

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

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10 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.

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INTRODUCTION

25 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,

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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.

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

50 Research has shown that a positive approach leads
to more behavioral changes (Boyatzis, 2008; Boyatzis
et al., in press). A series of longitudinal studies
have shown that coaching on the basis of the PEA
in intentional change theory results in a dramatic
55 improvement in social and emotional competencies in
MBA students, which result in more effective manage-
ment performance (Boyatzis, Stubbs, & Taylor, 2002).
Subsequent work provides evidence that PEA coach-
ing improves outcomes in other contexts. For exam-
60 ple, 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%
65 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
70 mentoring relationship. Other work has looked at med-
ical student-standardized patient interactions (Dyck,
2010), father-daughter relationships in family busi-
nesses (Overbeke, 2009), Information Technology (IT)
manager-subordinate relationships (Pittenger, 2012),
75 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
80 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.

85 Performance reviews and formal coaching
approaches often involve all four of the condi-
tions 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
90 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 nore-
95 pinephrine, 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
100 mentee to view the situation as hostile, and provok-
ing a defensive response that results in cognitive
impairment, perceptual and emotional closing down,
and poor health (Boyatzis, Smith, & Blaize, 2006;
Sapolsky, 2004).

105 While anticipating an uncertain future may always
induce a degree of stress-related arousal, the coun-
terproductive effects of this arousal may be amelior-
ated by the perception of a supportive mentoring
relationship. Conditions similar to the PEA coach-
ing with compassion approach are known to activate
110 the Parasympathetic Nervous System (PNS), result-
ing in activation of reward systems and modulation of
SNS arousal (Janig & Habler, 1999). Matsunaga et al.
(2008) have also shown that showing a participant an
image of an individual who they are fond of increases
115 activity in the PNS, endocrine, and immune systems.
Eisenberger et al. (2011) show that neural activation
in the ventromedial prefrontal cortex (VMPFC) medi-
ates the tendency for attachment figures to reduce
the perceived distress caused by a painful stimulation.
120 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
125 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 cog-
130 nitive 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
135 function (Boyatzis & McKee, 2005; Boyatzis et al., in
press).

The neuroscience of visioning

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

145 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.

150 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 pref-
erentially recruit regions further along the sensory
155 processing stream, rather than the primary visual cor-
tex (Ganis, Thompson, & Kosslyn, 2004). Similarly,
vivid remembering of a stimulus recruits higher per-
ceptual regions (superior temporal and fusiform gyri)
rather than early visual areas (Wheeler, Petersen, &
160 Buckner, 2000), and more vivid visual imagery of
felt objects is associated with activity in the right lat-
eral occipital cortex (Zhang, Weisser, Stilla, Prather, &
Sathian, 2004). Shedding further light on the role of
these higher visual regions, Addis, Wong, & Schacter
165 (2007) used a clever paradigm that differentiates con-
struction 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
170 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
175 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,
180 & Rehm, 1997), and improve well-being in the var-
ious 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
185 PNS with a resultant increase in openness, cognitive
function, and flexibility (Janig & Habler, 1999).

It has been claimed that such repeated visual imag-
ining prepares the brain for the later action or experi-
ence by using neural connections and circuits over and
190 over again (Kreiman, Koch, & Fried, 2000). We view
our coaching with compassion approach as retraining
individual’s emotional and social processing, shift-
ing them toward a more positive, compassionate, and
future oriented way of thinking about themselves and
195 reacting to others. At a neural level, we hypothe-
size that PEA coaching activates a parasympathetic
“safety circuit” (Eisenberger & Cole, 2012) that ame-
liorates the stress-related sympathetic response that is

often provoked by a future planning. In psycholog-
ical terms, PEA coaching engages positive motiva- 200
tional factors in order to change behavioral patterns,
rather than NEA coaching that encourages the exer-
cise of willpower, which depletes executive resources
(Baumeister, 2008).

Experimental design 205

There is a growing literature that examines pro-
cesses 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 210
constitutes an essential aspect of all coaching and
mentoring. The experimental design therefore empha-
sizes social interaction. Participants first experience
in-person interviews outside the scanner, one PEA and
one NEA, with two different coaches (whom they met 215
for the first time). This established a social and em-
otional 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 220
after the second interview. Next, the scanner para-
digm employed a controlled “mock video interview” for-
mat, designed to be as ecologically valid as possible
while also conforming to the limitations imposed by
good fMRI experimental design. A sense of social 225
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. 230
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 inter-
viewer acknowledged receiving the response. Hence,
our paradigm captured BOLD responses characteristic 235
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 240
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 245
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 250

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., PEApos and NEAneu were more positive, PEAneu and NEAneg 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 (PEApos and NEAneg) 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 promotion focus versus prevention focus (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 pre-screen questionnaire and if they met the pre-screen 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 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 the lead experimenter (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 the lead experimenter (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 (PEApos), and half were neutral (PEAneu). For the interviewer who had conducted the NEA interview, half the statements were neutrally phrased (NEAneu)

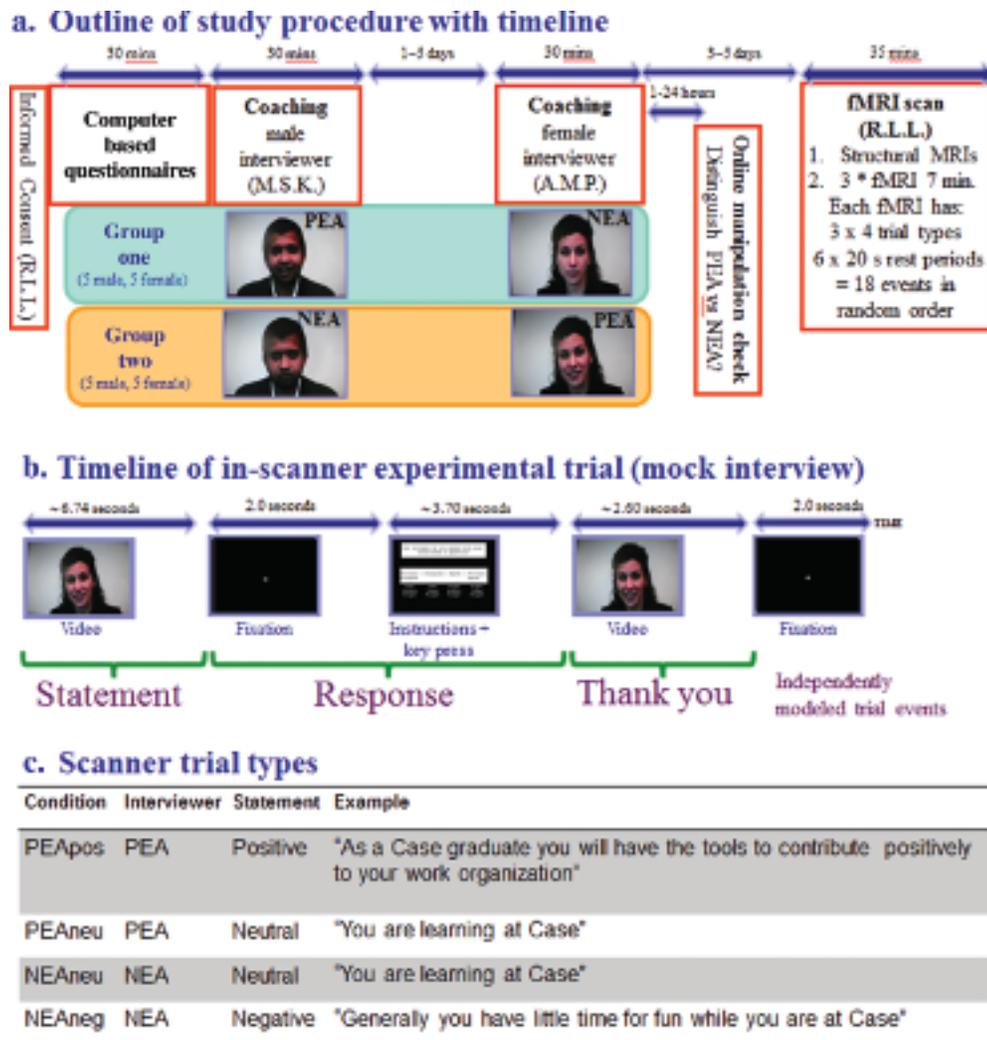


Figure 1. Schematic illustration of methods. (a) Study procedure, timeline, and participant groups, (b) timeline for a single trial in the scanner, and (c) the four conditions for experimental trials, with illustrative statement.

355 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.

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Participants

365 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, Sonata 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.

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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 (Table 1); 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

380

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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)

390 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
395 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

400 Immediately after being consented, participants com-
pleted three computer-based surveys in a private test-
ing area: the Depression, Anxiety, and Stress Scale
(DASS21, Lovibond, & Lovibond, 1995), the Berkeley
Expressivity Questionnaire (BEQ, Gross, & John,
405 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 ques-
410 tions 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
415 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 ques- 420
tionnaire was to reinforce the purpose of the study as
implied by the title used to describe the study to partic-
ipants “Brain imaging study of educational attitudes,”
and to distract participants from the key experimental
425 manipulation.

Interview sessions

During the consent process, participants had been
told that they would be interviewed by two PhD stu-
dents regarding their undergraduate experience and
future goals. The style in which the interviews were 430
conducted was based on Intentional Change Theory
(Boyatzis, 2008). This style of coaching has been
called coaching to a PEA) or coaching with compas-
sion (Boyatzis et al., 2006). This specific approach
emphasizes engaging the persons in contemplating 435
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 defi-
ciencies and told how to improve. The latter invokes
440 defensiveness and feelings of obligation associated
with the NEA.

The two interviewers were enrolled in the
Organizational Behavior PhD program and were famil-
iar with the theory and trained in the techniques of
coaching to the positive attractor, or coaching with
445 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

450 sequences of questions. In addition, the interviewers
followed distinct guidelines designed to produce the
appropriate arousals in the participants, as follows:

PEA coaching interview

455 After introducing himself/herself and explaining
the study again if this was the first of the interviews,
the interviewer asked the leading question: “If every-
thing worked out ideally in your life, what would you
be doing in 10 years?” this was followed with more
460 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
465 watch for signs that they were staying in the PEA.
They would note things such as energy level of the stu-
dent, 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 pre-
470 pared with the additional probing questions to bring
them back into the PEA state.

NEA coaching interview

475 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
480 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?
485 Do you have any fears about your time, experiences,
or performance here?”

Here again, the interviewer’s role was to moni-
tor the body language and mood of the person being
coached and watch for signs that they were staying
490 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,
495 the interviewer was prepared with the additional prob-
ing 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 500
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 505
induce a negative emotional state, in particular of guilt
and defensiveness, in the student.

Manipulation check

After the two interviews were completed, the lead
experimenter (R.L.L.) emailed each participant a link 510
to an online questionnaire about the two interview-
ers. 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 515
my future.” For this question, we concluded the manip-
ulation 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 520
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. 525
These consisted of three trials of each of the four con-
ditions, which were organized according to a 2×2 fac-
tor design. The first factor (PEA vs NEA) was deter-
mined by which of the two interviewers made the
statement, coded according to whether that interviewer 530
had previously conducted a PEA or NEA style inter-
view 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 535
NEA interviewer) or which was neutral.

Each trial consisted of a statement-response-thank
you sequence of variable duration (mean 15.04 sec-
onds). There were also six resting fixation periods of
20 seconds. The order of trials and resting conditions 540
was randomly determined for each participant within a
run. Examples of the statements in the four conditions
are as follows:

545 **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,”

550 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.

555 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.

570 **Equipment, MRI sequences, and preprocessing**

575 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.

585 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

595 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.

600 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

625 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

645 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.

650 A more sensitive fixed-effects analysis was also
used to identify neural markers of positive emo-
tion 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
655 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 simula-
tions for this contrast used $z > 3$ and cluster size of 17.
Supplementary Appendix reports peak activations with
660 $z > 3.5$, with peaks closer than 12 mm consolidated.

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

665 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.

670 RESULTS

Behavioral results

675 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.

680 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 feel-
ing significantly more guilty and self-consciousness
685 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
690 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 empha-
sizing conformity with externally defined goals in the

695 NEA. The interviews were not perceived by partici-
pants as being positive or negative in the simpler sense
of the social interactions being friendly versus rude.
Hence, there were no significant differences for ques-
tions about the degree the interviewer cared for the
participant or asked abrasive questions.

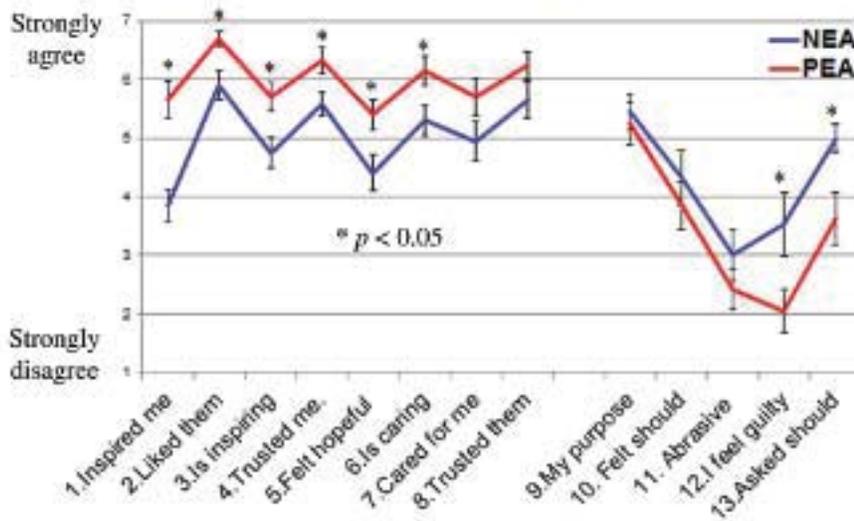
700 While in the scanner, participants responded to
statements made by the two interviewers by pressing
one of four buttons, from strongly disagree to strongly
agree. There was a significant effect of condition on
response, as determined by ANOVA ($F(3,57) = 55.4$,
705 $p < .001$). Posthoc contrasts 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
710 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

715 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 iden-
tify regions that passed the whole brain correction and
were generalizable to the population. Activation was
720 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 occip-
ital notch, and posterior inferior temporal sulcus), the
right anterior insula, left postcentral gyrus, left medial
725 parietal, right ventral fusiform gyrus, left precentral
sulcus (junction with middle frontal gyrus), right hip-
pocampal gyrus, and left posterior temporal (inferior
temporal sulcus). Peak activations from this analysis
are reported in Table 1 and are illustrated by colored
730 discs in Figures 3–5.

735 The second fixed-effects analysis used a single
assumed response to model the entire trial, and
contrasted the most positive (PEApos) and nega-
tive (NEAneg) conditions. The fixed-effects analysis
revealed effects within the sample, which may not have
been powerful enough to overcome individual varia-
tions in anatomy and neural response in the random
effects analysis. This more statistically powerful anal-
740 ysis 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
745 the population. Peak activations from the fixed-effects

a. Manipulation check by interview style



b. Scanner responses by condition

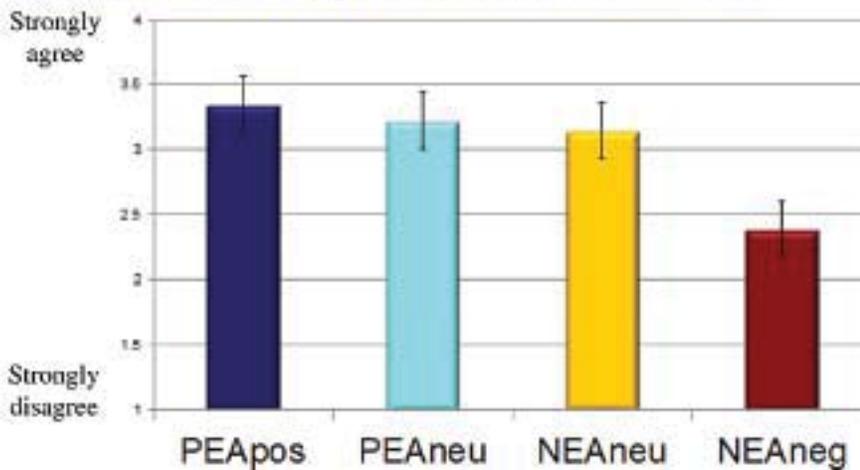


Figure 2. Behavioral responses for (a) the online manipulation check and (b) trials in the scanner.

AQ7 contrast are reported in Table 2, and the contrast is illustrated by coloring overlaid on the average fiducial surface of the left and right hemispheres shown in Figures 3–5.

750

DISCUSSION

755

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.

760

Visioning in the brain

765

The most robust and powerful differences between PEA and NEA coaching styles were found bilaterally

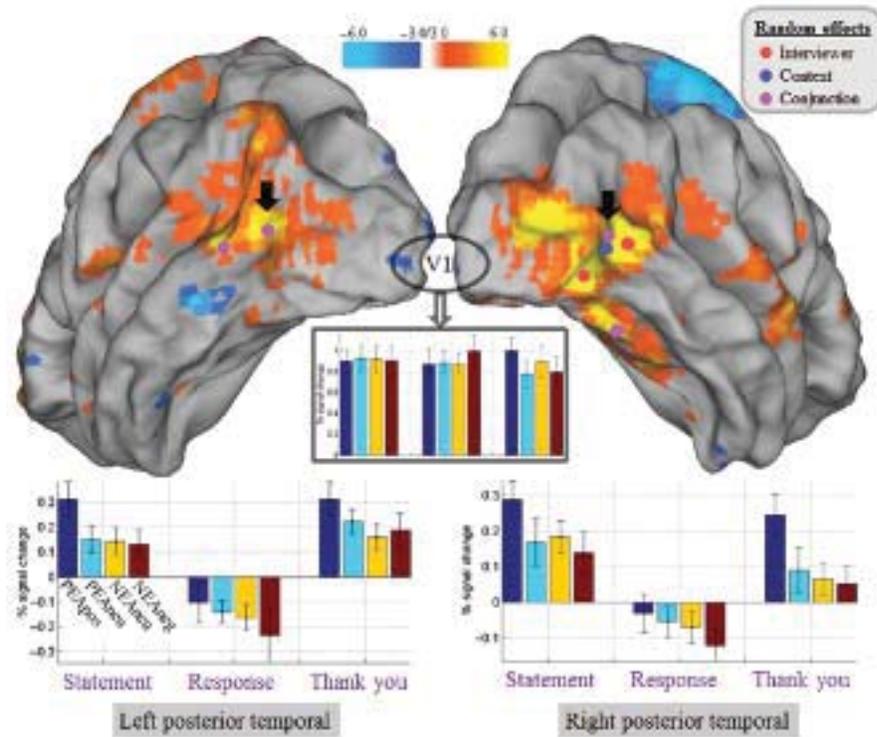


Figure 3. Neural correlates of positive visioning. The contrast of more positive with more negative coaching conditions reveals right lateralized recruitment of lateral and ventral visual areas, extending through visual association areas in temporal cortex. Foci from the random effects analysis are shown 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.

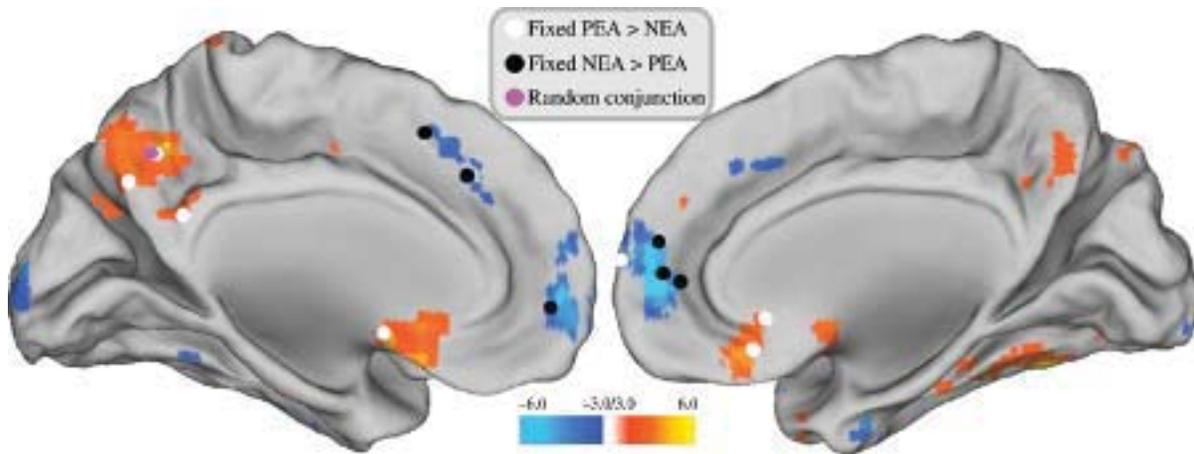


Figure 4. Medial parietal and prefrontal regions associated with positive versus negative coaching. Fixed (+ one random) effect foci are illustrated, which reflect differential recruitment of medial parietal, medial prefrontal, and cingulate regions.

770 in lateral occipital and posterior temporal cortices. This effect was more pronounced in the right 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 775

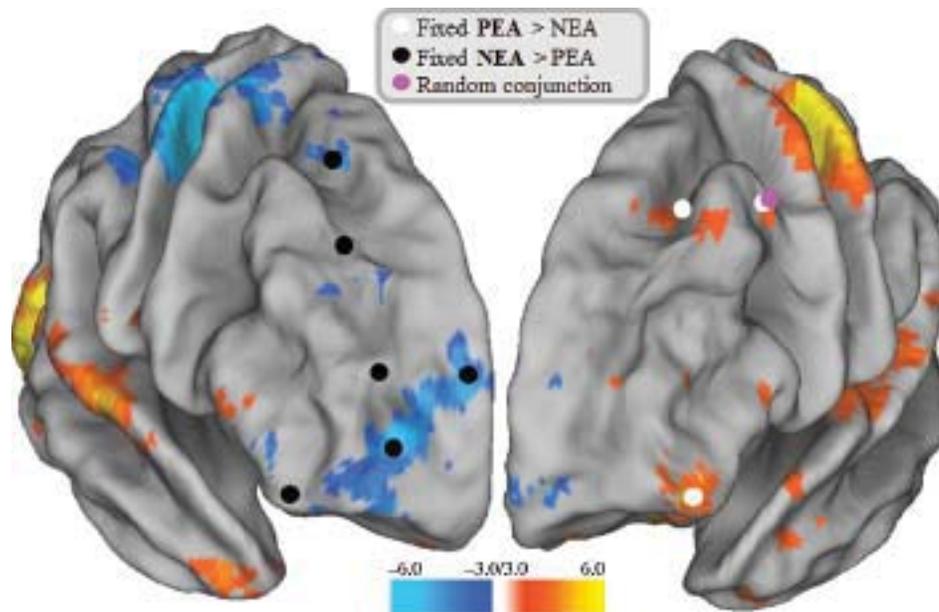


Figure 5. Frontal asymmetry associated with positive versus negative coaching. Lateralization of frontal brain activity has long been associated with positive emotion and/or approach behaviors (left) versus negative emotion and/or avoidance behaviors (right). Selected fixed- (+ one random-) effect foci 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.

780 calculated from estimates from the random-effects
 785 analysis). While these regions are 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 pri-
 mary 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.

790 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 signifi-
 cant because a preference for global over local visual
 processing has repeatedly been associated with posi-
 tive affect (Fredrickson & Branigan, 2005; Gasper &
 Clore, 2002) and with promotion/approach motivation
 (Forster, 2012; Forster & Higgins, 2005).

800 The regions identified in Figure 3 also demon-
 strate 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 inter-
 viewer, particularly when they make positive phrased
 remarks.

820 The involvement of these lateral occipital and pos-
 terior temporal regions in social processing is sup-
 ported 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 condi-
 tion was consistent across the entire trial. This suggests
 the modulation of these regions by condition is not
 simply due to differences in the perceptual process-
 ing 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 (Immordino-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 personality 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.

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REFERENCES

- Addis, D. R., Wong, A. T., & Schacter, D. L. (2007). Remembering the past and imagining the future: Common and distinct neural substrates during event construction and elaboration. *Neuropsychologia*, *45*(7), 1363–1377. doi: S0028-3932(06)00413-1 [pii]10.1016/j.neuropsychologia.2006.10.016
- Baumeister, R. F. (2008). Free will in scientific psychology. *Perspectives on Psychological Science*, *3*(1), 14–19. doi: DOI 10.1111/j.1745-6916.2008.00057.x
- Boyatzis, R. E. (2008). Leadership development from a complexity perspective. *Consulting Psychology Journal: Practice and Research*, *60*(4), 298–313. doi: 10.1037/1065-9293.60.4.298
- Boyatzis, R. E., & McKee, A. (2005). *Resonant leadership: Renewing yourself and connecting with others through mindfulness, hope, and compassion*. Boston, MA: Harvard Business School Press.
- Boyatzis, R. E., Smith, M. L., & Beveridge, A. (in press). Coaching with compassion: Inspiring health, well-being and development in organizations. *Journal of Applied Behavioral Science*.
- Boyatzis, R. E., Smith, M. L., & Blaize, N. (2006). Developing sustainable leaders through coaching and compassion. *Academy of Management Learning & Education*, *5*(1), 8–24. doi: 10.5465/amle.2006.20388381
- Boyatzis, R. E., Stubbs, E. C., & Taylor, S. N. (2002). Learning cognitive and emotional intelligence competencies through graduate management education. *Academy of Management Learning & Education*, *1*(2), 150–162. doi: 10.5465/amle.2002.8509345
- Brookshire, G., & Casasanto, D. (2012). Motivation and motor control: Hemispheric specialization for approach motivation reverses with handedness. *PLoS One*, *7*(4), e36036. doi: 10.1371/journal.pone.0036036 PONE-D-12-00045 [pii]
- Buckner, R. L., Andrews-Hanna, J. R., & Schacter, D. L. (2008). The brain's default network: Anatomy, function, and relevance to disease. *Annals of the New York Academy of Sciences*, *1124*(1), 1–38. doi: 10.1196/annals.1440.011
- Buckner, R. L., Head, D., Parker, J., Fotenos, A. F., Marcus, D., Morris, J. C., & Snyder, A. Z. (2004). A unified approach for morphometric and functional data analysis in young, old, and demented adults using automated atlas-based head size normalization: Reliability and validation against manual measurement of total intracranial volume. *Neuroimage*, *23*(2), 724–738. doi: S1053811904003271 [pii] 10.1016/j.neuroimage.2004.06.018
- Critchley, H. D. (2005). Neural mechanisms of automatic, affective, and cognitive integration. *Journal of Comparative Neurology*, *493*(1), 154–166. doi: 10.1002/cne.20749
- Curry, L. A., Snyder, C. R., Cook, D. L., Ruby, B. C., & Rehm, M. (1997). Role of hope in academic and sport achievement. *Journal of Personality and Social Psychology*, *73*(6), 1257–1267.
- Davidson, R. J. (1992). Anterior cerebral asymmetry and the nature of emotion. *Brain Cogn*, *20*(1), 125–151.
- Davis, M. H. (1980). A multidimensional approach to individual differences in empathy. *Psychology*, *10*, 85–114.

AQ8

- Denny, B. T., Kober, H., Wager, T. D., & Ochsner, K. N. (2012). A meta-analysis of functional neuroimaging studies of self- and other judgments reveals a spatial gradient for mentalizing in medial prefrontal cortex. *Journal of Cognitive Neuroscience*, *24*(8), 1742–1752. doi: 10.1162/jocn_a_00233
- Downing, P. E. (2005). Domain specificity in visual cortex. *Cerebral Cortex*, *16*(10), 1453–1461. doi: 10.1093/cercor/bhj086
- Dyck, L. (2010). *Resonance and dissonance in professional helping relationships at the dyadic level: Determining the influence of positive and negative emotional attractors on effective physician-patient communication*. (Unpublished doctoral dissertation). Case Western Reserve University, Cleveland, OH
- Eisenberger, N. I., & Cole, S. W. (2012). Social neuroscience and health: Neurophysiological mechanisms linking social ties with physical health. *Nature Neuroscience*, *15*(5), 669–674. doi: 10.1038/nn.3086 nn.3086 [pii]
- Eisenberger, N. I., Master, S. L., Inagaki, T. K., Taylor, S. E., Shirinyan, D., Lieberman, M. D., & Naliboff, B. D. (2011). Attachment figures activate a safety signal-related neural region and reduce pain experience. *Proceedings of the National Academy of Sciences USA*, *108*(28), 11721–11726. doi: 10.1073/pnas.1108239108 1108239108 [pii]
- Forster, J. (2012). GLOMO(sys): The how and why of global and local processing. *Current Directions in Psychological Science*, *21*(1), 15–19. doi: Doi 10.1177/09637214111429454
- Forster, J., & Higgins, T. E. (2005). How global versus local perception fits regulatory focus. *Psychological Science*, *16*(8), 631–636. doi: PSCI1586 [pii] 10.1111/j.1467-9280.2005.01586.x
- Fredrickson, B. (2009). *Positivity: Top-notch research reveals the 3 to 1 ratio that will change your life*. Crown Publishing Group.
- Fredrickson, B. L., & Branigan, C. (2005). Positive emotions broaden the scope of attention and thought-action repertoires. *Cognition & Emotion*, *19*(3), 313–332. doi: Doi 10.1080/02699930441000238
- Friston, K., Penny, W., & Glaser, D. (2005). Conjunction revisited. *NeuroImage*, *25*(3), 661–667. doi: 10.1016/j.neuroimage.2005.01.013
- Gagné, M., & Deci, E. L. (2005). Self-determination theory and work motivation. *Journal of Organizational Behavior*, *26*(4), 331–362. doi: 10.1002/job.322
- Ganis, G., Thompson, W. L., & Kosslyn, S. M. (2004). Brain areas underlying visual mental imagery and visual perception: An fMRI study. *Brain Res Cogn Brain Res*, *20*(2), 226–241. doi: 10.1016/j.cogbrainres.2004.02.012 S0926641004000709 [pii]
- Gaspar, K., & Clore, G. L. (2002). Attending to the big picture: Mood and global versus local processing of visual information. *Psychological Science*, *13*(1), 34–40.
- Gobbini, M. I., Leibenluft, E., Santiago, N., & Haxby, J. V. (2004). Social and emotional attachment in the neural representation of faces. *Neuroimage*, *22*(4), 1628–1635.
- Groopman, J. E. (2004). *The anatomy of hope: How people prevail in the face of illness* (1st ed.). New York, NY: Random House.
- Gross, J. J., & John, O. P. (1995). Facets of emotional expressivity—3 self-report factors and their correlates. *Personality and Individual Differences*, *19*(4), 555–568. doi: Doi 10.1016/0191-8869(95)00055-B
- Han, S., Weaver, J. A., Murray, S. O., Kang, X., Yund, E. W., & Woods, D. L. (2002). Hemispheric asymmetry in global/local processing: Effects of stimulus position and spatial frequency. *Neuroimage*, *17*(3), 1290–1299. doi: S1053811902912553 [pii]
- Higgins, E. T. (1997). Beyond pleasure and pain. *American Psychologist*, *52*(12), 1280–1300.
- Hubel, D. H., & Wiesel, T. N. (1962). Receptive fields, binocular interaction and functional architecture in the cat's visual cortex. *Journal of Physiology*, *160*, 106–154.
- Immordino-Yang, M. H., McColl, A., Damasio, H., & Damasio, A. (2009). Neural correlates of admiration and compassion. *Proceedings of the National Academy of Sciences USA*, *106*(19), 8021–8026. doi: 0810363106 [pii] 10.1073/pnas.0810363106
- Jack, A. I., Dawson, A. J., Begany, K. L., Leckie, R. L., Barry, K. P., Ciccio, A. H., & Snyder, A. Z. (2012). fMRI reveals reciprocal inhibition between social and physical cognitive domains. *Neuroimage*, *66C*, 385–401. doi: S1053-8119(12)01064-6 [pii] 10.1016/j.neuroimage.2012.10.061
- Jack, A. I., Dawson, A. J., & Norr, M. (2013). Seeing human: Distinct and overlapping neural signatures associated with two forms of dehumanization. *Neuroimage*. doi: S1053-8119(13)00468-0 [pii] 10.1016/j.neuroimage.2013.04.109
- Jack, A. I., Patel, G. H., Astafiev, S. V., Snyder, A. Z., Akbudak, E., Shulman, G. L., & Corbetta, M. (2007). Changing human visual field organization from early visual to extra-occipital cortex. *PLoS One*, *2*(5). doi: ARTN e452 DOI 10.1371/journal.pone.0000452
- Jack, A. I., Shulman, G. L., Snyder, A. Z., McAvoy, M., & Corbetta, M. (2006). Separate modulations of human V1 associated with spatial attention and task structure. *Neuron*, *51*(1), 135–147. doi: S0896-6273(06)00453-3 [pii] 10.1016/j.neuron.2006.06.003
- Janig, W., & Habler, H.-J. (1999). Organization of the autonomic nervous system: Structure and function. In O. Appenzeller (Ed.), *Handbook of clinical neurology Vol 74: The autonomic nervous system, Part I: Normal functions*.
- Johnson, M. K., Raye, C. L., Mitchell, K. J., Touryan, S. R., & Nolen-Hoeksema, S. (2006). Dissociating medial frontal and posterior cingulate activity during self-reflection. *Social Cognitive and Affective Neuroscience*, *1*(1), 56–64. doi: 10.1093/scan/nsi004
- Kanai, R., Bahrami, B., Duchaine, B., Janik, A., Banissy, M. J., & Rees, G. (2012). Brain structure links loneliness to social perception. *Curr Biol*, *22*(20), 1975–1979. doi: 10.1016/j.cub.2012.08.045 S0960-9822(12)01049-4 [pii]
- Khawaja, M. (2010). *The mediating role of positive and negative emotional attractors between psychosocial correlates of doctor-patient relationships and treatment adherence in Type 2 Diabetics* (Unpublished doctoral dissertation). Case Western Reserve University, Cleveland, OH.
- Kreiman, G., Koch, C., & Fried, I. (2000). Imagery neurons in the human brain. *Nature*, *408*(6810), 357–361.
- Le Duff, C. (2002, February 21). A pile of medals for a positive thinker. *The New York Times*.

- 1175 Leon-Pizarro, C., Gich, I., Barthe, E., Rovirosa, A., Farrus, B., Casas, F., . . . Arcusa, A. (2007). A randomized trial of the effect of training in relaxation and guided imagery techniques in improving psychological and quality-of-life indices for gynecologic and breast brachytherapy patients. *Psychooncology*, *16*(11), 971–979. doi: 10.1002/pon.1171
- 1180 Loehr, J., & Schwartz, T. (2001). The making of a corporate athlete. *Harvard Business Review*, *79*(1), 120.
- 1185 Lovibond, P. F., & Lovibond, S. H. (1995). The structure of negative emotional states: Comparison of the depression anxiety stress scales (DASS) with the beck depression and anxiety inventories. *Behaviour Research and Therapy*, *33*(3), 335–343. doi: 0005-7967(94)00075-U [pii]
- 1190 Martinez, A., Moses, P., Frank, L., Buxton, R., Wong, E., & Stiles, J. (1997). Hemispheric asymmetries in global and local processing: Evidence from fMRI. *Neuroreport*, *8*(7), 1685–1689.
- 1195 Matsunaga, M., Isowa, T., Kimura, K., Miyakoshi, M., Kanayama, N., Murakami, H., . . . Ohira, H. (2008). Associations among central nervous, endocrine, and immune activities when positive emotions are elicited by looking at a favorite person. *Brain, Behavior, and Immunity*, *22*(3), 408–417. doi: S0889-1591(07)00251-6 [pii] 10.1016/j.bbi.2007.09.008
- 1200 Matthews, S. C., Paulus, M. P., Simmons, A. N., Nelesen, R. A., & Dimsdale, J. E. (2004). Functional subdivisions within anterior cingulate cortex and their relationship to autonomic nervous system function. *Neuroimage*, *22*(3), 1151–1156. doi: 10.1016/j.neuroimage.2004.03.005 S1053811904001491 [pii]
- 1205 Meister, I. G., Krings, T., Foltys, H., Boroojerdi, B., Muller, M., Topper, R., & Thron, A. (2004). Playing piano in the mind—an fMRI study on music imagery and performance in pianists. *Cognitive Brain Research*, *19*(3), 219–228. doi: DOI 10.1016/j.cogbrainres.2003.12.005
- 1210 Overbeke, K. (2009). *Vision as a crucial mediator in predicting daughters' succession in family businesses*. Paper presented at the Academy of Management Annual Meeting, Montreal.
- 1215 Pelphrey, K. A. (2005). Neural basis of eye gaze processing deficits in autism. *Brain*, *128*(5), 1038–1048. doi: 10.1093/brain/awh404
- 1220 Pittenger, L. (2012). *IT professionals: Understanding what impacts their desire to engage in work* (Unpublished doctoral dissertation). Case Western Reserve University, Cleveland, OH.
- Platek, S. M., & Kemp, S. M. (2009). Is family special to the brain? An event-related fMRI study of familiar, familial, and self-face recognition. *Neuropsychologia*, *47*(3), 849. 1225
- Price, C. J., & Friston, K. J. (1997). Cognitive conjunction: A new approach to brain activation experiments. *Neuroimage*, *5*(4 Pt 1), 261–270. doi: S1053-8119(97)90269-X [pii] 10.1006/nimg.1997.0269 1230
- Quinn, J. (2013). *The importance of compassion and vision in physician leadership* (Unpublished doctoral dissertation). Case Western Reserve University, Cleveland, OH. 1235
- Roffe, L., Schmidt, K., & Ernst, E. (2005). A systematic review of guided imagery as an adjuvant cancer therapy. *Psycho-Oncology*, *14*(8), 607–617. doi: Doi 10.1002/Pon.889
- Sapolsky, R. M. (2004). *Why zebras don't get ulcers* (3rd ed.). Holt paperbacks. 1240
- Segerstrom, S. C., & Miller, G. E. (2004). Psychological stress and the human immune system: A meta-analytic study of 30 years of inquiry. *Psychology Bulletin*, *130*(4), 601–630. doi: 10.1037/0033-2909.130.4.601 2004-15935-004 [pii] 1245
- Spaniol, J., Davidson, P. S., Kim, A. S., Han, H., Moscovitch, M., & Grady, C. L. (2009). Event-related fMRI studies of episodic encoding and retrieval: Meta-analyses using activation likelihood estimation. *Neuropsychologia*, *47*(8–9), 1765–1779. doi: S0028-3932(09)00106-7 [pii] 10.1016/j.neuropsychologia.2009.02.028 1250
- Spielberg, J. M., Stewart, J. L., Levin, R. L., Miller, G. A., & Heller, W. (2008). Prefrontal cortex, emotion, and approach/withdrawal motivation. *Social Personal Psychology Compass*, *2*(1), 135–153. doi: 10.1111/j.1751-9004.2007.00064.x 1255
- Van Essen, D. C. (2005). A population-average, landmark- and surface-based (PALS) atlas of human cerebral cortex. *Neuroimage*, *28*(3), 635–662. doi: S1053-8119(05)00494-5 [pii] 10.1016/j.neuroimage.2005.06.058 1260
- Wheeler, M. E., Petersen, S. E., & Buckner, R. L. (2000). Memory's echo: Vivid remembering reactivates sensory-specific cortex. *Proceedings of the National Academy of Sciences USA*, *97*(20), 11125–11129. doi: 97/20/11125 [pii] 1265
- Zhang, M., Weisser, V. D., Stilla, R., Prather, S. C., & Sathian, K. (2004). Multisensory cortical processing of object shape and its relation to mental imagery. *Cognitive, Affective, & Behavioral Neuroscience*, *4*(2), 251–259. 1270