Positive Intelligence®

Positive Intelligence
Whitepaper Series

The Neuroscience of Positive Intelligence

Positive Intelligence provides a neuroscience-based approach to mental fitness.

This whitepaper both updates and expands on the original neuroscience foundation of Positive Intelligence, based on the latest findings in this fast-evolving field.

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Overview of Positive Intelligence:

The premise of Positive Intelligence is that certain modalities of the mind, generally associated with prolonged “negative” emotions, sabotage one’s mental wellbeing, performance, and relationships. These modalities are therefore labeled “Saboteurs” and associated with the “Survivor Brain.” Conversely, other modalities of the mind, generally associated with prolonged “positive” emotions, promote one’s wellness, optimal performance, and healthy relationships. These modalities are labeled “Sage” and associated with the “PQ Brain.”

To enhance mental fitness, Positive Intelligence prescribes a 3-step process:

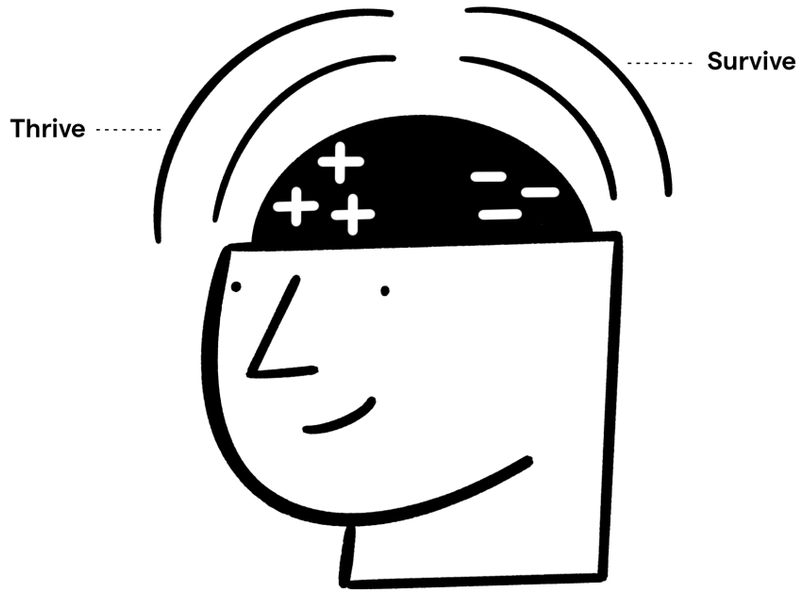
1. When you detect a Saboteur state, let go of the associated thoughts and emotions instead of pursuing them. This **weakens the Saboteurs.**
2. Perform “PQ Reps” to diminish the Saboteur response and enable a Sage response. This **strengthens Self-Command.**
3. Choose a Sage response. This **strengthens the Sage.**

PQ Reps are 10-second exercises that shift the mind’s focus to present-moment awareness of physical sensations. Examples include gently rubbing two fingertips against each other with such attention that you can feel the fingertip ridges of both fingers. Or focusing intently on the farthest away sounds for 10 seconds. Or noticing the rising and falling of your chest or stomach with each breath. In effect, **a PQ Rep is the core building block that constitutes mindfulness and meditation practices**. This enables us to use research on mindfulness and meditation to infer the impact of PQ Reps.

Default Mode Network (DMN) vs. Task-Positive Network (TPN):

Thanks to the development of tools like functional magnetic resonance imaging (fMRI) that enable scientists to map activity associated with thought, our understanding of human brain organization is becoming much clearer. Functions such as attention, memory, and perception all involve widespread networks consisting of numerous interconnected modules, each contributing specific elements to these larger processes. In fact, we now appreciate that the predominant functions of our cerebral cortex—that wrinkled cauliflower-like surface of the two cerebral hemispheres, are broadly divisible into two opposing networks. One, known as the Default Mode Network (DMN), consists of regions located predominately along the interior (medial) surfaces and is more active when we are preoccupied with our own inner mental lives (e.g., self-referential thinking, mind wandering, internal dialogue) (Gusnard et al., 2001; Spreng et al., 2009). Areas situated on the outer (lateral) surfaces of the hemispheres comprise the Task-Positive Network (TPN) that is engaged when we focus on attention-demanding tasks directed at external sources of stimulation (e.g., solving problems, planning, taking action in the world) (Corbetta & Shulman, 2002; Fox et al., 2005). Analogous to a playground teeter-totter, these two networks exist in a dynamic equilibrium; as activity in the DMN goes up, activity in the TPN goes down and vice versa(Fox et al., 2005; Gusnard et al., 2001). The tilt at any one moment reflects our mental state.

As you practice PQ Reps, for instance, you will find that your mind will invariably wander off, and you will need to lead it back to its focus. What you are experiencing here is quite literally the shift in balance between your DMN and TPN. Fine-grained analyses of fMRI data from longtime meditators reveal higher activity in the DMN during mind wandering, and a tilt in favor of the TPN as they become aware of this mental drift and refocus attention on their practice (e.g., monitoring their breath)(Fujino et al., 2018; Hasenkamp et al., 2012).



Likewise, while activity in the DMN is dominant during the intrusive thoughts and self-critical internal dialogue known as ruminative brooding (Killingsworth & Gilbert, 2010), the balance favors the TPN when we engage in attentive focus and reflective pondering — an adaptive form of rumination in which we purposefully engage in cognitive problem solving to alleviate the symptoms of our distress.

Recast in the language of Positive Intelligence, most of our Judge and Saboteur responses are creations of mind wandering DMN activity, while our Sage arises from the mindful actions of the TPN.

DMN, Saboteurs and the Survivor Brain

As your own experiences can likely attest, our default state appears to be one of mind wandering and internal chatter. When not engaged in a task, the wheels of our mind continue churning, and the content of these thoughts is quite likely what inspired you to consider Positive Intelligence in the first place: judging our past actions or lack thereof, rehashing past conversations or anticipating possible future conflicts, experiencing guilt and shame over perceived failings, generalized fretting, and so on. In one extreme example, this ruminative brooding is a core symptom of Major Depressive Disorder, and brain imaging studies of individuals struggling with this condition have established its connection with DMN activity. Specifically, we find increased brooding rumination in association with hyperactivity of medial prefrontal regions of the DMN (Berman et al., 2011; Hamilton et al., 2011; Kross et al., 2009; Nejad et al., 2013). The data concerning this relationship are increasingly clear as summarized in a new meta-analysis of 18 neuroimaging studies implicating the medial prefrontal cortex in brooding rumination while individuals are idling (Zhou et al., 2020). Moreover, a growing body of evidence suggests that a bidirectional relationship exists between our DMN and Survivor Brain.

The DMN is interconnected with subcortical structures of our more primitive limbic system that is heavily involved in regulating our emotional responses (Pessoa, 2017). To be precise, inferior regions of the medial prefrontal cortex are densely connected with the amygdala — a collection of nuclei located deep within the subcortical center of our brains that governs how we react to highly charged stimuli (Ghashghaei et al., 2007).

Feeling triggered by that person aggressively cutting you off during your commute? If you find yourself reacting with irrational levels of rage or fear, you have just been hijacked by your amygdala, or in the language of Positive Intelligence, the Judge Saboteur.
These connections are strengthened by persistent stress, making the triggering of such reactions easier with repetition. For example, fMRI data gathered from individuals who report experiencing higher levels of stress during the past month show enhanced communication between the amygdala and anterior regions of the DMN (notably the anterior cingulate which like the amygdala is part of the limbic system) (Taren et al., 2015). As with nearly all connections in the brain, these pathways are two-way streets that allow the DMN to influence functioning of the amygdala and vice versa. Our amygdala in turn governs interactions between the cortex, hypothalamus, and brain stem that are essential for core survival functions and govern our fight or flight responses, a key component of the Survivor Brain. Studies of individual differences in people managing with chronic stress are providing insights into how our reactions may alter brain networks that are key to Positive Intelligence.

Investigations employing diffusion tensor imaging (DTI)—a form of magnetic resonance imaging (MRI) that reveals the fine-grained architecture of the white matter tracts that comprise the connections within and between brain regions—indicate how major trauma affects our brains. Compared with individuals who have not experienced trauma, those who have been maltreated exhibit more sparse connectivity throughout the brain regardless of whether they develop psychiatric conditions or are resilient (Teicher et al., 2016). Compared with maltreated individuals who developed disorders, however, resilient people exhibit lower connectivity specifically within the amygdala (Ohashi et al., 2019).

It is possible that this has the effect of curtailing the spread of stress and fear responses by limiting the propagation of neural impulses between the amygdala, the DMN, and other regions of the Survivor Brain. Consistent with this interpretation, we know that individuals naturally prone to higher levels of anxiety show higher connectivity between the amygdala and anterior cingulate cortex—part of both the DMN and limbic system that is involved in pain and stress syndromes (Greening & Mitchell, 2015).

It is worth noting that these observations are correlational and therefore present a “chicken and egg” problem: is the experience of trauma precipitating these differences in brain structure, or are they present in resilient individuals prior to these traumatic experiences? The way out of this dilemma is to introduce some kind of manipulation, or treatment, and measure whether or not it has any effects on the brain-behavior relationship of interest; that is, to conduct an experiment. Interventions capable of altering the way that we respond to stress, such as PQ Reps, provide us with just such an opportunity.

Rebalancing Through PQ Reps

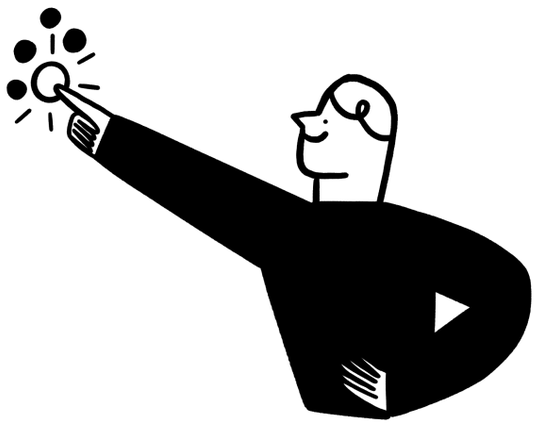
As stated, there are three complimentary approaches to increasing mental fitness through Positive Intelligence: 1. weaken the Saboteurs; 2. Strengthen Self-Command and the PQ Brain (through PQ Reps); 3. strengthen the Sage. Since our Saboteurs are predominantly creations of mind wandering DMN activity, while our Sage arises from the mindful actions of the TPN, rebalancing these two networks is critical. There's mounting evidence that this can be accomplished in part by cultivating mindfulness—a psychological state reflecting attention and awareness to what is happening in the present moment. Mindfulness requires that we engage in self-regulation of our attention, emotion and cognition; abilities that are products of the TPN and benefit substantially from even brief, regular practice.

PQ Reps are 10-second exercises that shift the mind's focus to present-moment awareness of physical sensations. In other words, mindfulness and focused-attention meditation practices consist of performing a variety of PQ Reps. This enables us to use the abundant research on mindfulness and meditation as evidence of the impact of PQ Reps. Because the scientific literature concerning the effects of mindfulness practices on the brain is voluminous and growing, a comprehensive review is well beyond the scope of this paper. Our objective here is instead to selectively highlight evidence that is especially relevant to the Positive Intelligence framework.

We point readers interested in delving further into this literature to several peer-reviewed overviews (Tang et al., 2015; Tang & Woollacott, 2020; Xue et al., 2011).

There is abundant evidence supporting the efficacy of mindfulness practices that are designed to strengthen our ability to remain in the present moment, and to be accepting of what we find there (Moore et al., 2012). As we'll soon see, a growing body of data indicate that even brief practice periods can bring about desirable behavioral changes by stimulating neuroplasticity—the experience-dependent sculpting of brain structure and function. Prescient neuroscientist Donald Hebb wrote **"neurons that fire together, wire together,"** meaning that when one neuron succeeds in triggering an impulse in another, the synaptic connections between the two are strengthened. The result is a neural circuit that can be more easily triggered in the future. In this way, for better or worse, our experiences literally hold the potential to reshape brain connectivity, and in doing so our behavior. **We get to "rewire" our brain.**

For starters, you can probably think of people in your life who display higher levels of mindfulness in their approach to the world. They are predisposed to attend more to what we are experiencing in the present moment in a non-judgmental way, and to exhibit lower levels of stress. We are beginning to appreciate the brain mechanisms that underlie this ability. Investigations employing structural MRI reveal that higher levels of this dispositional mindfulness are associated with lower grey matter volume (an index that captures the density of neurons and other support cells) in our old friend the amygdala (Taren et al., 2013). These skills can be developed with training and doing so sculpts the brain into an organ that is optimized to support the mindful Sage state.



One highly cited study used fMRI to evaluate brain activity in experienced meditators versus meditation-naive controls while they practiced several different meditation exercises. Across all practices, experienced meditators exhibited lower activity in key regions of the DMN (medial prefrontal and cingulate cortices) relative to controls. Likewise, skilled meditators showed stronger functional connectivity (a reflection of the ease with which regions exchange information) between TPN brain areas, including the dorsolateral prefrontal cortex. **In other words, regularly practicing PQ Reps downregulates the DMN in ways consistent with decreasing mind-wandering rumination while upregulating TPN brain regions required for improved cognitive control** (Brewer et al., 2011).

Importantly, the neuroplasticity sparked by these practices pays dividends for practitioners that persist well beyond the period of actually engaging in active mindfulness practice. This study is one of many demonstrating that performing a substantial number of PQ Reps over long periods of time can positively impact our behavior and brain.

For those of us lacking the time or inclination for such devotion, however, there is good news: **even brief periods of PQ Reps render significant results.**

Consider some early work looking at the effects of integrative body-mind training (IBMT) which encourages adopting a balance between relaxation and focused attention with a high degree of awareness of the body and breath, i.e. PQ Reps. Compared with control participants, college students engaging in just 5 days of 20-minute IBMT sessions show greater improvements in attention and emotional regulation (decreases in anxiety, depression and anger), along with decreases in levels of the stress hormone cortisol(Tang et al., 2007). A subsequent investigation reveals that in comparison to a control group instructed to simply relax, IBMT participants exhibit physiological evidence of less reactivity to stress by their autonomic nervous system, the division that governs our flight or fight response. This effect is evident during and after completion of just 5 brief (30-minute) IBMT sessions, and includes improved reactions in heart rate, respiratory amplitude and rate, and skin conductance (Tang et al., 2009). Moreover, following 5-10 hours of IBMT training, increases in the structural integrity of the white matter fibers that comprise the interconnections that enable efficient transmission of neural impulses between areas are detectable.

Intriguingly, these changes in brain structure predominantly involve the DMN (notably the posterior cingulate cortex) and are associated with improvements in mood states (Tang et al., 2012; Tang et al., 2010).

A classic study of Mindfulness-based Stress Reduction (MBSR) techniques pioneered by Kabat-Zinn (Kabat-Zinn, 1982) found that over 8 weeks of practice, individuals with depression experienced significant decreases in ruminative thinking (Ramel, 2004). A subsequent meta-analysis of 39 studies involving healthy adults demonstrates that MBSR is more effective than traditional meditation at decreasing intrusive ruminations (Eberth & Sedlmeier, 2012).

These behavioral changes are furthermore accompanied by profound and rapid alterations in brain structure. Compared with a waitlisted control group, meditation-naïve adults who participated in an 8-week MBSR program exhibited **increased gray matter within key regions of the DMN**, including the posterior cingulate cortex and temporo-parietal junction (Holzel et al., 2011). These changes reflect increases in the density in neurons within these regions, and likely contribute to better control over the incessant internal chatter of the DMN. While MBSR is a powerful tool, it is becoming apparent that some forms of mindfulness practice are more effective at tipping the balance between our DMN and TPN favorably. Focused attention meditation improves concentration by having us practice sustaining an intentional focus on a target such as our breath. By contrast, open monitoring techniques involve loosening our attentional focus while tracking the contents of our experiences without reacting or judging them (Mason et al., 2007). Both practices are effective at reducing mind-wandering, and they are also accompanied by decreases in DMN activity and increases in TPN activity (Brewer et al., 2011; Fujino et al., 2018).

The strength of these opposing (anti-correlated) brain responses are, however, greater during focused attention practices, which are essentially PQ Reps. Moreover, focused attention practices strengthen communication among brain regions of the DMN and the TPN, leading to better integration within each network (Brewer et al., 2011; Farb et al., 2007; Jang et al., 2011; Kilpatrick et al., 2011). Additional findings suggest that focused attention forms of meditation, which consist of PQ Reps, may also be more impactful on the balance between these systems than the third major form, nondual awareness practices.

Individuals with experience in Tibetan Buddhism underwent fMRI while at rest, or when engaged either in focused attention or nondual awareness meditation. To paraphrase, the instructions for the focused attention condition were to maintain attention on a visually presented fixation point, and to bring the mind gently back if and when it wandered off target. By contrast, in nondual awareness meditation participants were told to remain equally aware of both the inside and outside of the body, and to allow their experiences to freely ebb and flow. As with the comparisons against open monitoring practices above, activity in the DMN versus TPN was more highly anti-correlated during the focused attention meditation (Josipovic et al., 2011).

Results from a more recent study show how **focused attention meditation in the form of PQ Reps enhances our ability to intentionally control deployment of our attentional resources moment-to-moment.**

In short, a large and growing body of research provides unequivocal support for the benefits focused attention meditation, i.e. by doing PQ Reps, even when practiced in short intervals. When practiced consistently, these exercises enhance our ability to reduce mind-wandering and brooding rumination, and they also improve our ability to regulate our attention, emotion and cognitive functions. These desirable behavioral changes are accompanied by neuroplastic adaptations within specific brain regions that are driven by mindfulness exercises. More precisely, **PQ Reps downregulate DMN activity thereby weakening our Saboteurs, and they simultaneously upregulate our TPN thereby strengthening our Sage. Importantly, the brain alterations brought about through these exercises support our ability to operate in Sage mode even on a day when few PQ Reps are attempted.** This is analogous to physical strength developed through daily weight training still being available on a day when no additional training is done. **This cumulative strength capacity is simulated in the PQ app in the form of PQ Muscle Score.** These benefits of regular practice also appear to offset the negative impact of significant life stress.

Stress and Our Survivor Brain

Recall that our Survivor Brain includes interactions between the DMN and the amygdala—a structure within our limbic system that governs our emotional reactions to stress, and that the ease with which these regions communicate (i.e., their "functional connectivity") is increased within individuals under stress. Against that backdrop, it is remarkable that **even highly stressed unemployed individuals can reduce DMN-amygdala functional connectivity after just three days of intensive PQ Repping**. Importantly, these effects were absent in matched controls assigned to a relaxation intervention (Taren et al., 2015). The PQ Rep component of training therefore appears to be the key ingredient responsible for driving neuroplasticity. The regularity, more than the duration, of exercising seems to be crucial.

A recent study supports the effectiveness of brief regular practices on mitigating the impact of pandemic-related stress in healthcare workers. Compared with participants assigned to a waitlist control condition, those engaging in just 10 minutes of daily practice involving PQ Reps demonstrated more positive affect both on questionnaires and in assessments that captured momentary fluctuations in mood triggered by news about COVID-19(Kam et al., 2021). Lab-based research provides insights into the neural mechanisms supporting these sorts of behavioral changes.

Individuals with no meditation experience were randomly assigned to either a wait list control group or to an experimental group that received three hours mindfulness training. After training, the meditation group was asked to practice their new skill just 10 minutes each day. At the beginning of the study, and again at 8 and 16 weeks after the start, all participants had their brain waves recorded with electroencephalography (EEG) while performing a Stroop Task. This widely used paradigm stresses our cognitive control and attention by requiring individuals to rapidly read words denoting familiar colors that are printed either in a congruent (e.g., the word "orange" in orange ink), or incongruent color (e.g., the word "orange" in green ink). As you can imagine, incongruence between the word and color creates interference that requires a high degree of focus to negotiate without error. Over the 16-weeks of this brief but regular practice, the meditation group demonstrated improvements in the brain's ability to control attentional resources (Moore et al., 2012). Given the evidence discussed earlier, it seems very likely that these changes reflect down regulation of the DMN and upregulation of TPN activity.

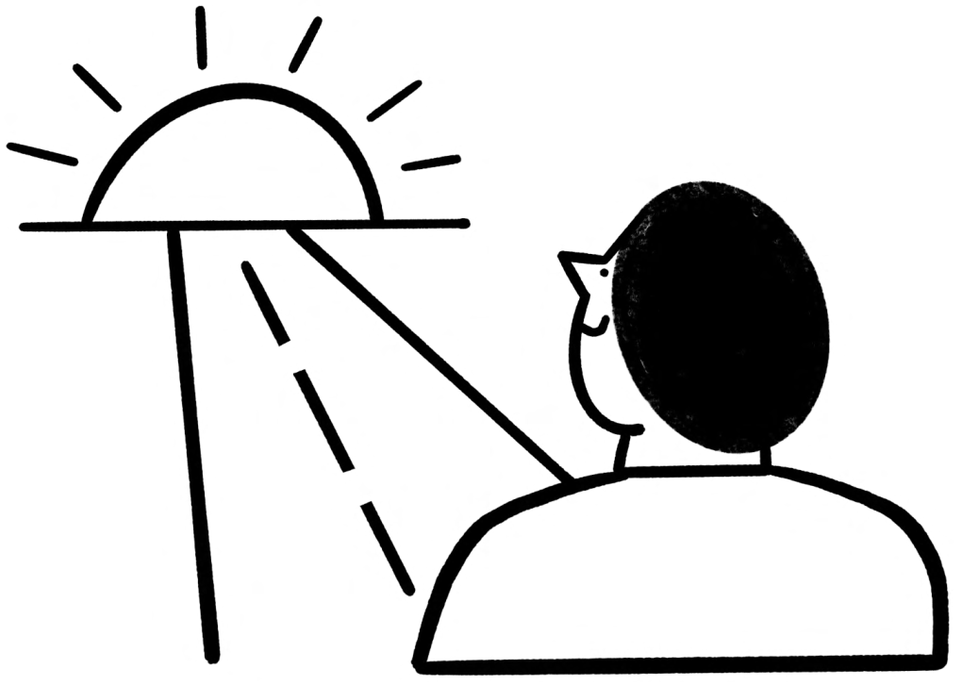
A critical point here is that **these small doses of PQ Repping practice have limited half-lives, and thus regular brief repetitions are optimally effective**, especially for new practitioners. A recent study had meditation-naïve individuals engage in 21 days of mindfulness training. Significant improvements were detected in levels of mindfulness, along with the ability to adopt a more objective perspective (i.e., decentering), and the perceived pleasantness of emotional experiences. However, there practice effects did not carry over to the following day (Levi et al., 2021). Instead, daily boosters were necessary to maintain these positive effects on behavior, at least in those who were new to mindfulness practices.

That said, there is some evidence that changes in brain structure and function associated with mindfulness exercises scale with the number of hours that a person has practiced (Taren et al., 2013). This implies that entering a Sage state will become easier with experience.

These dual dynamics are reflected in the PQ app. The PQ Charge Meter accounts for the limited half-life of the immediate effects of PQ Reps. The PQ Muscle Score reflects the cumulative underlying changes in brain structure over time through sustained practice.

The main take-aways here are that committing to even **as little as 10 minutes a day of practicing PQ Reps can significantly improve our ability to regulate attentional focus and control**. These exercises induce structural and functional neuroplasticity that alters the balance of the DMN versus TPN and reactivity of the emotional response network, paving the way to operate in Sage space even when not actively engaged in training.

Additional developments in neuroscience point to several other potential connections between the brain and Positive Intelligence framework that are worthy of our consideration.



Strengthening the Sage Through Observation and Mental Simulation

The discovery of individual neurons in regions of the TPN (i.e., premotor regions of the frontal lobes and inferior posterior parietal lobes) that respond when a monkey either performs an action itself, or observes another individual doing so, has had a wide-reaching impact on neuroscience (di Pellegrino et al., 1992; Rizzolatti & Craighero, 2004). The so-called "mirror neurons" have been proposed to constitute the basic mechanism for action understanding by mapping the behavior of others onto the monkey's own action repertoire. The monkey sees another grasp an object and this activates some of the same neurons involved in their producing that specific action themselves.

Of importance to us, fMRI data support the existence of similar mechanisms in comparable regions of the human brain (Frey & Gerry, 2006; Iacoboni et al., 1999; Johnson-Frey et al., 2003). These mirror responses facilitate our understanding of the intentions behind others' actions (Rizzolatti et al., 2000), and tip the balance to favor our responding similarly (i.e., action priming) (Craighero et al., 1998). **This supports the premise that both Saboteur and Sage states are "contagious."** Being in the presence of a person in Sage state would makes it more likely for us to respond similarly in Sage by priming key components of the TPN. **Likewise, mirror responses may underlie our ability to empathize with others, a core Sage trait** (Leslie et al., 2004) (Iacoboni, 2005) (Shamay-Tsoory, 2011).

Related discoveries concerning the role of TPN regions in imagining actions build on this theme. If, while remaining still, you imagine how it would look and feel to perform an action, numerous brain regions involved in actually performing the same movements exhibit increased activity. For instance, close your eyes and imagine tapping out a rhythm with the fingertips and thumb of your right hand. If we were scanning your brain, we would find increased activity within premotor and parietal regions of your TPN that are also engaged when actually producing these movements (Johnson et al., 2002; Macuga & Frey, 2012). Not unlike the mirror responses, this "motor imagery" can selectively prime neural circuits and enhance skill learning by stimulating experience-dependent neuroplasticity, i.e., "stimulation through simulation" (Johnson-Frey, 2004; Wohldmann et al., 2007). **This supports the premise that visualizing Sage actions would be an effective way of increasing the efficiency of the neural circuits that engender Sage responses through neuroplasticity, leading them to become our default over time.** This is the basis for the exercises in the PQ app that involve visualizing a shift from Saboteur to Sage response in order to lay neural pathways to make future Sage responses more likely.

Ongoing Research:

Neuroscience is fast evolving. The goal of this whitepaper has been to update and expand the neuroscience foundation of Positive Intelligence. This whitepaper will be periodically updated as new research becomes available.

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