Weisser, Stilla, Prather, & Sathian, 2004). Shedding further light on the role of these higher visual regions, Addis, Wong, and Schacter (2007) used a clever paradigm that differentiates construction of an imagined event (both past and future) from subsequent elaboration of that event. They show that lateral visual areas are more strongly associated with construction than elaboration, whereas medial parietal and lateral frontal areas were more strongly associated with elaboration.

There is broad evidence that the act of visioning contributes to human performance and well-being. Visual imagining of desired states or actions has been a part of preparation for many Gold medalist Olympians and professional athletes for years (Le Duff, 2002; Loehr & Schwartz, 2001). It has also been shown to improve performance in music (Meister et al., 2004), in academic achievement (Curry, Snyder, Cook, Ruby, & Rehm, 1997), and improve well-being in the various disease states (Leon-Pizarro et al., 2007; Roffe, Schmidt, & Ernst, 2005). It is believed that a positive visioning also works by arousing hope (Curry et al., 1997; Groopman, 2004) that in turn stimulates the PNS with a resultant increase in openness, cognitive function, and flexibility (Janig & Habler, 2000).

It has been claimed that such repeated visual imagining prepares the brain for the later action or experience by using neural connections and circuits over and over again (Kreiman, Koch, & Fried, 2000). We view our coaching with compassion approach as retraining individual's emotional and social processing, shifting them toward a more positive, compassionate, and future oriented way of thinking about themselves and reacting to others. At a neural level, we hypothesize that PEA coaching activates a parasympathetic "safety circuit" (Eisenberger & Cole, 2012) that ameliorates the stress-related sympathetic response that is

often provoked by a future planning. In psychological terms, PEA coaching engages positive motivational factors in order to change behavioral patterns, rather than NEA coaching that encourages the exercise of willpower, which depletes executive resources (Baumeister, 2008).

Experimental design

There is a growing literature that examines processes involved in positive emotion, regulatory focus, and imagining future events. However, the present study aims to make a novel contribution by focusing on the social interaction between individuals, which constitutes an essential aspect of all coaching and mentoring. The experimental design therefore emphasizes social interaction. Participants first experience in-person interviews outside the scanner, one PEA and one NEA, with two different coaches (whom they met for the first time). This established a social and emotional frame for subsequent interactions between the participant and each of the two interviewers. To assess the effectiveness of this social framing, an online manipulation check survey was sent to participants after the second interview. Next, the scanner paradigm employed a controlled "mock video interview" format, designed to be as ecologically valid as possible while also conforming to the limitations imposed by good fMRI experimental design. A sense of social interaction was maintained by using full screen pre-recorded videos showing the head and shoulders of the interviewer as they addressed the participant. Each trial took the form of a brief social exchange. First, the interviewer posed a personally directed question. The participant was then given a chance to respond (using a button press). As soon as the participant gave a response, a brief video played in which the interviewer acknowledged receiving the response. Hence, our paradigm captured BOLD responses characteristic of PEA and NEA coaching interactions.

The scanner paradigm involved four trial types. In two of the conditions, the interviewers posed either positively or negatively valenced questions consistent with the social frame already established with that interviewer (PEApos and NEAneg). The other two conditions consisted of identical neutrally valenced questions asked by each of the two interviewers (PEAneu and NEAneu). The rationale for this was to provide insight into the effect of the valence of the question independent of the social framing achieved by the prior in-person interviews, while avoiding a break with the prior frame by having the interviewers act inconsistently with their prior roles. This design allowed us to examine in a statistically independent

way the effects of interviewer (whether the prior interview was PEA or NEA) and context (the effect of the valence of the question, coded as more or less positive, i.e., PEAp_{os} and NEA_{neu} were more positive, PEA_{neu} and NEA_{neg} were more negative). Since these factors tap overlapping constructs, and we did not have a strong prediction about the degree to which they might interact, in addition to examining the main effects of interviewer and context in isolation we also examined their conjunction, i.e., we looked for regions that were influenced by both the interviewer and context (Friston, Penny, & Glaser, 2005; Price & Friston, 1997). We also compared the most positive and negative conditions (PEAp_{os} and NEA_{neg}) using a *t*-test.

In line with our theoretical rationale outlined above, our primary predictions were that more positive conditions would be associated with greater activity in lateral occipital areas associated with visual imagery (e.g., Zhang et al., 2004), and ventromedial prefrontal areas associated with parasympathetic arousal (Eisenberger & Cole, 2012). In contrast, more negative conditions should produce greater activity in anterior cingulate/medial prefrontal areas associated with sympathetic arousal (Critchley, 2005). Secondary to this, we predicted asymmetry in activation of lateral prefrontal areas on the basis of prior working linking prefrontal asymmetry to approach versus withdrawal motivation (Brookshire & Casasanto, 2012; Davidson, 1992; Spielberg, Stewart, Levin, Miller, & Heller, 2008). However, since much of this prior work on prefrontal asymmetry relies on EEG signals that are hard to accurately localize, we did not have clear hypotheses about where such asymmetries might arise in the lateral prefrontal cortex.

MATERIALS AND METHODS

Design overview

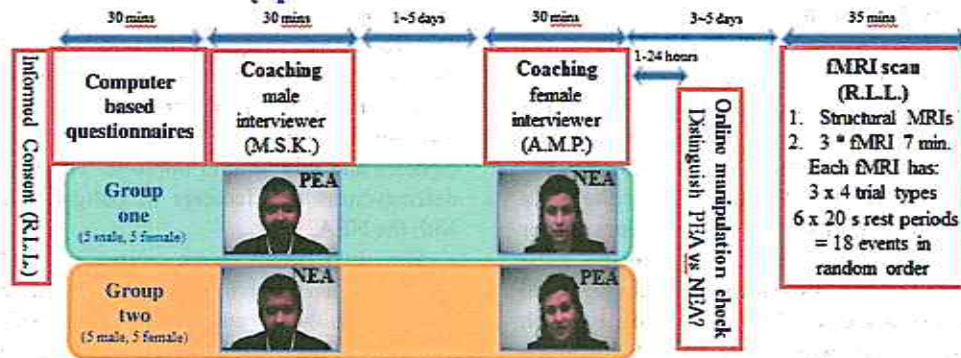
Subjects were recruited through campus newspapers and word-of-mouth. They filled out an online prescreen questionnaire and if they met the prescreen requirements they were able to schedule an initial session using an online scheduling tool. The timeline of the study procedure from the start of the first session is outlined in Figure 1a. After the participant was consented (by lead experimenter (R.L.L.)), they completed some computer-based surveys in a private testing area, and then they experienced a 30-minute interview conducted by the male interviewer (M.S.K.). A second 30-minute interview with the female interviewer (A.M.P.) was conducted on a subsequent day,

within 5 days of the first interview. Each participant experienced two interviews: a coaching with compassion style interview designed to provoke the positive emotional attractor (PEA), and a coaching for compliance style interview designed to provoke the negative emotional attractor (NEA). Participants were randomly assigned to conditions, with the constraint that equal numbers of participants were assigned to each permutation of participant gender, interviewer gender, and interview style (see Figure 1a). After the second interview was conducted, participants were emailed a link to fill out an online questionnaire asking their opinions of the two interviewers. This served as a manipulation check. The link was sent by R.L.L. As with subsequent interactions, we were careful to avoid interactions between the participant and the interviewers, which might overshadow or confuse the effect of the interviews.

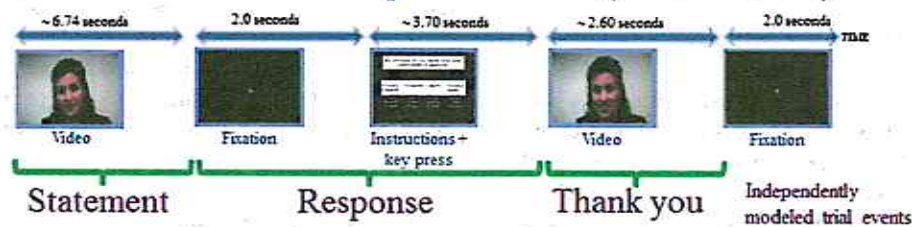
If selected for fMRI, participants completed the fMRI session under the supervision of R.L.L., three to 5 days following the second interview. The fMRI paradigm involved a controlled video-conference style interaction between the participant and the two interviewers with which the participant was now familiar. Each trial started with a video clip in which one of the two interviewers proposed a statement to the participant about their undergraduate experiences. After a brief pause, a response screen appeared and remained on screen until participants indicated the degree to which they agreed or disagreed with the preceding statement on a four-point scale. As soon as the participant responded, a brief video clip played in which the interviewer thanked the participant for his/her response.

Hence each trial involved an interactive exchange between the participant and one of the two interviewers. The videos consisted of a face-on view of the head and shoulders of the interviewer, who maintained eye contact (i.e., looked at the camera) as they spoke. The timeline for in-scanner experimental trials is depicted in Figure 1b. Participants experienced four types of scanner trials, summarized in Figure 1c. Each interviewer made statements (concerning the participant's undergraduate experience) in one of the two emotional tones: either the question posed was neutral (these questions were identical for the two interviewers), or the question adopted a tone congruent with the style of interview previously experienced by the participant with that interviewer. Hence, half the statements made by the interviewer who had conducted the PEA interview with the participant were positively phrased (PEAp_{os}), and half were neutral (PEA_{neu}). For the interviewer who had conducted the NEA interview, half the statements were neutrally phrased (NEA_{neu})

(a) Outline of study procedure with timeline



(b) Timeline of in-scanner experimental trial (mock interview)



(c) Scanner trial types

Condition	Interviewer	Statement	Example
PEApos	PEA	Positive	"As a Case graduate you will have the tools to contribute positively to your work organization"
PEAneu	PEA	Neutral	"You are learning at Case"
NEAneu	NEA	Neutral	"You are learning at Case"
NEAneg	NEA	Negative	"Generally you have little time for fun while you are at Case"

Figure 1. Schematic illustration of methods. (a) Study procedure, timeline, and participant groups, (b) timeline for a single trial in the scanner, and (c) the four conditions for experimental trials, with illustrative statement.

and half were negative (NEAneg). Following acquisition of a structural image (approx. 10 minutes), participants underwent three fMRI runs of 7 minutes. Each fMRI run comprised 12 experimental trials (3 of each condition, PEApos, PEAneu, NEAneu, NEAneg) and 6 resting fixation periods of 20 seconds.

Participants

Thirty-one full time undergraduates of sophomore standing at Case Western Reserve University between the ages of 18 and 21 years (15 male, mean age 19.6) were enrolled in the study. The online pre-screen and scheduling tool (Experiment Management System, Sona Systems) were used to establish that these participants were right-hand dominant, native

English speakers, had no neurological disorders or diseases, were not pregnant, did not experience claustrophobia, were not declared Cognitive Science majors, or enrolled as International Students. Of the 31 who enrolled, all participated in the initial questionnaire and interview sessions, and 23 participated in the fMRI study.

Usable fMRI data were obtained from a final total of 20 participants (10 female). Individuals were selected for fMRI on the basis of three constraints: (1) Even numbers of each gender experienced a same-gender interviewer in the NEA and PEA conditions (Figure 1a); (2) Participants did not evidence very low empathy (IRI) or expressiveness (BEQ), and did not report severe or extremely severe levels of anxiety, depression, or stress (DASS-21); (3) Otherwise the participants selected were those who

demonstrated maximal sensitivity to the manipulation as assessed by the postinterview questionnaire. The first two participants (one female) selected for fMRI were excluded from the final analysis due to technical errors with the scanner paradigm. One further participant was dropped because they demonstrated no variance in their responses while in the fMRI scanner, and appeared cognizant of the goals of the study when debriefed. Participants were compensated for their time at the rate of \$25 to complete the questionnaires and the two interviews, and an additional \$25 if they completed the fMRI scan. This research was approved by the appropriate local Institutional Review Board

Initial questionnaire session

Immediately after being consented, participants completed three computer-based surveys in a private testing area: the Depression, Anxiety, and Stress Scale (DASS21, Lovibond & Lovibond, 1995), the Berkeley Expressivity Questionnaire (BEQ, Gross & John, 1995), and the Interpersonal Reactivity Index (IRI, Davis, 1980). The DASS21 is a scale that has been shown to reliably measure depression and anxiety. It is composed of 21 items, two of which were excluded for the purposes of this study. These questions were rated on a scale from 0–3 and asked about their experiences in the past week. An example item was: I find it hard to relax. The BEQ has 16 items and measures one's ability to outwardly display their emotions and to what extent. The IRI is a measure of empathy consisting of four components—fantasy, perspective taking, empathetic concern, and personal distress (Davis, 1980).

In the same session, participants also answered a long questionnaire concerning their attitudes to various educational practices. The purpose of the latter questionnaire was to reinforce the purpose of the study as implied by the title used to describe the study to participants "Brain imaging study of educational attitudes," and to distract participants from the key experimental manipulation.

Interview sessions

During the consent process, participants had been told that they would be interviewed by two PhD students regarding their undergraduate experience and future goals. The style in which the interviews were conducted was based on Intentional Change Theory (Boyatzis, 2008). This style of coaching has been

called coaching to a PEA or coaching with compassion (Boyatzis et al., 2006). This specific approach emphasizes engaging the persons in contemplating their desired future, or visioning, instead of the more typical approach for coaching or advising in which a person is reminded of his/her weaknesses or deficiencies and told how to improve. The latter invokes defensiveness and feelings of obligation associated with the NEA.

The two interviewers were enrolled in the Organizational Behavior PhD program and were familiar with the theory and trained in the techniques of coaching to the positive attractor, or coaching with compassion. Each interviewer had 2 or more years of experience in using these coaching methods with undergraduates, graduate students, and executives. The PEA and NEA interviews involved distinct scripts of sequences of questions. In addition, the interviewers followed distinct guidelines designed to produce the appropriate arousals in the participants, as follows:

PEA coaching interview

After introducing himself/herself and explaining the study again if this was the first of the interviews, the interviewer asked the leading question: "If everything worked out ideally in your life, what would you be doing in 10 years?" this was followed with more specific probes if needed, such as, "Where would you be living? How would you be spending your time? What would you be like as a person? Who would you be with?"

The interviewer's role was to monitor the body language and mood of the person being coached and watch for signs that they were staying in the PEA. They would note things such as energy level of the student, leaning forward in their chair, direct eye contact, and smiling. If a person began to slip into a negative mood or become disengaged, the interviewer was prepared with the additional probing questions to bring them back into the PEA state.

NEA coaching interview

After introducing himself/herself and explaining the study again if this was the first of the interviews, the interviewer asked four specific questions, "What challenges have you encountered or do you expect to encounter in your experience here? How are you doing with your courses? Are you doing all of the homework and readings?" If the person seemed to slip from the NEA mood, the interviewer was prepared

with additional probing questions, which were: "How demanding is your class schedule? How often do you go to classes? What grades do you expect to get here? Are you getting sufficient time from your instructors? Do you have any fears about your time, experiences, or performance here?"

Here again, the interviewer's role was to monitor the body language and mood of the person being coached and watch for signs that they were staying in the NEA. They would note things such as a loss of energy, gazing at the walls or windows, leaning backward or slumping in their chair, not making direct eye contact, frowning, or looking worried. If a person began to slip into a positive mood or become engaged, the interviewer was prepared with the additional probing questions to bring them back into the NEA state, which as we observed is more typical of how many parents and faculty "advise" students. The aim of the NEA interviews was not to create a hostile or rude environment. The interviewers always maintained a polite and respectful tone. Rather, the aim was to keep the student focused on assessing their performance in terms of externally defined ideal standards and what he/she should be doing to get closer to those ideal standards. These were the emotional triggers used to induce a negative emotional state, in particular of guilt and defensiveness, in the student.

Manipulation check

After the two interviews were completed, R.L.L. emailed each participant a link to an online questionnaire about the two interviewers. Participants were asked to rate on a 7-point scale the degree to which they agreed or disagreed with statements regarding each of their interviewers. For example, one question read, "S/he inspired me about my future." For this question, we concluded the manipulation worked if the participant agreed more with the statement when referring to the PEA interviewer than to the NEA interviewer. The questionnaire consisted of 13 questions, 9 of which were targeted toward the PEA condition and 4 of which were targeted toward the NEA condition. The full list of questions is given in supplementary materials.

fMRI stimuli/task

Each of the three BOLD runs contained 12 trials. These consisted of three trials of each of the four conditions, which were organized according to a 2×2 factor design. The first factor (PEA vs NEA)

was determined by which of the two interviewers made the statement, coded according to whether that interviewer had previously conducted a PEA or NEA style interview with that participant. The second factor was the emotional tone of the statement and thank you, which was either consistent with the style of the interview (positive for the PEA interviewer, negative for the NEA interviewer) or which was neutral.

Each trial consisted of a statement-response-thank you sequence of variable duration (mean 15.04 seconds). There were also six resting fixation periods of 20 seconds. The order of trials and resting conditions was randomly determined for each participant within a run. Examples of the statements in the four conditions are as follows:

PEApos: "As a Case graduate you will have the tools to contribute positively to your work organization"

PEAneu/NEAneu: "You are learning at Case."

NEAneg: "Generally you have little time for fun while you are at Case,"

The Neutral statements were duplicated, each statement spoken once by each of the interviewers, whereas the positive and negative statements were unique to the appropriate interviewer for that participant.

The timing of events in a trial (Figure 1) was as follows: the statement videos varied in duration with a mean 6.74 seconds. These were followed by a fixed 2-second fixation period. A prompt then appeared asking participants to respond by indicating (via button press) whether they agreed or disagreed with the statement in the video on a four-point scale ("Strongly Disagree, Disagree, Agree, and Strongly Agree."). Participants could take as long as they wanted to respond (mean 3.70 seconds). Immediately after the response was registered, a brief thank-you video appeared (mean 2.6 seconds). These were randomly selected from a large pool of clips, with some variation on the phrase "Thank you." The interviewer and the emotional tone of the thank-you clips matched that of the statement. A 2-second fixation slide immediately followed. The next trial or resting fixation period would then begin.

Equipment, MRI sequences, and preprocessing

A 4-Tesla Siemens-Bruker hybrid research MRI scanner was used. Participants experienced structural image acquisition (T1 and T2w), and three blood oxygenation level-dependent (BOLD) runs (TR = 2000, TE = 20, flip angle = 90°) containing 180 echo planar imaging (EPI) volumes each. BOLD EPI images

consisted of 38 contiguous 3.8 mm slices, producing 3.8 mm cubic voxels. The paradigm was presented by a PC running E-Prime and projected onto a screen on the head coil and visible through an angled mirror adjusted to accommodate each participant. Responses were obtained through four buttons, two under the index and middle fingers of each hand and were recorded and time stamped by E-Prime.

Motion was corrected across and within runs using a rigid-body rotation and translational algorithm. Spatial transforms were computed to realign BOLD images where they were moved into a common atlas space determined by coregistration of an average epi image with the T2-weighted structural image. The T2-weighted structural image was aligned with the T1-weighted magnetization-prepared rapid-acquisition gradient echo (MP-RAGE) structural sequence. The T1 image was aligned with an average T1 atlas through a series of affine transformations. This atlas had been created specifically for the Bruker 4T magnet and was aligned to the Washington University in St. Louis 711-2B version of Talairach atlas space (Buckner et al., 2004). The BOLD images were then re-sampled into 3-mm isotropic voxels. Data were smoothed using a 2-voxel (6 mm) FWHM Gaussian kernel.

To ensure that event files were accurate and to check for excess movement or outliers, images were graphed to show the percentage of BOLD signal change against the baseline across all three consecutive runs. Timecourses were examined from two regions of interest: the first targeted early visual cortex and the second targeted motor cortex. The graph produced using the visual mask showed increased activity during the presentation of videos and decreased activation during resting fixation. The graph produced using the motor mask showed increased activity at the time of response. As a result of excessive movement yielding unreliable data, the first run of one participant was excluded from further analyses. Subsequent analyses of BOLD data used a general linear model (GLM), modeling out baseline and linear trend, and assuming a standard hemodynamic response function. This analysis was conducted using the Washington University in St. Louis software, FIDL.

Statistical analysis

We conducted both random and fixed-effects analyses. The random-effects analysis, using a single estimate per participant and condition, was used to allow inference concerning the population from which the sample was drawn. The random-effects analysis used $2 \times 2 \times 3$ repeated measures ANOVA design.

The factors were interviewer (PEA vs NEA), context (PEApos vs PEAneu, NEAneu vs NEAneg), and trial event (statement, response, thank you). The modeled period for the statement and thank-you periods corresponded to the duration of the videos (from onset to offset). The modeled response period included the 2-second pause prior to the onset of the response screen, and terminated at the moment response was made (Figure 1b). We focused on three effects that shed light on the processing of positive versus negative emotion, by looking at the effects of interviewer, context, and their conjunction (Friston, Penny, & Glaser, 2005; Price & Friston, 1997). *F*-tests from the random effects ANOVA analysis were corrected for sphericity and converted to *z*-stats. Whole brain multiple comparison correction was achieved using threshold and cluster size cut-offs established using Monte Carlo simulations. For the random effects analysis, the threshold used was $z > 3.0$ and cluster size of 13 face-contiguous voxels.

A more sensitive fixed-effects analysis was also used to identify neural markers of positive emotion within the study sample. This analysis used an assumed response function fitted to the duration of the whole trial (i.e., from onset of statement to offset of the thank you). The two conditions PEApos and NEAneg were contrasted to form a whole brain image of regions that responded more to one of these conditions. Whole brain correction established using Monte Carlo simulations for this contrast used $z > 3$ and cluster size of 17. The supplementary material reports peak activations with $z > 3.5$, with peaks closer than 12 mm consolidated.

Statistical parametric maps were mapped to a surface-based representation using Caret (Van Essen, 2005) for visualization.

Graphs for regions were created using estimates from the random effects analysis. The graphs depict average percent-signal change over all participants, separately by the condition and trial event (statement, response, thank you). Error bars show the standard error of the mean across participants.

RESULTS

Behavioral results

We first checked for any effects of gender, looking at effects of the gender of the participant, the gender of the interviewer, and gender match/mismatch between participant and interviewer. There were no significant differences found for either the manipulation check or for the behavioral responses during the scans. Hence, all subsequent analyses were collapsed across gender.

Analysis of responses from the online manipulation check questionnaire indicated that participants agreed that the PEA interviewer inspired, cared about, and evoked hope in them significantly more than the NEA interviewer (Figure 2a). Participants also reported feeling significantly more guilty and self-consciousness with the NEA interviewer than the PEA interviewer. This confirms that our NEA and PEA interview scripts were effective. Notably the largest advantage for the PEA coach was seen for the statement "S/he inspired me about my future." The largest advantage for the NEA coach was for "S/he asked questions about things I should be doing at Case regarding my studies." This confirms the interviews worked in the manner intended, by inspiring hope in the PEA and by emphasizing conformity with externally defined goals in the NEA. The interviews were not perceived by participants as being positive or negative in the simpler sense of the social interactions being friendly versus rude. Hence, there were no significant differences for questions about the degree the interviewer cared for the participant or asked abrasive questions.

While in the scanner, participants responded to statements made by the two interviewers by pressing one of four buttons, from strongly disagree to strongly agree. There was a significant effect of condition on response, as determined by ANOVA ($F(3,57) = 55.4$, $p < .001$). Posthoc contrasts indicated that participants agreed with PEApos questions significantly more than NEAneg questions ($t(19) = 9.89$, $p < .001$) and NEAneu questions ($t(19) = 2.96$, $p < .001$), but not PEAneu questions ($t(19) = 1.67$, n.s.). Participants agreed with NEA questions significantly less than NEAneu questions ($t(19) = 7.60$, $p < .001$) and PEAneu questions ($t(19) = 8.65$, $p < .001$).

fMRI results

We conducted two statistical analyses of the fMRI data. The first random effects analysis modeled all trial types as well as individual events within trials. This more statically conservative analysis was used to identify regions that passed the whole brain correction and were generalizable to the population. Activation was observed from the random effects analysis for the PEA in 12 ROIs: the right lateral occipital (posterior middle temporal gyrus, interior temporal gyrus near the occipital notch, and posterior inferior temporal sulcus), the right anterior insula, left postcentral gyrus, left medial parietal, right ventral fusiform gyrus, left precentral sulcus (junction with middle frontal gyrus), right hippocampal gyrus, and left posterior temporal (inferior temporal sulcus). Peak activations from this analysis are reported in Table 1 and are illustrated by colored discs in Figures 3–5.

The second fixed-effects analysis used a single assumed response to model the entire trial, and contrasted the most positive (PEApos) and negative (NEAneg) conditions. The fixed-effects analysis revealed effects within the sample, which may not have been powerful enough to overcome individual variations in anatomy and neural response in the random effects analysis. This more statistically powerful analysis allowed us to identify more widespread effects and assess their consistency with our hypotheses. While all 126 reported fixed effects are robust in the sense that they pass whole brain correction (see methods), they are limited to the sample and may not generalize to the population. Peak activations from the fixed-effects contrast are reported in the supplementary material, and the contrast is illustrated by coloring overlaid

TABLE 1
Random effects analysis

X	y	Z	n-vox	Peak z-stat	Region
<i>Main effect of Interviewer (PEApos + PEAneu vs NEAneu + NEAneg)</i>					
52.5	-66	3	38	4.7	Right lateral occipital (posterior middle temporal gyrus)
46.5	-78	-9	14	4.1	Right lateral occipital (inferior temporal gyrus, near occipital notch)
28.5	15	-6	39	3.9	Right anterior insula
<i>Main effect of Context (PEApos + NEAneu vs PEAneu + NEAneg)</i>					
37.5	-66	3	20	3.5	Right lateral occipital (posterior inferior temporal sulcus)
<i>Cognitive Conjunction of Interviewer and Context</i>					
37.5	-66	6	182	3.1	Right lateral occipital (posterior inferior temporal sulcus)
-40.5	-72	6	51	2.9	Left lateral occipital (inferior temporal sulcus, near occipital notch)
-25.5	-27	69	14	2.9	Left postcentral gyrus
-7.5	-60	42	35	2.3	Left medial parietal
40.5	-48	-12	25	2.3	Right ventral fusiform gyrus
-37.5	0	48	13	2.2	Left precentral sulcus (junction with middle frontal gyrus)
19.5	-48	-18	14	2.1	Right parahippocampal gyrus
-46.5	-60	3	14	2.0	Left posterior temporal (inferior temporal sulcus)

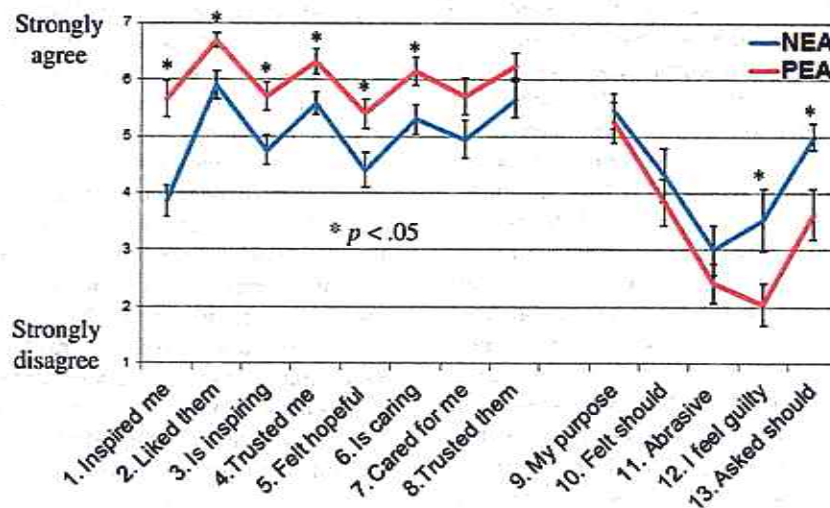
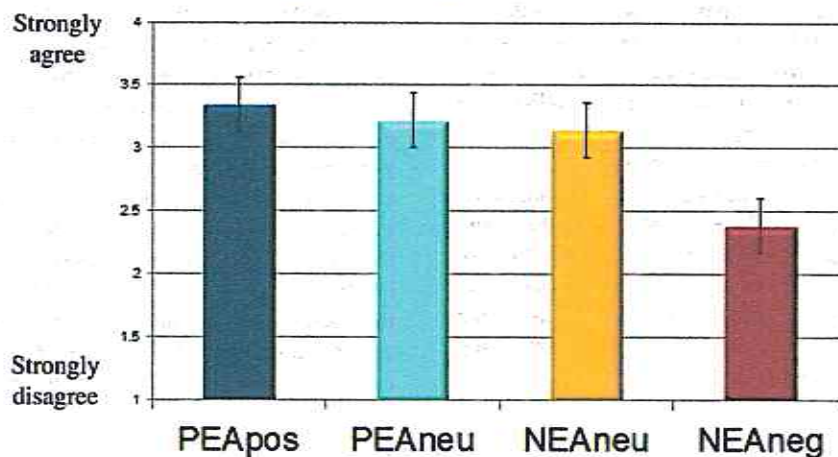
(a) Manipulation check by interview style**(b) Scanner responses by condition**

Figure 2. Behavioral responses for (a) the online manipulation check and (b) trials in the scanner.

on the average fiducial surface of the left and right hemispheres shown in Figures 3–5.

DISCUSSION

It is known that PEA coaching is more effective at achieving change in behavior than NEA coaching; however until now, the mechanisms of this effect have largely been a matter of speculation. This initial study was designed to emphasize the social interaction between mentor and mentee that represents a fundamental aspect of all coaching. A social frame was achieved by an initial coaching interview with

each coach. This framing was demonstrated to be effective, and to persist days after the interviews, by an online survey. The scanner paradigm represented an experimentally controlled method for measuring differences in BOLD response associated with more or less positive coaching interactions.

Visioning in the brain

The most robust and powerful differences between PEA and NEA coaching styles were found bilaterally in lateral occipital and posterior temporal cortices. This effect was more pronounced in the right

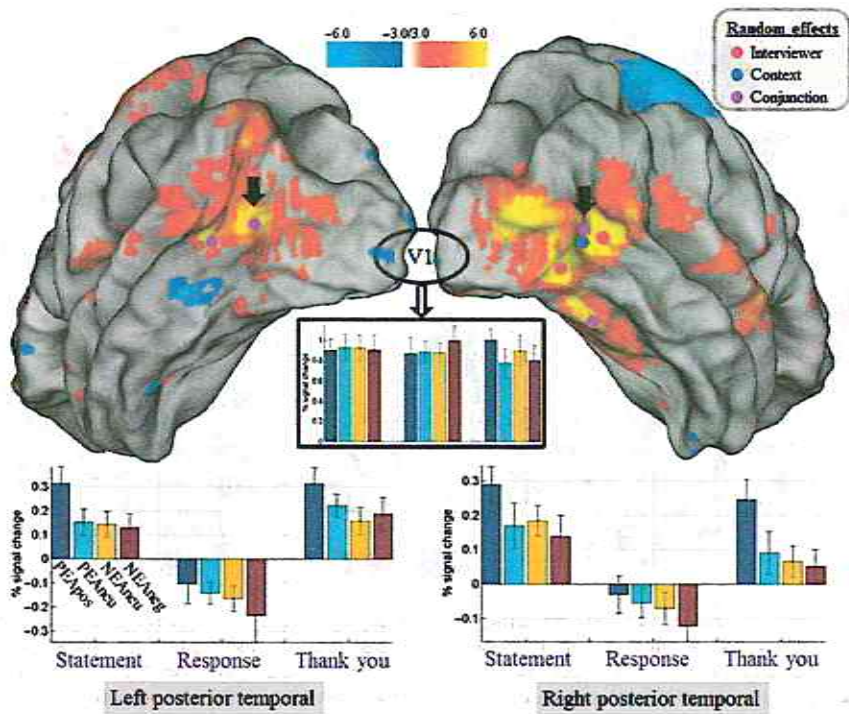


Figure 3. Neural correlates of positive visioning. The contrast of more positive with more negative coaching conditions reveals right lateralized recruitment of lateral and ventral visual areas, extending through visual association areas in temporal cortex. Foci from the random effects analysis are shown overlaid on an activation map from the fixed effects contrast (PEApos-NEAneg). The graphs show mean activity by condition and trial event, with standard error across participants. The bias toward more positive conditions is consistent across trial events, including the response period when the interviewer's face is not visible and activity falls below resting levels. The inset graph is taken from bilateral V1, illustrating that the bias is not driven by basic visual processing.

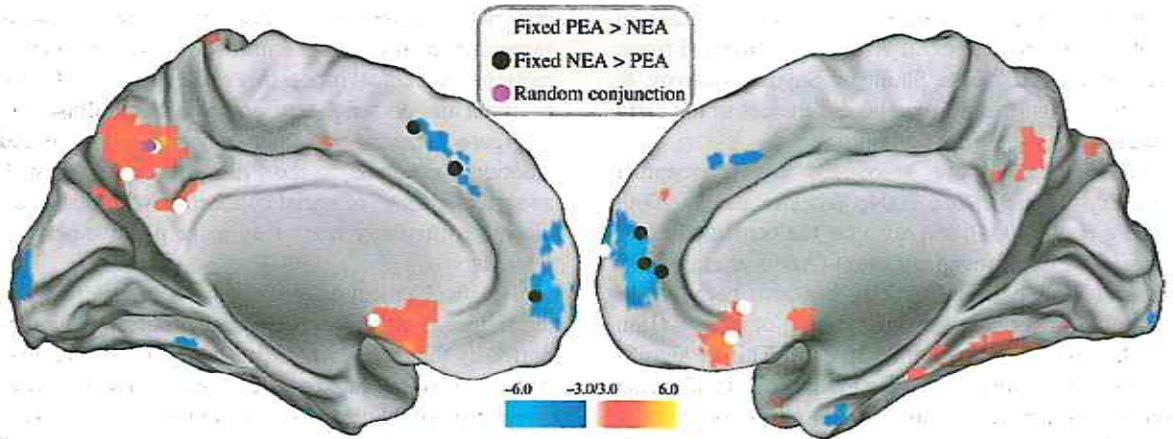


Figure 4. Medial parietal and prefrontal regions associated with positive versus negative coaching. Fixed (+ one random) effect foci are illustrated, which reflect differential recruitment of medial parietal, medial prefrontal, and cingulate regions.

hemisphere, and extended to posterior aspects of the superior temporal sulcus and gyrus as well as right ventral occipital (fusiform gyrus). These effects are illustrated in Figure 3, which also shows graphs

depicting neural response for different trial events and conditions (mean and standard error across participants were calculated from estimates from the random-effects analysis). While these regions are

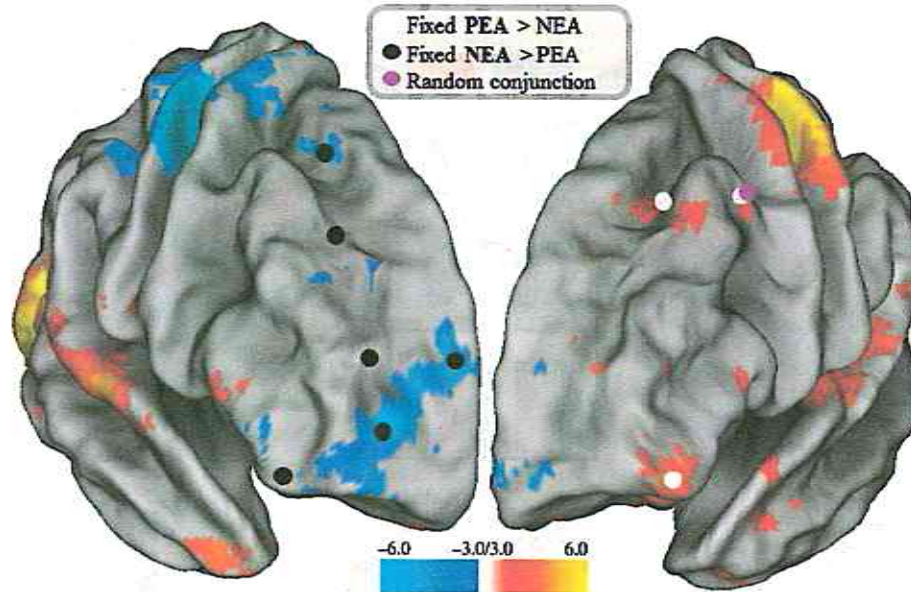


Figure 5. Frontal asymmetry associated with positive versus negative coaching. Lateralization of frontal brain activity has long been associated with positive emotion and/or approach behaviors (left) versus negative emotion and/or avoidance behaviors (right). Selected fixed- (+ one random-) effect foci are illustrated, which reflect asymmetries in the recruitment of frontal regions. Notably there is mirror image recruitment of closely homologous regions in superior frontal sulcus and the most anterior portion of the inferior frontal gyrus.

involved in higher visual processing, they do not appear to be driven by bottom-up differences in visual processing, such as might occur if participants tended to look away more when presented with videos featuring the NEA coach. To test this, we examined BOLD responses in a region of interest that included regions of the primary visual cortex corresponding to both foveal and peripheral visual fields (derived from: Jack et al., 2007; Jack, Shulman, Snyder, McAvoy, & Corbetta, 2006), and found no differences in the early visual processing by condition.

These regions are associated with perceptual imagery (Ganis et al., 2004; Wheeler et al., 2000; Zhang et al., 2004), in particular the construction, or formation, of an imagined event (Addis et al., 2007). Right lateral occipital activity has also been linked to global rather than local processing of stimuli (Han et al., 2002; Martinez et al., 1997). This is significant because a preference for global over local visual processing has repeatedly been associated with positive affect (Fredrickson & Branigan, 2005; Gasper & Clore, 2002) and with promotion/approach motivation (Forster, 2012; Forster & Higgins, 2005).

The regions identified in Figure 3 also demonstrate a good correspondence with a network of areas involved in the perceptual processing of social cues, including face, body, and gaze perceptions (Downing,

2005; Pelphrey, 2005). Similar to the effects we observe, this social processing tends to produce stronger and more extensive activations in the right hemisphere. However, left hemisphere regions are also clearly implicated in aspects of social processing that relate to our findings. Kanai et al. (2012) show reduced grey matter density in left superior temporal sulcus is associated with loneliness and with decreased socioemotional perceptual processing skill. Hence, the lateral occipital and posterior temporal activations illustrated in Figure 3 may in part indicate increased social and emotional openness to the PEA interviewer, as well as a greater sense of social connection with that interviewer, particularly when they make positive phrased remarks.

The involvement of these lateral occipital and posterior temporal regions in social processing is supported by the observation that activity in these regions was considerably higher, when social perceptual cues were present (Figure 3, "Statement" and "Thank you" periods), than when they were not ("Response" period). However, it is notable that the effect of condition was consistent across the entire trial. This suggests the modulation of these regions by condition is not simply due to differences in the perceptual processing of social stimuli, but likely reflects other processes (e.g., visual imagery associated with visioning).

Medial and subcortical regions

Findings on the medial surface fit our predicted association of PEA with PNS. There was greater activity in VMPFC/subgenual cingulate for the PEA condition, consistent with a role for this region in generating a safety signal associated with a sense of social-emotional security (Eisenberger & Cole, 2012; Eisenberger et al., 2011; Matsunaga et al., 2008). Increased PEA activity in the medial parietal cortex/posterior cingulate was also likely related to a sense of social attachment. The medial parietal cortex has been found in prior studies to activate more when viewing pictures of known and/or liked individuals, particularly family members, as opposed to famous faces or unfamiliar faces (Gobbini, Leibenluft, Santiago, & Haxby, 2004; Matsunaga et al., 2008; Platek & Kemp, 2009). Medial parietal cortex has also been implicated in the emotions of admiration and compassion for others (Immodino-Yang, McColl, Damasio, & Damasio, 2009), and is the region most consistently associated with humanizing, as opposed to dehumanizing, depictions of others (Jack, Dawson, & Norr, 2013).

As hypothesized, we also saw an association between NEA coaching and regions implicated in sympathetic arousal. There was greater NEA activity in the medial prefrontal cortex regions previously associated with SNS response (Critchley, 2005). This activity was in a cortex adjacent to cingulate the cortex regions classically associated with an SNS response (Eisenberger & Cole, 2012; Matthews et al., 2004).

An unanticipated dissociation was observed between the medial parietal cortex and a medial prefrontal region that has been reliably associated with self-trait attribution (Denny, Kober, Wager, & Ochsner, 2012). A dissociation between these regions has been previously observed in a related paradigm (Johnson, Raye, Mitchell, Touryan, & Nolen-Hoeksema, 2006); however in that study, they found medial parietal/posterior cingulate to be more strongly associated with prevention rather than promotion focus—the reverse mapping to our findings. One possibility, anticipated by Johnson et al. (2006), is that medial parietal/posterior cingulate activation is driven by social engagement, explaining the involvement of that region in PEA coaching.

Medial parietal and posterior cingulate cortex have also been consistently associated with a mental time travel, including both autobiographical recall and imagining future events (Buckner, Andrews-Hanna, & Schacter, 2008). However, there is some debate concerning the degree to which activity in this area is

specifically associated with the mental time travel, as opposed to being driven by the social and emotional content that typically predominates during the mental time travel. Recent evidence suggests that the social and emotional content is the key factor (Jack et al., 2012). Further, there is evidence that distinct parts of medial parietal/posterior cingulate are involved in cases of mental time travel that are devoid of social and emotional content (Spaniol et al., 2009).

D'Argembeau et al. (2008) found greater activity of the self-trait medial prefrontal region when participants imagined positive rather than negative future events. Johnson et al. (2006) found this region to be more strongly associated with prevention focus in study 1 and promotion focus in study 2. Given the present findings that this region was more strongly activated by the NEA than the PEA, it is apparent that further work will be needed to identify the key factors that drive activity in this region.

Prefrontal asymmetry

Figure 5 shows selected foci from the fixed-effects analysis, and one random-effects focus, illustrating a tendency for greater activity in the left hemisphere for PEA and the right hemisphere for NEA conditions. These effects are consistent with prior work linking prefrontal asymmetry to promotion/approach versus prevention/avoidance motivation (Brookshire & Casasanto, 2012; Davidson, 1992; Spielberg et al., 2008).

Note that regions in central and postcentral sulcus should be ignored as these reflect sensorimotor differences due to an increased tendency for participants to agree (right hand) with PEA and disagree (left hand) with NEA statements.

Limitations and future questions

This initial study of the neural basis of coaching was limited in a number of ways. Although the scanner paradigm was designed to mimic a real-life social interaction, it was necessarily somewhat artificial. The neutral questions were designed to allow us to compare identical questions associated with different interviewers. However, a complicating factor is that these questions were likely perceived as different depending on the interviewer who asked them. Hence an analysis not reported here revealed there were brain areas that were more or less active for the neutral

questions as compared to both the other conditions. A better way to distinguish the effect of the existing relationship with the interviewer from the tone of the questions would be to vary the prior coaching sessions between participants, so identifying the effect of prior coaching sessions on neural activation. This is planned for a follow-up study. There are a number of points that differentiate PEA from NEA coaching, including focus on the future versus past performance, emphasis on positive versus negative emotional experiences, and finer grained differences in terms of the specific emotional states evoked, which include hope, compassion, mindfulness, and playfulness. Future studies may seek to examine the contributions of these individual elements, helping to identify the neural mechanisms associated with specific elements of the intervention.

We were not able to identify effects of personal variables in this limited sample; however, prior work has suggested neural differences associated with individual differences in promotion and prevention focus.

CONCLUSION

These initial findings suggest that positive approaches to helping others to learn or change may be more effective than other more typical but somewhat negative approaches because they activate neural regions and circuits that cause the person to be more cognitively and perceptually open and engage positive motivational processes. More specifically, these findings support our theoretical predictions that the PEA is associated with visioning, engagement of the PNS, and approach motivation; whereas the NEA is associated with engagement of the SNS and avoidance motivation. They also support the broader theoretical approach of Intentional Change theory (Boyatzis, 2008), which places a clear emphasis on the role of psychophysiological processes in effective coaching. Future studies should further examine these effects while controlling for various factors, like future versus past oriented thought, age and role of the participants, trait dispositions, and neuroendocrine interactions. Future studies may contribute to the elaboration of a physiologically based theory of effective coaching, capable of informing the training and socialization of people in a variety of helping professions, such as doctors, nurses, teachers, and managers, not to mention parents. We eagerly anticipate the improved social outcomes this knowledge is likely to afford.

Supplementary material

Supplementary material is available via the "Supplementary" tab on the article's online page (<http://dx.doi.org/doi=10.1080/17470919.2013.808259>).

Original manuscript received 10 January 2013

Revised manuscript accepted 20 May 2013

First published online 26 June 2013

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