

## Intelligence

In the literature, psychologists describe two forms of intelligence that each contributes separately to our ability to perform tasks. These are “fluid intelligence” and “crystallized intelligence.” Whereas crystallized intelligence is the information and knowledge about things we have learned over the years, fluid intelligence is our ability to strategize and problem-solve. In the example of taking a test, we would recall knowledge about facts and information we learned from class and from studying our notes to answer the test questions (crystallized intelligence), but we may need to answer the questions in a strategic way like crossing out all multiple choice responses that clearly are not the answer and narrow the choices down to the two most possible, working from there to get the correct response (fluid intelligence). Stankov et al. (2006) studied the physiological neural oscillations (or rhythmic, repetitive neural signals between brain regions in the central nervous system) involved in human intelligence, or what we know is our ability to learn, access what we’ve learned, and problem-solve. They discuss the importance of synchronicity in brain activity to intelligence and propose that the degree of synchronization in brain activity may account for differences between individuals’ cognitive processing abilities. In a small pilot study completed in 2004, Dr Alpiner demonstrated under fMRI that individuals who’d received training for timing and rhythm using the Interactive Metronome demonstrated more synchronous activity in the brain when compared to individuals who did not receive this training. Other researchers (Taub et al., 2007) who studied the effect of IM training on reading achievement theorized that synchronized metronome tapping (via Interactive Metronome) increases the efficiency of the brain’s timing (or synchronicity of neural oscillations), thus improving the ability to process, store, and retrieve information.

*Stankov, L., Danthiir, V., Williams, L.M., Pallier, G., Roberts, R.D., and Gordon, E. (2006). Intelligence and the tuning-in of brain networks. Learning and Individual Differences, 16, 217-233.*

Cognitive psychologists, including Chabris (2006), are reporting evidence that “general intelligence,” or attention, memory, thinking, language..., depends largely upon how quickly and efficiently our brain can process information. When speaking, listening, reading, remembering, etc brain structures communicate with one another via neural oscillations, or signals, in the millisecond range. Due to heredity, illness, or injury, these neural connections can be slow or inefficient. The Interactive Metronome is an engaging and rewarding training program that increases the speed and efficiency of timing in the brain, continuously measuring it and providing real-time feedback to the millisecond. Timing in the brain is essentially the timing of these millisecond neural oscillations that are so critical for thinking and language.

*Chabris, C.F. (2006). Cognitive and Neurobiological Mechanisms of the Law of General Intelligence. Integrating the Mind. Hove, UK: Psychological Press.*

Do you know anyone with this problem? Problem: Person has a goal in mind, starts to work toward accomplishing the goal, somewhere along the way seems to forget what (s)he was supposed to be doing or has gotten distracted with something else, goal is not accomplished. In this paper, Chiappe & McDonald (2005) explain that working memory (or the ability to keep the goal in mind and pursue it while constantly updating information about the task in memory and tuning out distractions) is a determiner of fluid intelligence, or our ability to adapt, think strategically, and problem-solve. If an executive function, which performs the role of directing our attention where it needs to be, is not doing its job adequately, then distractions can take over and lead behavior in a direction that is not compatible with the initial goal. We often see this in individuals with ADHD, a diagnosis where there is documented evidence of impaired synchronization or timing in the brain. This may also occur after a traumatic brain injury or stroke. The timing of neural signals or oscillations must be fast and synchronized (or efficient) for the brain to do its job effectively, but in some cases communication in the brain is out of sync. When out of sync or slow, problems with attention, "memory," following directions, and learning arise. Interactive Metronome is a patented training program that improves synchronization and timing so that optimal performance can be achieved, whether at home, work, or school.

*Chiappe, D. & Macdonald, K. (2005). The evolution of domain-general mechanisms in intelligence and learning. The Journal of General Psychology, 132(1), 5-40.*

Conway et al. (2003) describe in detail how working memory is at the center of "intelligence," that it is tied to our ability to rapidly process information, and that its success largely depends on our ability to control and direct our attention toward information relevant to the task and away from distracting information that may interfere with getting the task done. And, of course (!), all of this must be accomplished while our brain continuously processes incoming information. Essentially, our brains must multitask to be efficient and achieve goals. Imagine a network that connects centers of the brain involved in this process. Regions of the network ordinarily send electrical signals (at millisecond speeds) to other areas of the network via neural oscillations in a synchronous, repetitive manner to remember this, attend to that, forget about this, don't worry about that. This network may have damage to some of the wires in certain places that slow down the flow of information, making the brain's task of keeping up with information and sending information where it needs to go rapidly and efficiently impossible. The symptoms of this would be inability to pay attention, slow to process information, slow to respond to questions, distractibility, forgetfulness, poor ability to follow directions, etc.... The Interactive Metronome, a treatment program that improves synchronicity and timing in the brain, has become a standard of care in the treatment of conditions such as ADHD, Dyslexia and other Reading Disorders, Autism, Traumatic Brain Injury, Stroke, and other neurological conditions. By addressing the core problem of synchronization and timing, many of the time-related symptoms improve, like the ability to pay

attention, remember, follow directions, and process information and respond more timely.

Conway, Andrew R.A., Kane, M.J., and Engle, R.W. (2003). *Working memory capacity and its relation to general intelligence. Trends in Cognitive Sciences, 7(12), 547-552.*

Have you heard all of the brain fitness buzz about working memory lately? If one is to improve cognitive performance, whether for school, work, or personal achievement, one MUST work on strengthening working memory. As we've seen with several other recent studies, Engle and colleagues (1999) support the view that working memory function is largely dependent upon a person's ability to pay attention and tune out distractions. In doing so, our brain must perform several operations simultaneously and efficiently. Other studies have examined the neurological underpinnings of attention, information processing and working memory and have found them to be part of a neural network where signals are sent back and forth at millisecond rates. A good analogy is a train station where trains are coming, going, parking, stopping, starting and tracks are shifting to and fro to allow or stop traffic at different places and times in a precisely timed way to avoid collisions or derailings. Picture your brain doing the same...the neural oscillations or electrical signals are the trains, the neurons or wires that connect regions of the brain are the tracks. There is a constant shuffle going on where signals are sent forth, held back, rerouted, etc and all in a precisely timed, synchronous way. EXCEPT when there is a problem with the "track." Then the signals are not sent where they need to go or in a timely, organized, or synchronous way. Symptoms result: inability to focus or attend, to follow directions, to manage time, to remember, to comprehend what is read, to learn, etc... The Interactive Metronome (IM) is the only program available that measures timing in the brain and improves it with progressive, rewarding exercises and real-time millisecond feedback for synchronization as the person moves his body to a steady, rhythmical beat. Those who've completed IM training overwhelmingly report positive results with improvement in many areas of function that depend upon precise, synchronized timing in the brain.

Engle, R.W., Tuholski, S.W., Laughlin, J.E., and Conway, Andrew R.A. (1999). *Working memory, short term memory, and general fluid intelligence: A latent-variable approach. Journal of Experimental Psychology, General, 128(3), 309-331.*

Fink and Neubauer (2005) showed that more intelligent (or "brighter") individuals perform better on cognitive tasks for two reasons: 1) they have more capacity in working memory (the ability to hold and manipulate information in temporary memory storage) and 2) their brain can process information more rapidly. They demonstrated that those individuals with higher intelligence, as a result of these two factors, have a tendency to estimate time much more accurately. Researchers (Taub et al., 2007) theorize that "cross-domain effects" of Interactive Metronome training (or its

effect on so many different cognitive and motor abilities) may be attributed to its effect on these critical skills: attention, processing speed, and working memory.

*Fink, A, Neubauer, A.C. (2005). Individual differences in time estimation related to cognitive ability, speed of information processing and working memory. Intelligence, 33, 5-26.*

Here is another study showing the link between mental timing (“temporal information processing”) and intelligence (Hembold et al., 2006). The faster you can process information, the more intelligent you are. Each person is born with a certain potential for achievement. This potential may not be fully realized when the brain’s clock speed is slow or areas of the brain are not communicating in a synchronized fashion. Interactive Metronome training consists of performing movements in synchrony with a metronome beat, promoting synchronized, timed communication in the brain across areas critical for speech, language, thinking, and motor skills. Immediately following each movement, audio or visual feedback is provided about how close the person was to the actual beat and a score for each movement is provided in milliseconds. Over time, a person’s timing and rhythm improve significantly resulting in many cognitive and motor improvements.

*Hembold, N., Troche, S, and Rammsayer, T. (2006). Temporal information processing and pitch discrimination as predictors of general intelligence. Canadian Journal of Experimental Psychology, 60(4), 294-306.*

In this larger follow-up study, Hembold and colleagues (2007) proved that there is a very strong relationship between higher intelligence (better performance on cognitive and motor tasks) and the ability to rapidly process information (or think fast). They found that timing in the brain was significantly related to several factors that determine intelligence: speed, capacity, and memory. In the clinical world, professionals who work with children and adults with developmental disorders and acquired injuries and illnesses see the connection between timing skills, thinking, and motor coordination as they perform the Interactive Metronome Short or Long Form Assessment as part of their initial evaluation of the patient. This assessment provides several millisecond scores, which reflect the accuracy, efficiency, and synchronicity of timing in the brain. The more that difficulty is seen with timing of body movements to the auditory metronome, the more uncoordinated and inattentive/cognitively impaired the person tends to be. As timing improves, improvement is typically seen in a variety of different areas with the most common being: attention, organization, memory, speech/language, and motor coordination.

*Hembold, N., Troche, S., and Rammsayer, T. (2007). Processing of temporal and nontemporal information as predictors of psychometric intelligence. Journal of Personality, 75(5), 985-1006.*

“A number of studies show that there is a relation between intelligence and millisecond variability in timed behaviors.” Madison et al (2009) attempted to define the neurological underpinnings of intelligence, or how the brain operates. They wanted to know whether lapses in attention account for the differences in cognitive performance between individuals or whether basic neural timing differences may account for it (in other words, this would be the variability in timing of electrical signals between neurons, which are the communication pathways of the brain that process incoming information and conduct our thoughts, emotions, and actions). Based upon the results of their study, they argue that there are differences between individuals in timing in the brain that largely determine how quickly a person can process information and respond to it and that this ultimately determines their level of intelligence (or IQ). The faster the processing, the higher the intelligence. Interactive Metronome is a brain fitness tool that is used in a variety of settings, including in the home, to improve timing in the brain. It is “interactive” in the sense that it not only provides a steady beat to move along to, but it also provides real-time feedback telling you to the millisecond how close to or far away from the beat you are so you can make adjustments and get progressively closer to the beat. In a comparatively short period of time (weeks), mental timing improves, along with a host of time-related abilities: attention/focus, impulse-control, organization, time-management, homework completion time and other routine tasks, memory, speech/ language, and coordination.

*Madison, G., Forsman, L., Blom, Ö., Karabanov, A., and Ullén, F. (2009). Correlations between intelligence and components of serial timing variability. Intelligence, 37(1), 68-75*

According to Ullén et al (2008), there exists quite a large body of literature demonstrating that “coordination of neuronal activity in the millisecond range, within and between brain regions, is essential for a broad range of cognitive functions, such as working memory, perceptual binding and awareness, and attention.” In this particular study, they provide further evidence that the timing of neural signals between & within areas of the brain is the basic foundation of intelligence. It is not surprising that precisely timed and efficient communication within the brain is required for optimal cognitive performance in school, at work, and at play. Interestingly, the researchers measured timing in the brain by having the individuals tap to a beat. This is very similar to the Interactive Metronome (IM), the only brain fitness tool of its kind, designed specifically to measure & improve timing in the brain at the millisecond level that is so critical for our speech, language, thinking, and motor abilities. IM training easily fits into your daily routine and takes only weeks to complete. The most commonly reported improvements following this training to improve the timing of neural signals are: faster and better reading comprehension, faster and more accurate completion of work or homework, improved focus and attention, less distractibility, better control of impulses, better organizational skills, improved memory (especially short-

term), and better motor coordination.

*Ullén, F., Forsman, L., Blom, Ö., Karabanov, A., and Madison, G. (2008). Intelligence and variability in a simple timing task share neural substrates in the prefrontal white matter. The Journal of Neuroscience, 28(16), 4238-4243.*