

# The Psychological Refractory Period Paradigm

Researched and Composed by Jacob Wilson, BSc. (Hons), MSc. CSCS

## Abstract

The athletic regimen requires extreme levels of attention. An ability to narrow in on relevant cues is vital to optimization of performance. Moreover, attention which is redirected toward irrelevant cues will impede hyperplastic processes. The following paper will review the physiological refractory period, single channel hypothesis, information processing theories, and the interference paradigm. Special care will be taken upon presentation of narrowed in concentrative powers, as well as manipulation of the refractory period in question. A historical review of various processes involved in perception will also receive recognition.

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The human mind can be viewed as an extremely complex processor of information (Ramsey NF, Jansma JM, Jager G, Raalten TV, Kahn RS, 2003). Within this framework, a minimum of three stages are inferred from the time a stimulus is presented to the actual response execution. These include (1) identification of the stimulus, (2) response selection, and (3) response initiation / programming (Schmidt R, Lee T, 1999). However, the athlete can only process a limited amount of information. The term, which addresses this, is attention. Schmidt and Lee (1999), define attention as "a concept that describes limitations in the processing of information." While Weinberg and Gould (2003) classify it as "(a) focusing on relevant cues in the environment, (b) maintaining that attentional focus over time, (c) having awareness of the situation, and (d) shifting attentional focus when necessary." When the two are synthesized, we see that attention is somehow limited, and therefore must be directed to that which is relevant.

It is well established that "divided attention," or a focus on multiple tasks or thoughts, can elicit a marked decline in performance (Pashler 1995, Klingberg T, Roland PE 1997, Strayer DL, Drews FA, Johnston WA 2003, Daniels GL, Newell KM 2003, ). As an illustration, in one study, participants walked on a treadmill and were asked to avoid falling obstacles. The experimental group performed a cognitive (requiring thought) activity, while the control only had to avoid the obstacle (Weerdesteyn V, Schillings AM, van Galen GP, Duysens J. 2003). Both velocity of walking and avoidance of failure were lower in the former, which indicates that divided attention can lower performance. Still other experiments have provided evidence that the concept of attention itself is a vital component of "motor memory (Katja Stefan, Matthias Wycislo, and Joseph Classen 2003)."

But what are these limiting mechanisms? To understand such a concept, a methodology known as the "psychological refractory period paradigm (McCann, R. S., Remington, R. W., & Van Selst, M, 2000)" has been devised. In this paradigm subjects are exposed to two stimuli. In response to a single stimulus, we would

expect the following (shortened for simplicity's sake):

Stimulus 1 à Response 1

However, the above procedure implements a second stimulus before the response has been initiated:

Stimulus 1 à Stimulus 2 à Response 1 and Response 2 follow

However, as was described in the treadmill experiment, we find that there is a decrement, or slowing in the response, in both R1 and R2. This, again, is divided attention and has a very real applicability to one's training. There is a characteristic interference which occurs, and ultimately causes such a decrement. What this interference is has been under hot debate for decades.

### **Bottle Neck Theory**

Posner (1978), and Wellford (1981) are well known for their proposed bottleneck, or single channel, approach. The single channel theory varies in interpretation (Schmidt R, Lee T 1999). In its crudest sense, a single channel is available, in which only a single piece of information can be processed at once. This, however, is easily refuted, as we would be inhibited from performing any two activities simultaneously. There is a variation of this theory which will be discussed further into the article, which may have much more insight into attentional theories. That is, the bottleneck may actually exist, but in a specific stage in information processing.

The single channel theory can also be thought of in a more expanded viewpoint as a "fixed" capacity. Think of the capacity as a fuel. Then envision tasks as having a capacity "cost." This would explain why certain tasks can be performed simultaneously, and cause a decrement in performance. The theory predicts that this source of capacity is limited to the cost inherent in each task. It is comparable to RAM. One method of evaluation, using a second task to test the first, is known as the probe technique (Posner & Boies, 1971). By introducing a second task, you can inherently recognize if it has a high capacity demand by analyzing the amount of decrease in performance in the first task. If the task has a high capacity need, then the subject will not be able to perform task 1 as well. If the task has a low capacity, the opposite will occur.

The problem with this theory is that there appears to be a trend for certain high capacity tasks to be able to work with other high capacity tasks. Schmidt R and Lee T (1999) point out one experiment in which participants:

- A. Had to respond to a stimulus manually
- B. Had to respond to a stimulus vocally

In both tasks, which require attention (in that they require precise decision making), subjects had to execute a tracking task (tracking is where you follow something, i.e. while in a car, you follow or track the road). Results are as follows:

Task A: Decrement in performance

Task B: No decrement in performance

The problem here is that the capacity model would have predicted both to receive a

decrease in performance. This was not the case.

Why then can some activities be performed together, and others not? It turns out that the single channel hypothesis may indeed be able to shed light on the subject. However, you must first take into account, the various stages that occur prior to the initiation of a response.

### Theoretic Frame Works for Human Information Processing

The earliest theorists in this field were known as association or behavioral theorists. They were concerned with a concept known as **S-R**. The S stands for stimulus, and would include such things as sound waves traveling to your ears. The R represents the human's response to S. Finally the "-" represents the bond between the two. That is, what exactly is it that strengthens or weakens that bond. The key aspect of behavioral theorists is that they had to "observe" the behavior of the individual. While that may seem obvious, it actually is only a reflection of what cannot be viewed. The reason why so many theories exist in motor acquisition is that the processes are actually within the subject, and cannot be viewed, even with our most advanced technology. Thus, inference must be made. A theoretical framework, whose predictions fit that which is observed, must be in place. Associationists were not interested in these internal processes, but rather the external.

Pavlov conducted the first study in this theoretical framework. The experiment involved a sounding device (a bell), and had canines as the subjects. Pavlov would ring a bell every time the dogs ate. After several trials, the subjects would drool every time they heard the bell. Eventually, he removed the food, and only rang the bell. However, the dogs still drooled. In this case, the bell was the stimulus, and drooling was the response. Such a concept is known as "classical conditioning."

Thorndike picked up where Pavlov left off. This giant in the field devised what are known today as Thorndike's Three Laws.

**1.** The Law of Readiness – The learner must be in a state of readiness to learn. This is to say, that to place information into permanent memory, the human must be capable of receiving this information. There are certain times in your life where the acquisition of certain informational processes can take place; once passed, it is too late.

**2.** The Law of Effect – I find this to be his most fascinating law. It exclaims that if a response is satisfying to a subject, they will most likely repeat it.

There is a reason this is called a law: because it is powerful! Unfortunately, many detrimental habits that humans partake in are also satisfying. This has everything to do with the concept of attention. Certain distracters may cause satisfying results. You will therefore be likely to engage in these distractive activities. Athletes should understand how to deal with such occurrences by properly analyzing what is causing the distractions and what exactly the consequences are. For example, an antecedent may be an enjoyable conversation that you had earlier the day. While training, you allow that thought to spring up in your mind.

The consequence is a reoccurrence of the satisfaction, which took place earlier in the day. You may therefore become accustomed to allowing the mind to wander! However, there is also a negative and obvious consequence. That consequence is

decreased performance in the gym. There are many people who train whilst emerged in a complete fog. That fog is composed of utterly irrelevant information. As an athlete, you can counter such an occurrence by learning to redirect your attention. Before you train, you might incorporate imagery. In doing so, you would pre-program the events to follow perfectly. So perfectly, in fact, that no thought could enter which was not relevant. You could also incorporate attention drills, which enhance your ability to narrow in. Indeed, psychological skills are no different then physical skills, in that they must be practiced vigorously (Weinberg and Gould 2003)! The procedure you initiate could be summed up as follows:

Imagery (antecedent) → Optimal Focus (behavior) → Increased Pump, Greater workouts, Greater gains (consequences) = Likely To Repeat

Therefore, one must understand that when modifying a behavior, they must also analyze the antecedents and consequences, and re strategize in order to combat these areas. The point is that you want to structure an environment which facilitates Thorndike's second law.

I say this because his law also has a second aspect to it. If there is a negative consequence, the subject will not likely repeat it. You want to structure an environment which is laden with rewards. We will discuss this subject in future issues, as there are literally endless ways in which to propel you to new levels within this issue alone!

**3. Law of Exercise** – This law states that the more you train, or exercise a skill, the more stable it becomes, and the greater performance will be. Practice is the number one variable of permanently increasing one's capacity. Directing your attention is also a skill. With practice, you can actually have the ability to narrow into any stimulus, while eliminating all others. Gould and Weinberg provide a specific drill in a review on the concept of concentration. The point of this drill is to obtain the skill of actually shifting your attention. I will outline their protocol:

Note: your eyes are closed until stage five.

**Awareness of Auditory Stimuli Stage** – You will begin by taking special care to sense all the sounds around you. So great will this care be that you will mentally name each one. Once this has occurred, you will stop naming the sounds, direct your attention away from your internal thoughts, and sense all of the sounds as a blend. Gould and Weinberg suggest comparing it to "listening to music."

**Awareness of Somatic Stimuli Stage** – Most likely, as you read this, you do not notice the sensations in your feet, and gluteal area. However, once I told you to notice them, you became fully aware. The body continually receives multiple stimuli from numerous areas. As you directed your attention toward these areas, these sensations appeared to heighten. This is what this stage is all about. It not only shows the power of attentional direction control, but enhances your ability to expand your awareness. You will repeat the same process as the auditory stage. However, you will instead first become aware of all the physical stimuli occurring, such as the feeling of your glutes in your chair, and your back as well. Again, classify each feeling, and then attempt to sense all of them at once, without naming them.

**Emotional Awareness Stage** – You will attempt to address each of your emotions in this stage. Embrace each one, as well as all of your thoughts. Attempt to sense

them with the utmost awareness. Then, release them and loosen up with slow and deep breathing.

**Lens Stage** – Gould and Weinberg compare your concentration to a zoom lens. This exercise is extremely powerful, and ends the process. After the emotional awareness stage, open your eyes. Now, find an object in the room and take note of it. You will now, while keeping the object in view, attempt to see all other objects in the room. Try and experience each object visually. Now, direct your attention to the object of interest. Try focusing on it, while eliminating all other objects in the room. Once you are focused, attempt to stay focused on the object for as long as possible. To take this skill to a new level, attempt to widen or narrow your focus on the object, as if your eyes were a lens. But, you must still maintain focus.

This four-stage process takes each of your senses into account, and allows you to master them! During an imagery session, you can practice narrowing in on a certain weight training tasks.

Hull was another famous associationist. Working with Thorndike's second law, he found that positive reinforcement was more productive than negative reinforcement. However, he also realized that human movement is goal-oriented, and that we are always working to adapt to our environment. In essence, you are working on the environment to produce a change that better adapts you to your surroundings.

We can actually synthesize Hull's findings. You must understand, that it is pivotal that you structure an environment that is both challenging and rewarding. Setting goals and reaching them is extremely rewarding (Knowlden, 2003). One key is to focus on process goals. These are goals that center on actions, which will move you toward performance and outcome goals. However, the control you have over them is superior when compared to the latter two. For example, you have less control over the judging in a bodybuilding contest than you do over your pre-workout routine.

One example of positive feedback is to make a checklist of items for your current diet. By checking off the boxes, you will be reaching process goals, which is satisfying. Soon, however, when you see the results of your hard work, you will receive intrinsic reinforcement, or reinforcement which comes from within.

The next framework concerns the Gestalt Theorists. These theorists stepped back and watched the whole picture. They recognized that we are not only working on the environment, but that the environment is also working on us! Moreover, the human mind distains states of chaos, and is always attempting to give meaning to the environment. Think of a time that you were lost. During this trial, your heart rate rose, and your palms began to sweat.

These theorists devised three laws: the law of Proximity, the law of Similarity, and the law of Closure. The first states that when we see things close together, we tend to group them together. The second states that things which are similar to one another will be grouped together. Finally, the third Gestalt law asserts that humans tend to reconcile a space by closing a contour.

The final and most recent framework is called the Cognitive Theory. This is one of the most accepted theories in the field. First, you must understand that the brain is

an active information processor. The interval from the instant a stimulus is perceived to the instant a response is initiated is called Reaction Time (RT). What goes on during that interval is of much interest.

Step 1 → You identify the stimulus → Compare the stimulus to past experiences → A response is selected → You initiate the Response → A Consequence, whether positive or negative occurs → You now benefit from the consequence. If it was positive, you will most likely continue activity (Hull's work with Thorndike's second law).

That was an overview. The process must be looked into in far greater depth. We begin with the concept of "Processing." The human body has various senses. There is the kinesthetic, olfactory (smell), auditory (sound), visual, and tactile (touch). Such senses are perceived with special organs and nerves. Upon perception of a stimulus in the environment, the information must be processed, or translated. I liken this to various languages. If you cannot speak a certain dialect, the information contained within a phrase held behind the symbols of that dialect must first be represented by symbols which you can comprehend (a-b-c) before they can be made of use. Similarly, visual stimuli must be coded, such that they can be stored and compared with past memory, and a decision can ultimately be made.

Information processing then begins with perception of a stimulus. The body then must recognize or form a pattern out of this information. This is similar to the Gestalt theory discussed earlier. Through rigorous processing, the information is coded and a pattern formed. Finally, the information contacts memory.

Schmidt and Lee state that, "When previously processed information influences current information processing, then we assume that memory is the reason. Indeed when viewed this way, it is obvious that everything we do is influenced by memory. The current state of our skills and knowledge reflects previous information processing (1999, p. 55)."

The first form of memory is short term sensory store. This is apparently a limitless source of memory, but only lasts 250 ms to 1 second. As the name implies, it acts as a storage site, but has a fast decay rate. The next source of storage is short term memory. This lasts for a few minutes (Latash, 1998, p. 155), or an estimate of 2-3. It is postulated that it is limited to 3-7 chunks of information (Cowan, 2001). A chunk is referred to as a grouped amount of information. For example, I may say to you, "How are you?" There are 9 letters in that sentence; however, it is grouped into three chunks. The human mind can actually improve the ability to chunk information. Ericcson and Chase (1990) found that:

*"After more than 230 hours of practice in the laboratory, a subject was able to increase his memory span from 7 to 79 digits. His performance on other memory tests with digits equaled that of memory experts with lifelong training. With an appropriate mnemonic system, there is seemingly no limit to memory performance with practice."*

However, Schmidt and Lee (1999, p. 57) assert that this was probably chunked information within the proper range discussed. They also state that short-term memory is able to be perceived consciously. As the result of experience or practice of that which is stored in short-term memory, information can eventually be entered into long-term, or permanent, memory.

The second phase, or response selection phase, occurs as a result of comparison with past experiences. Thus, each of our decisions is very much based on our past experiences. If a student goes into a science class and has never heard of the word myofibril, then he is facing a first time experience. If, however, he has spent time on abc, then he will have a past experience to compare to, and will ultimately be ahead of his fellow classmates. This is one of the reasons we provide so much free information on the site. Our goal is to educate, as much as improve others physically. It is of vital importance that those who utilize this site also increase their associative spread.

Once the response has been selected, a program must be initiated. For example, in your memory, a motor program exists which contains the instructions to bench press a weight. The sequences involved in this procedure have been refined over numerous trials. Every time you make a mistake, it can also be stored as a past experience. The body can then make the necessary corrections. When you have a positive outcome, the body can again refine the motor program. There is now debate as to whether or not a motor program can be initiated subconsciously or not. The staff at abc and myself have researched this area extensively and will report on it in the future. There are some interesting findings, however.

I have only touched on the concept of information. What it is and how it is quantified will be addressed in the future. Mr. Knowlden has done extensive research in this area.

## **Applications to Attention**

While typing with both hands, it is impossible for me to simultaneously grab the protein shake on my desk. This is a form of structural interference, and can be applied in principle to attentional limitations. In the earlier stages of information processing, much information can be processed (Pashler, 1995). This is known as parallel processing. However, in the latter stages, such as response programming, there appears to be evidence of purposeful blockage of processing mechanisms when a second stimulus is presented. Pashler and colleagues (1984, 2001) postulate that what is occurring instead of capacity drain is an inhibitory "bottle neck." This is to say that certain tasks require similar neural structures for their execution. Therefore, when an action is selected, others which might otherwise interfere with that action are inhibited. In one experiment, Klingberg and Roland (1997) had subjects perform an auditory go/no go task with an auditory memory task. When performed together, there was a notable increase in reaction time as compared to separate initiations. Using positron emission tomography, it was found that these tasks showed overlapping activity in the cortex.

This theory is rapidly gaining acceptance. The process, when viewed, looks like this:

Stimulus 1 presented à Response 1 Initiated

If stimulus 2 is presented within 50-500 milliseconds before response 1 takes place, then interference occurs in the processing of response 2. This is known as the Psychological refractory period ( ). As the space between s1 and s2 increases, so too does the refractory period decrease.

This simply means that within the spoken timeframe, a delay occurs in the processing of stimulus 2. However, this delay is lessened with increased separation of time, in reference to the presentation of introduced stimuli. Another interesting effect is when two stimuli are presented within 10 milliseconds of each other. When this occurs, they are grouped as a complex set of movements. In this case, reaction time is slower overall. Several factors of the refractory period are summarized as follows:

1. Practice of the presentation of 2 stimuli diminishes the interference effects. However, they do not completely diminish. From this a structural form of interference is postulated.
2. S-R compatibility refers to the cohesiveness of the stimulus and response. In other words, does the response you desire match the stimulus presented. The more compatible they are, the quicker the information is processed.

Interestingly enough, this goes hand and hand with weight training. The more focused your mind is on weight training, the smoother informational processing needed to complete a repetition will be.

3. It appears that certain processes can operate in parallel in latter stages. These processes are postulated to occur because they do not use the same aspects of the nervous system. Thus, parallel processing is relative.

From the above, it is now much clearer how athletes fake each other out. First, it is understood that reaction time is consuming. If an athlete presents one stimulus to an opponent that the opponent directs his attention to, followed by a second stimulus, then a refractory period, which lasts a minimum of 200 ms and as long as 500 ms ( ) will occur. An example would be a shoulder fake to the right, followed by an explosive drive to the left. However, if you are an athlete in such a sport, you must separate moves by at least 50 milliseconds so that the two moves are not synthesized to one reaction time.

### **Key Points**

Attention can indeed be interfered with. The competitive athlete must be aware of such an occurrence. A realization of the decrement in performance should be clear in your mind. This is one reason why pre-workout routines work in such a proficient manner. It is interesting to note that studies indicate that when a pre-routine is denied, that performance is lowered. Gayton, Cielinski, Keniston, and Hearn (1989) had basketball players shoot in conditions with and without a pre-shot routine. It was found that a "significantly larger number of baskets were made in the pre-shot routine condition than without the routine."

A motor program is a representation of a pre-programmed and coordinated sequence of movements prior to the presentation of a stimulus. However, refraction and delays in processing will occur when an attention-demanding stimulus interferes with what should rightfully be R1 (the exercise at hand).

This review was a window into several serious subjects; subjects which will ultimately lead to a zone-like focus that you would have never thought possible.

It is interesting to note that The Lord himself directs his attention. As the Psalmist said:

*Psalms 34: 15 The eyes of the LORD are upon the righteous, and his ears are open unto their cry. 16 The face of the LORD is against them that do evil, to cut off the remembrance of them from the earth.*

Yours in Sport

Jacob Wilson

President Abcbodybuilding/Co-Editor of the Journal of HYPERplasia Research

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