FLANKER TASK

The use of the Eriksen Flanker Task as training instrument for cognitive control in inhibition disorder

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ABSTRACT

A frequently used cognitive task to measure participants' cognitive performance is the so-called Eriksen Flanker task (1974). This task requires a response where you have to indicate the direction of a central arrow, which is flanked with (un)corresponding arrows at its side. The Flanker task has many modified versions, adjusted to the different ways you can use the task to measure different aspects of executive cognitive functions. Such cognitive tasks, although often too simple and straightforward to represent daily life, tell us a lot about one's executive cognitive functioning. Executive functions are very important for human behavior because they help us to engage with our surroundings and to participate in society. Problems of inhibition may have neural causes and may lead to negative behavioral consequences. Inhibitory problems can be determined by the Flanker task which might also be useful to practice cognitive control in individuals suffering from inhibitory disorders.

Keywords:
Flanker Task, cognition, inhibition, measurement, digital testing

INTRODUCTION

Eriksen Flanker Task

A frequently used cognitive task to measure participants' cognitive performance is the so-called Eriksen Flanker task [1]). This task requires a response where you have to indicate the direction of a central arrow, which is flanked with (un)corresponding arrows at its side. The Flanker task has many modified versions, adjusted to the different ways you can use the task to measure different aspects of executive cognitive functions. For example, versions differ by varying the number of distractors, using letters instead of symbols, or adding rule modulation during the trial. Such cognitive tasks, although often too simple and straightforward to represent daily life, tell us a lot about one's executive cognitive functioning. Executive functions are very important for human behavior because they help us to engage with our surroundings and to participate in society. Cognitive control, another wording for executive functions, relates to how certain goals or plans influence our behavior. It makes use of top-down mental processes such as inhibition and decision-making. Inhibition is outright stopping on the moment that an individual is prepared for action [2]. A simple and relatable example might be when you are driving on a road with a constant speed and suddenly having to hit your breaks when a traffic light turns red. Even though you were prepared to keep speeding, you had to quickly cancel putting your foot down on the gas paddle and switch to the breaks. Inhibition control is vital in the most simple tasks and we use it every day. Without inhibitory control, or when having awfully slow inhibition, one could have less social skills, be more susceptible to forming addictions, and exert conflicting and antisocial behavior. With too much inhibition, one can heighten sensitivity to punishment and being anxious and avoidant [3]. A healthy balance between action and inhibition is thus essential in order for someone to function properly.

Inhibitory problems

Problems of inhibition may have neural causes and may lead to negative behavioral consequences. These problems can be determined by the Flanker task which measures inhibitory control. Moreover, the Flanker task might be useful to practice cognitive control in individuals suffering from inhibitory disorders.

As is mentioned above, excess of inhibition as well as insufficient or slowed inhibitory control vastly disturbs our daily functioning. Unfortunately, poor inhibitory control is quite common when suffering from neuropsychological disorders such as attention deficit hyperactivity disorder (ADHD), autism spectrum disorder (ASD), and obsessive compulsive disorder (OCD) amongst others. Inhibition disorder, therefore, is not one specific diagnostic condition but rather an umbrella term that includes several disorders in subjects who all cope with behavioral and emotional control, impulsivity, and other forms of inhibition imbalance. Since an imbalance in inhibition is a quite common problem, and because it is a vital part of our executive functioning, it has the fortunate advantage that many studies have been done on the neural underpinnings of inhibition. Now, there are many different types of inhibition and studies in the field of neuroscience and psychology tend to refer to different kinds. For example, psychologists more often discuss distractor inhibition, physical response, or emotional inhibition, while in neuroscience other kinds of inhibition are examined such as reflex inhibition, circuit or system inhibition, and postsynaptic inhibition [4]. The present paper will address the most general form of inhibition as stated in the paragraph above and defined as 'canceling a prepared response' [2].

A number of studies examined the mechanisms behind the inhibition process. Inhibition control, like most executive functions, is mediated by the prefrontal cortex (PFC) of the brain, and in particular the right inferior frontal cortex (IFC). There is also evidence that the basal ganglia play a role in motor response inhibition [5]. In short, inhibiting neurotransmitters, such as glycine or GABA, are produced and released by brain cells and directly inhibit the postsynaptic action potentials in surrounding neurons [6]. This inhibition can then cause the cancelation of a motor response, which is often conscious, or it can start/stop unconscious processes such as the release of other neurotransmitters or hormones [4].

When suffering from an inhibition disorder, one might have higher or lower quantities of receptors for these neurotransmitters, or an imbalance in concentrations of the neurotransmitter itself [7; 8]. The exact cause for the poor inhibition differs per disorder; e.g., autism is associated with the presence of weakly active GABA receptors, which means that there is little inhibition as the neurotransmitters cannot be taken in. Schizophrenia, in contrast, is associated with relatively few glutamate receptors (glutamate being the main excitatory neurotransmitter), leading to an excess of inhibition. Though different causes, both disorders have an imbalance of inhibition. Moreover, a greater imbalance can cause epileptic seizures or brain coma [9].

Not only does this imbalance affect one's health, but it also influences human behavior and social functioning. As mentioned above, relatively little or slow inhibition can be a risk factor for antisocial behavior. In the example mentioned above, having to hit your breaks at a traffic light, it would mean that someone does not hit the brakes and fails to stop at the red light. Now, this could have disastrous consequences but it is still a rather human mistake. Yet, in some cases, too slow inhibition can lead to more serious and structural outcomes such as aggression and criminal behavior. As for the other end, too much inhibition has been an established risk factor for developing anxiety disorders [3]. Criminology studies therefore often include behavioral inhibition in children as risk factor for later psychopathologies, that again form risk factors for antisocial behavior. Therefore, it is of individual as well as societal importance to study disorders with poor inhibitory control and find its causes.

Identifying the exact neurological source of the inhibition disorder is often difficult, let alone expensive and time-consuming. Therefore, diagnosing and studying individuals with poor inhibitory control can be done through observations and test performance. For example, through tasks that measure the inhibition of motor response or inhibition of selective attention [4; 5; 8].

The Task

As aforementioned, the Eriksen Flanker task is one way to measure such cognitive performance. Eriksen and Eriksen [1] designed this task to measure the inhibition of inappropriate responses in a specific context. In the task, a screen displays a central target stimulus, which is flanked by non-target stimuli that correspond to the direction of the target (congruent), to the opposite direction (incongruent), or to neither (neutral). There is also a modified version of the Flanker task that shows arrow symbols, where the original task of 1974 used letters as stimuli, and did not include a neutral condition.

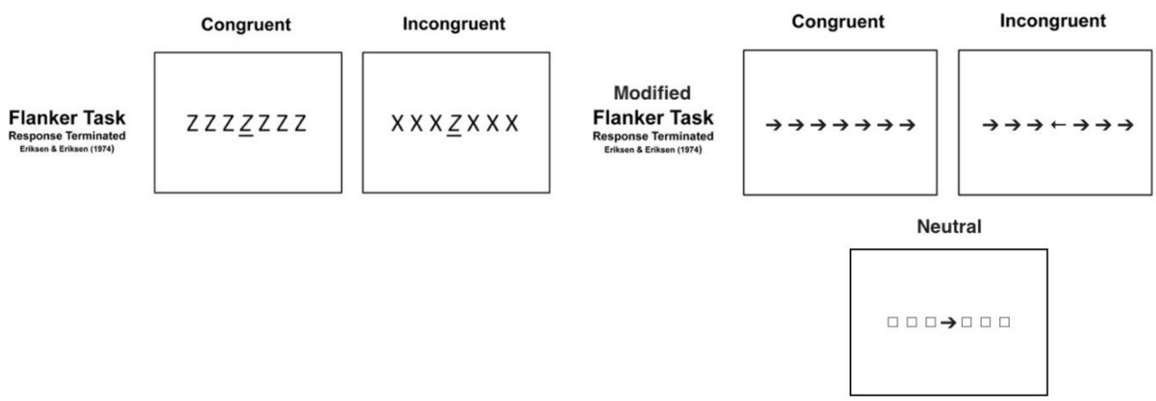

Figure 1. On the left side, the original Flanker task with letters, where the underlined Z is the target [10]. On the right side, the modified Flanker task with arrow symbols as stimuli and the additional neutral condition.

When doing the test, a subject is asked to give a directional response on the keyboard that corresponds with the direction of the arrow stimuli or the instructed associated letter (for example, press left for S and right for K), as fast and accurate as possible. Thus, the subject is required to attend to pre-specified visual information while ignoring competing information [1]. Especially the incongruent trials require inhibitory control; participants have to adjust their response when the target and/or flankers are suddenly changed in direction. This inhibition of response is measured by response accuracy, which is determined by the number of correct responses (failure to respond is often counted as an incorrect response), and reaction times across trials with incompatible stimuli and neutral stimuli [11].

The anterior cingulate cortex (ACC) has been found to be activated during the performance of the Flanker task, especially during the response on incongruent items. It is suggested that the ACC monitors the amount of conflict and, consequently, enhances the amount of control needed for the next trial (which is referred to as the Gratton effect) [12]. This conflict control must be mediated by inhibition. Clearly, the Flanker task activates all kinds of top-down control processes. It is suggested that these top down-processes can be strengthened by training as the neural underpinnings of inhibition are subject to plastic changes [13]. When these processes are improved on, it would not only show in test scores, but also in behavioral gains in daily life.

Inhibitory control training

Notably, the Flanker task has been proven to be an effective and reliable tool for cognitive and inhibition control training. After a 3-week training program, where subjects practiced to ignore the flankers, a group of healthy individuals showed improved selective attention and conflict resolution [14]. When subjects were asked to focus on the target (discrimination training), scores did not improve. Moreover, analysis of electroencephalography (EEG) recordings demonstrated that the inhibition training increased the magnitude of 'rejection positivity' (an event-related component) to incongruent distractors, which implies that inhibitory control is improved on. These gains were greatest for those with the poorest inhibitory control to start with [14]. Hence, the improvement by training is correlated with 'pre-training' cognitive control [15]. Another example of a study that used the Flanker task in a training environment is that of Wang, Richard, and Schmular [16], where thirty healthy participants followed a 2-week training program. The training consisted of 5 sessions a week, each of 1.5 hours a day, practicing a modified Flanker task as well as videogames. The results indicated a training effect for younger adults. The Flanker task has also been shown effective as training material for executive attention in children of ages 4 and 6 [17]. Strong improvement in executive attention and intelligence was found from ages 4 to 6 years. Both 4- and 6-year-olds showed more mature performance after the training than did the control groups.

Flanker task and neuropsychological disorders

Although there are quite some studies with training programs on healthy individuals, as seen in the examples above, training programs in people with inhibition disorder have not been done yet. Notably, studies using the Flanker task in individuals with a specific inhibition disorder show that these participants perform differently from healthy controls, as is expected. For example, children with ADHD showed increased missed responses and an enhanced interference effect [18], while students with OCD had slower overall RTs [19]. In addition, children with ASD responded more slowly on incongruent trials. This result seems in contrast to findings on a Go/No-Go task and the Stroop task, which both are also inhibitory control tasks, on which the children with ASD performed comparable to their matched controls [11]. This suggests that the Eriksen Flanker task might be a better instrument to measure inhibitory control in individuals with inhibition disorder than other similar tests.

It is surprising that no form of inhibitory control training using this task has been studied in these kinds of samples, considering that these individuals would gain the most from improving inhibitory control. If it is confirmed that inhibition is trainable and that the Eriksen Flanker task is a trustworthy measurement as well as training tool for inhibitory control, developing and pursuing training programs for individuals with inhibitory disorders is only a rather obvious follow-up.

Practical aspects of the task

Apart from its promising beneficial effects, training through the Eriksen Flanker task also seems feasible. Firstly, the task does not require excessive explanation or guidance from other people. Therefore, even young children could follow the training program. Second, as the Eriksen Flanker task is designed fairly simple, it can easily be installed on tablets at home. This way, many people can follow the program at once and there is great flexibility of time and location. Further, if desired, data can then be sent to researchers, but also to psychologists or teachers who can monitor the progress made. This kind of set-up has already been used in an inhibitory control training program with 20 kindergarten aged children. The children played a game on a tablet for 10 minutes, every day for 3 weeks. The results showed that this 'pure response inhibition' training improved the reasoning ability of the preschoolers [20]. Reasoning, as you might imagine, can be crucial when your inhibition control does not come naturally. That is, when someone has good reasoning abilities, they may still distinguish inappropriate responses and ignore irrelevant environmental distractors. As discussed, suffering from an inhibition disorder presents challenges for behavioral and cognitive functioning during the day, that can affect both the individual and his or her surroundings. Inhibitory control, which is a top-down process that is controlled by the PFC, can however be trained.

CONCLUSION

The Eriksen Flanker task has been proven to be an effective training method in healthy individuals, improving selective attention, conflict resolution, and reasoning ability. It may thus be recommended to apply such a training in individuals who suffer from an inhibition disorder. As no such training programs or longitudinal experiments have been studied yet with such a sample future research may be directed on how this training with the Flanker task would be most effective and feasible.

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