DEVELOPMENT OF A MANUAL FOR VISUOSPATIAL ORGANIZATION ACTIVITIES FOR PERSONS WITH BRAIN DAMAGE

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CERTIFICATE

This is to certify that this dissertation entitled "**Development of A Manual for Visuospatial Organization Activities for Persons with Brain Damage"** is a bonafide work submitted in part fulfillment for degree of Master of Science (Speech-Language Pathology) of the student Registration number 19SLP035. This has been carried out under the guidance of a faculty of this institute and has not been submitted earlier to any other University for award of any other Diploma or Degree.

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September 2021

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DECLARATION

This is to certify that this dissertation entitled **"Development of A Manual for Visuo-Spatial Organization Activities for Persons with Brain Damage"** is the result of my own study under the guidance of Dr. Hema N, Assistant Professor, Department of Speech-Language Sciences, All India Institute of Speech and Hearing, Mysuru, and has not been submitted earlier to any other University for award of any other Diploma or Degree.

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Table of Content

List of Tables

List of Figures

Chapter 1

Introduction

Cognitive sciences are the discipline of science that studies cognition. Cognition was derived from the Latin noun *cognition* (from the verb *cognosco*, which means “to become acquainted with” or “to know”). As per the description given by the American Psychological Association for cognition states that

“All forms of knowing and awareness, such as perceiving, conceiving, remembering, reasoning, judging, imaging and problem-solving.”

Cognition also means as simple as thinking. Neisser (1997) gave a definition for cognition in which mentions all the mental processes using which a piece of information is received, modified, reduced, refined, preserved, and restored, and finally used for processing. Cognition also comprises processes that are related to the acquisition, storage, retrieval, and information processing. On the other hand, human cognition is also described as the type of cognition that encompasses both conscious and unconscious cognition, as well as concrete and abstract cognition, intuitive and conceptual cognition. Memory, association, concept generation, pattern recognition, language, attention, perception, action, problem-solving, and mental imagery are among the most well-known cognitive activities (Best, 1999).

Internal mental processes that function when a stimulus is presented to an individual before a behavioral reaction can be noticed are known as cognitive processes. These cognitive or mental processes often comprise a wide range of mental operations ranging from fundamental tasks like sensation, perception, and attention to more complicated functions like memory, learning, language, problem-solving, reasoning, and decision making (Smith & Kelly, 2015). These cognitive processes are studied from various perspectives within diverse circumstances, particularly in the domains of linguistics, neurosciences, psychiatry, psychology, education, philosophy, anthropology, biology, systematics, logic, and computer science.

1.1 Cognitive Processes

Cognitive processes are internal mental processes that occur after a stimulus in the environment has been experienced but before an overt behavioral reaction has been observed. These processes are usually not seen directly; instead, they are observed as specific behavior patterns as a result of the processes that have incurred (Smith & Kelly, 2015). Cognitive processes are any of those mental functions assumed to be comprised in the acquisition, storage, interpretation, transformation, and utilization of data.

The processes that are included under cognition are of a vast range and can vary from fundamentals tasks to complex operations. Simple processes such as sensation, perception, and attention, as well as more sophisticated functions like memory, learning, language usage, problem-solving, reasoning, and decision-making, are examples of cognitive operations. Several fundamental theories are often used to explain them. For example, depending on the task demands, the serial processing approach, parallel processing approach, and combination theory suggest that cognitive processes are both serial and parallel. This phrase is used to describe the mental process (Kellogg, 2015).

Cognitive psychologists draw conclusions about cognitive processes by critically evaluating observable behavior. The mechanistic functioning of cognitive processes, as well as how the processes may be linked to consequences beyond the laboratory and their biological roots in the brain, are of primary interest to researchers (Smith & Kelly, 2015). The information must be transferred throughout the cognitive process, which generally occurs to link numerous informational inputs or complicated inputs to build a minimally flexible cognitive system. This system has a range of minimally flexible behavioral outputs, with these processes typically involving at least a minimal level of one of the paradigmatic processes described in some cognitive sciences, such as perception, memory, learning, emotion, intentions, self-representation, rationality, and decision-making or something aptly close to it (Newen, 2017).

Perception is generally known as the ability to actively create mental representations of the information that our senses get from the world by capturing, processing, and actively building mental representations (Kellogg, 2015). Perception is a dynamic process that enables us to interact with our surroundings, and it can be classified into five senses: visual perception, auditory perception, somatosensory perception, olfactory perception, and taste perception. Furthermore, the additional are vestibular perception, pain perception, proprioception, kinesthetic perception, and spatial perception.

Memory is the ability to store information or a representation of past experiences, which is based on mental processes such as learning or encoding, retention across time, and retrieval of the stored information. It is the mental ability that encodes, stores, and recovers data (Atkinson & Shiffrin, 1968). It is learned that memory is vital to experience and is an indication that learning has occurred over time. Memory is typically classified into three categories – sensory memory, short-term memory, and long-term memory.

Attention signifies the state of mental alertness. It refers to the internal cognitive process through which one consciously picks information from the world.

Attention can also be learned as the capacity to focus and retain an interest in a task, as well as the ability to manage distractions. Attention is simply how the active processing of a small quantity of data from the vast amount of data available through our senses, stored memories, and other cognitive processes take place (De Weerd, 2003). Sustained attention, selective attention, divided attention, and concentrated attention are all examples of distinct forms of attention. Different tasks carried in an individual's day-to-day activities can include either one kind of attention or a combination of a few based on the complexity of the tasks and the distractors present in that environment.

Spatial cognition is a field of cognitive science concerned with how humans and other animals perceive, interpret, cognitively represent, and interact with spatial features in their surroundings (Waller & Nadel, 2013). Spatial cognition refers to the ability to precisely perceive distances and orientations in order to avoid collisions and make the appropriate turns. The acquisition, organization, usage, and modification of information about spatial contexts are all part of spatial cognition. Spatial cognition refers to the set of mental processes which include underlying spatial actions and thoughts. For information or the actions to be considered as part of the cognition, it should include features like location or place, size or shape of the information, order or the direction of the information, continuity or extent, its relations and configurations, sequences, hierarchies and finally dimensionality (Montello & Raubal, 2012). The study of spatial cognition potentially involves all of the primary mental operations like perception, attention, memory as well as categorization, problem-solving, and language. Since these overlap across multiple psychological processes, the study of spatial cognition brings together a diversity of interests, perspectives, and approaches and is relevant to a wide range of allied researchers (Waller & Nadel, 2013).

The visual sense dominates the spatial universe, but our other sensory systems contribute equally to spatial information. Integration through a multisensory mode is a unique capacity of the human brain's spatial organization that attempts to maximize the extraction of spatial information (Postma & Koenderink, 2017). For successful contact with the outside world, we need to have a good sense of space. Most of the behaviors carried in one's day to day routine involves spatial cognition and psychological process that underlie this. From directing oneself to the washroom in the morning to getting back home, driving the car in traffic involves processes of spatial cognition.

Spatial perception is the capacity to be aware of the links between the individual and the world around them and inside themselves. Most psychologists state that the most fitting way to define spatial perception is in terms of the environment and how it is being by accounting for the features like distances, sizes, forms, and orientations of the entities and surfaces that are being perceived. It is also thought that perception's role is to retrieve these features and produce another alternative manner and equally acceptable method to describe the world (Fajen & Phillips, 2012).

Spatial memory is referred to as the capacity of an individual to know or have a depiction of where it is and consequently to be able to navigate successfully in its environment (Barnes, 1988). Visuospatial working memory is the system that is used both in immediate memory and in long-term memory when a spatial stimulus is employed. This system is heavily dependent on a central processor of limited capacity (Baddeley & Lieberman, 2018). It temporarily maintains the limited information that was received, which is kept on standby or is made available for immediate access by other cognitive processes (Awh & Jonides, 2001).

Spatial attention involves selecting a stimulus based on its spatial location. The item's active region is chosen, and it is subsequently subjected to additional cognitive processing; for example, the stimulus might enter the working memory and become the target of the movement. Many types of object-based attention revolve around the spatial selection. Spatial attention is crucial in early processing before stimulus identification is established. The object is recognized by drawing attention to a specific region in visual space and enhancing perception or binding the item's features there (Vecera & Rizzo, 2003).

Tversky (2009) explains in detail that human cognition can be studied from several perspectives in terms of spaces. Most commonly viewed is the space of the body, the space around the body, the space of navigation, and the space of external representations. The space of the body, the space around it, the space of exploration, and the space of depictions, which is unique to humans, serve diverse tasks in human activity and thus in human cognition. When speaking of the space of the body, it has a perceptual side to it. It is involved in perceiving the sensations from outside and inside the body and the actions that the body does. The space in which it is possible to act or view without having to change locations or by rotating in place, this space is referred to as the space around the body. It encompasses any nearby items that could be acted on or should be avoided and represents the objects that can have an immediate impact on us. The space of navigation is the potential space in which an individual might move around to different locations. Since it is significant to be viewed all at once, its patched together from a range of different experiences such as perceptual, that is, the actual navigation, or cognitive like maps or descriptions. It is known mainly from recollection, rather than simultaneous perception, instead of the space of the body and space around the body. Finally, Tversky talks about the space of external representation, which he defines as typically the space on paper intended to depict a physical space, such as a map or architectural plan, or a metaphoric space like a diagram or graph. People create external perceptions to aid cognition. They can be perceived directly, but they are representations of an external item.

With reference to spatial cognition, the capacity to observe the visual environment, generate mental representations of visual objects, manipulate these representations mentally, and reconstruct elements of the visual experience are all referred to as visuospatial abilities (H. Kim & Cameron, 2016). It describes the capacity of a person to recognize visual and spatial links between things, as well as their ability to envision objects and create global forms by identifying small components for various visuospatial characteristics, which are of great interest in the present study.

1.2 Neurological Correlates of Cognition Processes

Imaging studies and brain mapping techniques have allowed us to study more about cognitive skills and the areas in the brain to which they can be localized. These studies began with evolutionary studies with respect to intelligence and correlating with neural parameters like the size of the brain, thickness of the cortex, and the proportion of the gray matter in the brain (Gray & Thompson, 2004). All these studies have examined brain activities during the performance of cognitive tasks.

In general, a number of brain regions, including those in the parietal lobe, dorsolateral prefrontal cortex, anterior cingulate cortex, and specific areas in the temporal and occipital lobe, have been associated with intelligence (Brancucci, 2012).

Using MRI, it was found that Brodmann areas 18 and 19 is the extrastriate cortex, and area 37, which is the fusiform gyrus, contributes to identification, imagery, and expansion of visual input. Wernicke's area was found to be involved when the input was given through auditory mode. Wernicke's area was found to be involved when the input was given through auditory mode. Information processing was found to be activating areas like Brodmann areas 40, the supramarginal gyrus, area 7, the superior parietal cortex and, area 39, the angular gyrus. These parietal regions collaborate with frontal areas to form a working memory network that compares several possible task responses (Colom et al., 2009).

PET scan data was compared with the lexical access study on normal brain and lesion data. It was discovered that visual imagery, word reading, and visual attention are not done by a single brain area but rather by a group of brain areas working together (Posner et al., 1988).

The ventral occipital lobe appears to produce the visual word form in the posterior region of the brain. If active selection or visual search is necessary, the parietal lobe is found to be activated, which is usually a deficit in individuals with parietal lobe lesions (Friedrich & Posner, 1985). Among the anterior and posterior systems of attentions, a separation is observed and assists in understanding how attention is involved in early visual processing as well as information selection for output (Posner et al., 1988).

Image scanning mechanisms are similar to those engaged in visual-spatial attention. Patients with right parietal lobe lesions have difficulties scanning the left side of a picture and reacting to visual information from the left. It is found that the right hemisphere is not only responsible for visuospatial scanning but also for image generation (Bisiach & Luzzatti, 1978). Studies where the hemisphere was separated and studies individually showed that the isolated left hemisphere could create complex visual pictures, but the isolated right hemisphere cannot (Kosslyn et al., 1985). It was also seen that the hippocampus takes part in storage and conscious retrieval in memory-based tasks (Posner et al., 1988).

The anterior cingulate gyrus has been linked to the higher-level aspects of attention and regardless of whether the activity is involved with language functions, spatial location, or object processing (Posner & DiGirolamo, 1998).

Brain injury or brain damage is the injury that is sustained to the brain that impairs its functions. Brain injury is something that occurs after birth and is non-hereditary. It could be congenital, degenerative, or may be induced by birth trauma, and hence they are known as acquired brain injury. The term acquired brain damage, or acquired brain injury, is sometimes used to refer to brain damage that did not occur before or during birth (Gillis,1996). Acquired brain injuries are of two types – traumatic and non-traumatic. Traumatic brain injury is referred to the alterations in brain function and mainly covers those that are inflicted by an external force, and non-traumatic refers to those that cause changes in the brain due to other internal factors like lack of oxygen supply or disturbed metabolic functions within the brain.

Traumatic brain injury is also classified as primary and secondary – It differentiates brain damage that occurs as a result of trauma (also commonly referred to as mechanical forces) from that which occurs secondary to cerebrovascular disease, tumors, infection, progressive neurological disease, and metabolic or neurochemical disturbances, although some have interpreted the term to include brain damage resulting from or in any traumatic event in the broadest sense (Gillis, 1996). In literature, four different labels are used apparently to refer to the same entity or population. These include traumatic closed head injury, head trauma, closed head trauma, and non-focal brain damage (Gillis, 1996).

Given the significance of spatial abilities in many aspects of daily life, including environmental learning, academic competencies such as science and mathematics, and motor skills, it appears especially vital to determine whether these skills are adaptable and at what age they develop (Fernández-Méndez et al., 2018).

Based on impact degree, Linn and Petersen (1985) divided tests for spatial abilities into three groups. One type of ability was spatial visualization, which is the ability to manipulate complicated spatial information when many processes are necessary to reach the proper result. Gender differences in spatial visualization have statistically depicted no significance and had a low impact size. Another group of spatial perception is the ability to identify spatial relationships even in the presence of irrelevant information. Gender variations in spatial perception were statistically significant, with a modest effect size. Mental rotation, or the capacity to rotate two- or three-dimensional figures rapidly and correctly in mind and compare them to other comparable figures, was the third type of ability. The only spatial skills category with a high gender difference impact size that was also statistically significant was mental rotation.

1.3 Need for the Study

Acquired brain injury is one of the most common causes of disability in adults (Feigin et al., 2010) and among which stroke (Strong et al., 2007) and Traumatic Brain Injury (TBI) are the two most common causes of acquired brain injury (Feigin et al., 2010). Impaired visuospatial skills can affect day-to-day activities to a great extent in individuals brain damage often suffer from anosognosia, lack of awareness of having a disability or a disorder, which indeed makes it difficult in identifying the impairment in patients. Hence, it is crucial to target visuospatial skills, which can allow them to gain some functionality back and help to improve the quality of living. There is a lack of resource material that is easily accessible to the clinicians, and that can be implemented without requiring extensive technology. Here is an attempt to develop a manual in an electronic format for telerehabilitation, which includes activities to improve visuospatial skills in persons with brain damage.

1.4 Aim

The current study aims to develop a treatment manual containing activities that target visuospatial skills for persons with brain damage.

1.5 Objectives

1. To construct a treatment manual to treat visuospatial skills in persons with brain damage
2. To determine the content validity of the constructed treatment manual.
3. To conduct a pilot study on persons with brain damage by using the constructed manual.

Chapter 2

Review of Literature

Visuospatial skills allow an individual to identify visual and spatial relationships among objects in their surroundings. Although the sensory system and senses are involved in visuospatial processing, it happens to be a central nervous system disorder when a visuospatial dysfunction occurs. Proto et al.. (2009) stated that visuospatial disturbances were frequently seen repercussions of stroke and traumatic brain injury. It is reported that visuoperceptual problems are the second most prominent symptom of brain injury (Stringer, 2003). It was estimated from the survey that 82% of right cerebral stroke patients and 65% of left cerebral stroke presented with visual neglect (Stone et al., 1993). Impaired visuospatial skills can hamper a broad range of common skills essential for daily living activities and affect the quality of life (Cucca et al., 2018).

The most predominantly seen is unilateral neglect, and the most common features that show up are in terms of visuospatial dysfunction. Prism adaptation was described as a rehabilitation method for unilateral neglect (Rossetti et al., 1998). It is a bottom-up approach where the method typically involves a short exposure period to a prismatic optical shift of approximately 10-15° to the contralateral side of the neglect, which is combined with a task such as pointing to visual targets while using the prisms. Following the prisms' removal, a "carry-over" effect is often observed, and it is also stated that this treatment through prism adaptation can significantly aid in reducing the behavioral insufficiencies of unilateral neglect by utilizing a bottom-up approach (Rode et al., 2003). Prisms manage to create a displacement of 10° in the visual field in the rightward direction in patients who suffered from left side neglect. These patients were exposed to the prism for a range of 2-5 minutes which enabled them to point straight ahead manually to a 9° shift to the right. This led to compensation of 70% for the suffered neglect for a 10° optical displacement. In the study conducted by Rode et al. (2006), for which six individuals with left neglect participated, all the participants showed positive outcomes and significant improvement to unilateral after the exposure to prism adaption. Prism adaption was also found to show improvement in visuospatial skills. Researchers have claimed to still uncertain whether prism adaption is to be used as a mode of compensation for the patients or an approach to recovery theory (Rode et al., 2006), and the process by which the prism adaption functions is also still being discussed (Jacquin-Courtois et al., 2010). Prism adaptation may potentially impact spatial cognitive processes in the domains of attention and perception by activating brain mechanisms associated with multisensory integration and higher spatial representations.

Lezak et al. (2012) reported that symptoms of neglect had been shown to stabilize two months post-stroke in some individuals, while yet others still suffer from it, and it has been linked with the poor operation of daily routine activities. Similarly, other visuospatial skills can also affect an individual's routine activities. Hence, rehabilitation focusing on visuospatial skills is required, along with routine speech-language therapy.

2.1 Rehabilitation for Impairment in Visuospatial Skills

Rehabilitations programs were constructed to target visuospatial skills for individuals with visual-spatial deficits. There are various programs available, and they can either be a bottom-up approach or a top-down approach. By activating the individual's higher cognitive levels through methods like visual scanning, the top-down strategy focuses on improving both perceptual and behavioral distortions. The bottom-up practice attempts to modify the sensorimotor level by initiating passive sensory stimulation, and one such technique is the Transcutaneous Electrical Nerve Stimulation (TENS) (Conti & Arnone, 2016).

A randomized control trial was conducted by Chen et al. (2012), where it was examined whether promoting global-to-local encoding enables the improvement in accurate retrieval in patients with visuospatial memory deficits and who suffered from a stroke in the right hemisphere. Eleven participants were recruited for the study; six were included in the treatment group, and five were included in the control group. The training session included three phases – in the pretraining phase, participants were required to reproduce **Rey-Osterrieth Complex Figure (ROCF)** image by drawing it on a blank paper after they were given a copy. In the next phase, that is, the training phase, the participants were given either rote repetition training or global processing training. After thirty minutes of the training phase, the post-training phase was initiated, where participants from both the training groups had to reproduce the ROCF image again. The results showed that global processing training showed significant improvement in visuospatial memory deficits in patients who suffered from a right-brain stroke. Rote practice showed that without step-by-step guidance limited the degree of improvement in memory. The treatment effect was seen both immediately after training and 24 hours afterward. The treatment effect was observed immediately after training as well as 24 hours post-training. The results from this study consistently show that by using the principle from cognitive rehabilitation that an effective treatment is based on specific training aimed at improving specific neurocognitive deficits and that a global processing approach can promote improvements in visuospatial memory after a right-brain stroke.

Constraint-Induced Movement Therapy is another cognitive treatment technique that entails the deliberate protection of the unaffected side in order to train the counter lesion side to respond more normally (Wolf et al., 2002), and Bilateral Movement Training (BMT) is a technique that encourages the patient to utilize the unaffected limb or bodyside to successfully direct the impaired region (Stewart et al., 2006) are studied to a great extent in regards to treatment to visuospatial dysfunction. The development of bilateral tasks that involve postural control, coordination, and gait has been found to benefit from these cognitive exercises. According to studies, when the individual demands bilateral environmental reactions such as crossing the street or attending a significant event, this regimen becomes challenging. Researchers believe that due to additional stimuli to which the individual must respond in a more complicated environment, compensating by the patient's ipsilateral side is hampered (Punt & Riddoch, 2006).

Visuospatial scanning therapy is another approach that is advanced cognitive training that takes a top-down approach to recovery (Pizzamiglio et al., 2006). It is a traditional approach that best describes the compensatory strategy for visual neglect and visuospatial inattention. This scanning therapy targets on direct maintaining of individuals to scan thoroughly towards the side that is neglected, which is followed by conducting more complex tasks which accentuate visual inspection and attention to the stimuli on the neglected side. The objective of this technique is to improve overall function by facilitating visuoperceptual rehabilitation (Diamond, 2001). Visuospatial scanning has several variants concerning many contributing parameters, but in general, requires the participant to distribute their attention broadly to the target that appears in the visual field. Improvements have been reported by researchers to generalize in functional reading, writing, and motor tasks (Cicerone et al., 2005). Many months after the therapy was terminated, follow-up interviews with the patients revealed that their scanning skills had improved. Patients observed an increase in their abilities; they became more conscious of their deficits, which helped them devise compensatory strategies (Pizzamiglio et al., 1989).

A newly developed and upcoming computer technology that creates a simulated environment in which a person can interact with a three-dimensional environment using electronic devices like goggles or gloves is the **virtual environment training system**. Rehabilitation programs have been constructed based on this technology. This is a bottom-up technique that was developed to help people with visuospatial dysfunction. Virtual reality instrument intends on diverting the attention by creating a visual cue to the contralateral side of the area where the lesion is present. The rationale behind this method is that it allows individuals with spatial neglect to compensate for the loss on the contralateral side of the lesion by using their ipsilateral sight. Individuals with unilateral neglect have shown that this technology can lessen asymmetry between the left and right sides with training. Virtual reality intervention allows for flexible use in the least restricted setting, allowing the patient to use this approach to gain independence when doing ordinary tasks (Conti & Arnone, 2016). Researchers have suggested that this method of intervention has been as beneficial as the traditional methods of intervention (J. Kim et al., 2007).

Computer-based cognitive rehabilitation (CBCR) is a type of adjunct therapy that involves using specifically created software applications to improve cognitive skills through systematic practice of cognitive activities on a computer or other electronic device. (Politis & Norman, 2016; Svaerke et al., 2019). CBCR programs can be used and closely monitored by clinicians, which allows innovation in the field of cognitive rehabilitation. These programs allow the patients to connect with clinicians from the comfort of their homes, provided they have access to the required equipment. CBCR provides the flexibility of manipulating the programs as per the need of the patients participating in the program. Consequently, it is possible to target distinct cognitive processes (Politis & Norman, 2016). A retrospective study was conducted by Chen et al. (1997), patients with traumatic injury to the brain were assessed to determine whether the CBCR program was beneficial for them by using The Bracy Process Approach (Bracy, 1985). Individuals with TBI were selected for this study and were divided into two groups. The experimental group received a CBCR program, and the control group received a traditional rehabilitation program. They found out that both groups showed significant improvement in attention, visuospatial ability, memory, and problem-solving but did not show any significant difference between the groups (S. H. A. Chen et al., 1997).

A randomized, controlled, unblinded cross-over design was conducted by Svaerke et al. (2019) with patients who were given early and late CBCR programs. The patients chosen for this study are those who were in the subacute phase after stroke and had visuospatial neglect or homonymous hemianopia. This included seven patients in the early intervention (EI) group who received training immediately after inclusion (mean = 19 days post-stroke) for three weeks and seven patients in the late intervention group (LI) who received training after an extended period after the onset of stroke (mean = 44 days post-stroke). CBCR program showed an improvement in visuospatial skills significantly when administered early in the subacute phase after stroke. Significant improvement was not observed when observed in the LI group. EI and LI groups both showed improvements during the intervention in visuospatial functions. LI group showed improvements in two measures – visuoperceptual functioning and visuospatial skills.

An exercise was developed by Nemoto et al. (2020), which was motor and cognition-based, which they called the **"cube exercise".** This exercise is intended to work on improving visuospatial skills and assess the feasibility for older adults to perform this exercise. The occipital-parietal and temporal lobes were stimulated with a picture of a three-dimensional structure in this exercise, which was reported to improve visuospatial abilities. Yellow, white, pink, and blue colored cubes were utilized with six different designs on each surface. Participants were instructed to build the block using a model image provided to them.

It was a 12-week program with three degrees of difficulty that gradually progressed. This was a type of activity that had cognitive training and required physical activity from the participants. A total of 35 adults with frailty were recruited for the study and were divided into two groups – the locomotive exercise group and the visuospatial exercise group. 77.3% of the participants were able to complete the locomotive part of the task, and 84.6% were able to complete the visuospatial part of the task. Pre and post-tests of intervention were conducted using tools like mini-mental state examination (MMSE) and clock drawing test (CDT). It was found that there was significantly more improvement in the visuospatial exercise group than in the locomotive group. In the locomotive exercise group, five people exhibited improvement, five participants showed decile, and twelve participants showed no meaningful change in the CDT measure. In the visuospatial exercise group, eight people exhibited gains in the CDT test, whereas none showed deterioration, and 5 showed no change. The cube exercise was discovered to be a viable program for strengthening visuospatial skills and global cognition in older individuals (Nemoto et al., 2020).

Cancellation tasks are most commonly seen in the assessment of visuospatial skills and visual neglect. It is used for assessment purposes as well as in the scope of intervention for visuospatial skills. **Cancellation tasks** are those which are primarily used to evaluate visuospatial skills. The tasks involve correctly identifying the target stimuli in which the individual is encouraged to cancel out the stimuli and using the outcome to evaluate the individual's performance. While providing training, this task is usually accompanied by visual scanning therapy, which aims to improve visual scanning behavior in the individual with unilateral neglect by encouraging them to pay attention to the entire visual field of stimulus actively. Cancellation tasks require the participants to cross out or "cancel" all stimuli of the specified type while ignoring stimuli of all other types or "distractors". Cancellation tasks often entail searching or scanning the visual field for a specific letter or symbol against a background of distractor letters or symbols placed randomly or in structured rows and columns. Cancellation tasks that have symbols arranged randomly were found to be more complex and sensitive in detecting neglect as compared to those that are assembled in structured rows and columns (Lowery et al., 2010). Cancellation tasks that have symbols arranged randomly were found to be more complex and sensitive in detecting neglect as compared to those that are arranged in organized rows and columns. Mesulam's symbol cancellation test is one of the most common tools used for this task, and it provides a measure of attention, organization, and neglect (Mesulam, 1985, 2000). The cognitive domains that are involved in this task are sustained and selective attention, psychomotor speech, visual searching, and motor coordination. These cancellation tests can be categorized based on the type of stimuli used, by the size of the matrix, and configuration of the matrix, according to Brucki and Nitrini (2008).

For the purpose of assessing several cognitive skills and identifying mild cognitive impairment, dementia, and visuospatial deficits, **the trail-making test** is a widely used neuropsychological task (Fernández & Marcopulos, 2008; Lu & Bigler, 2002; Peña-Casanova et al., 2009). Partington (1938) was developed the original trail-making instrument, which measured divided attention among individuals; this tool was also referred to as Partington's pathways (Armitage, 1946). From this original concept, several researchers have adapted this instrument to expand the use of the tool and increase the number of measures that can be assessed with it. Trail making test has been released in several different version including those with paper-and-pencil form and electronic form.

Barncord and Wanlass (2001) came with an alternative approach to the trail-making test to construct an instrument without any culture-bound symbol system or language-based keys. This research was created and evaluated as an alternate trail-making test with similar psychometric features that may be utilized with people who know the Arabic number system or a specific language alphabet. The Symbol Trail Making Test (STMT) uses symbols that aren't linguistic or numerical in nature. The authors state that STMT additional section assesses the incidental memory during administration. This instrument consists of three trials in total. Task 1 consists of 24 circles on a page, each containing a distinct symbol, eight of which match to a sequential key at the top of the page. The participant must draw a continuous line connecting the symbols matching the key as quickly as possible in order to complete this challenge. Task 2 consists of eight symbols, each of which is duplicated three times on the page. For a total of 24 circles, each sign is displayed in three different ways (white, grey, and dotted backgrounds). At the top of the page is a key with the eight symbols and a sequence key for alternate background colors. The next task requires the participant to draw a continuous line linking the symbols that match the key. The participant, for example, draws a line from the first sign on a white backdrop to the identical symbol on a grey background. This is then linked to a dotted-background version of the same sign, which is linked to a white-background version of the second symbol, and so on. The 16 target symbols from tasks 1 and 2 make up Task 3. The target symbols are divided into 16 numbered groups and are each coupled with two foils. Task 3 requires the subject to identify the target symbols in each triad from the foils.

Gray (2006) created the "Comprehensive Trail Making Test," which consisted of a standardized set of five "visual search and sequencing tasks" which measured cognitive operations like attention, concentration, resistance to distraction, and cognitive flexibility. Like any other trail-making task, the basic idea behind the task was to trail number and/or letter series as quickly as possible. The trails were said to become progressively more difficult with the addition of distractors. Trail 1 requires the participant to draw a line joining the numbers 1 through 25 in order, with each number is shown in a simple black circle. Trail 2 begins identically to trail 1, with the participant trailing from numbers 1 to 25, but there are additional 13 empty distractor circles on the same page. Trail 3 demands the participant to link circles 1 through 25 in the correct order once again. This test contains nineteen distracter circles that contain irrelevant line drawn figures and thirteen empty distracter circles. Trail 4 presents numbers both numerically and in the verbal form in an attempt to increase cognitive strain. In trail 5, the participant must draw a line in an alternate pattern connecting the numbers 1 through 13 and the characters A through L. On the same page, there are fifteen empty distracter circles. The task of the Comprehensive Trail Making Test is essentially identical to the original Trail Making Test; however, new factors were added in order to make it more sensitive to cognitive functions. Time completion has been used as the measure on all five of the trails.

The typical trail-making test is used as a measure for psychomotor speed, attention, sequencing, mental flexibility, and visual scanning, according to Kim et al. (2014). Researchers have also found that trail-making task taps on a variety of cognitive abilities, including visual scanning, visuomotor tracking, working memory, executive set-shifting, divided attention, and problem-solving (Reitan & Wolfson, 1985). The Trail-making test is the second most commonly used task in neuropsychological evaluation. This task is administered as a straightforward “connect-the-dots” type of activity in which the individual is required to draw a line to connect the consequent elements in the circle as indicated in the key sequence. The traditional trail-making task consists of two parts A and B. Part A needs the individual to link randomly dispersed numbers in ascending order, whereas Part B includes both numbers and letters and expects the individual to connect them alternately. Part A was said to be primarily a task of visual attention, perceptual tracking, and simple sequencing tasks, whereas part B is associated with alternate sequencing patterns and as a tool for measuring executive function.

In a cognition-based activity, **matching tasks** are one of those which are used very frequently. Patterns are unique combinations of numerous objects or pieces that come together to form a single entity. Pattern matching can be stated as the comparison between the existing item or image and with the data stored in the person's memory. These can be patterns produced by the object itself or features such as usage, utility, shape, color, or the general category. Individuals interpret the patterns by interpreting a few of the elements at that time allows the individual to bypass the working memory (Jung et al., 2013). Raven's *Advanced Progressive Matrices* (APM) is a well-known test used for measuring the skills for observing the sense and importance of new sequences that take place and the correlation between them (Raven, 2003). This tool includes two series of tasks – 12 in the first and 36 in the latter all these tasks have the same structure. Eight elements that form a consistent and coherent sequence with the ninth element are presented to the participant is expected to determine the missing element from the choices that are given to them. It was determined that Raven's APM consisted of the operationalization of the pattern identification ability (Wojtasinski & Francuz, 2019).

A study by Leicester et al. (1969) evaluated the effects of parietal lesions on the scanning of the visually presented string of letters. The stimuli used for this study were string letters; they were words or non-words for different word lengths varying from four to six. A non-word was created from the word by replacing certain letters in words. Participants were presented with a pair of a string of letters. They could either be word and non-word or word and non-word, which was derived from the word itself. In this, they were required to mention if these strings of letters were a match or not a match. Eighteen patients with left hemisphere injury and six patients with right hemisphere injury were involved in this study and were subjected to evaluation. Results of this task showed that it was a sensitive method for determining and evaluating visual neglect. Contralateral neglect was seen in fourteen of the eighteen patients with left hemisphere injury and in all six patients with right hemisphere injury. When the right stimuli were generally on the opposite side of the neglect, the correct responses and incorrect responses were more concentrated on the contralateral side of the neglect. Fourteen patients with left hemisphere injury had right neglect out of a total of eighteen patients. When they made mistakes, the correct stimulus was mostly on the right side of the visual field. The other four patients who did not show neglect performed similarly on both sides of the visual field. When they were presented on the preferred side, the patient was able to perform well, and her neglected side results turned out to be poor. The significance of the link between neglect and task competence was confirmed by this adjustment.

Croisile et al. (2008) used the activities for working on visuospatial skills, which also included pattern recognition and matching task. This required the client to match symbols from the key provided to the question and identify they match or not. These activities were conducted on 85 normal individuals, and the training period took place for one month through online mode. Results showed that individuals who participated in this study showed significant improvement in their cognitive skills compared to the baseline done before the training.

Apart from Pattern Matching Task, within spatial cognition, **the mental rotation task** is one of the most studied tasks for spatial skills. It is known to be a dynamic process that requires the individual to mentally rotate the stimulus image and match with the options given to them by judging whether both are the same (Shepard & Metzler, 1971). Mental rotation is imagining what an object will look like when it is rotated. It is the ability to rotate a two-dimensional image or a three-dimensional figure accurately and to compare them with other similar figures. The mental rotation tool was first introduced by Vandenberg and Kuse (1978). Vandenberg's and Kuse's Mental Rotation Test is the commonly used tool to measure spatial abilities. Mental rotation tasks usually consist of two-dimensional drawings of three-dimensional geometrical figures. One of them being a reference and four other drawings. These additional drawings include the rotated image of the reference, and the participant has to indicate a reference rotated image. The mental rotation test given by Vandenberg and Kuse comprises 24 items which are drawings of three-dimensional figures which are to be compared with each other. Each item in this tool has five-line drawings, which include a geometrical target figure on the left followed by four response choices – two rotated reproductions of the target and two distractors. The participants are required to indicate which two of the four response choice figures are rotated reproductions of the targeted figure.

The effect of mental rotation training was assessed by Stransky et al. (2010) by considering the mental rotation test (MRT) scores in sixty-two neurotypicals. Twenty-eight individuals were randomly allocated to one of three groups in this study: "One-day training," "Spaced training," or "No training." The Training group received a variety of activities for training for mental rotation, which included paper-based mental rotation worksheets, Personal Computer-based activities, and mental rotation tests. The group that underwent training for one-day performed MRT to baseline score and then underwent a 40-minutes training session which was followed by another round of MRT. Participants were given a second training session again, followed by MRT for the third time and a fourth MRT after a week of the training. The activities in the spaced-training were segmented into two sessions on two consecutive days. Similarly, this group also performed MRT before starting the session and after each session doing a total of four MRT. No training group was used as the control group who repeated MRT for times. The findings showed that individuals who underwent training performed better and had an advantage that was maintained for one week and that training distribution had no influence on performance.

The long-term and short-term gains, transfer gains generated by mental rotation training were examined in healthy older adults by Meneghetti et al. (2018). Forty-three healthy older adults were taken on for the study. Mental rotation training was provided for a group of fourteen adults, and fifteen adults were coached to utilize the strategy based on imagery and definitive object manipulation, following which they were coached with two mental rotation tasks. Fourteen adults were in the control group, which involved alternate non-spatial activities. The mental rotation task included comparing three-dimensional images and specifying whether they match or not and a Tetris game. Tetris is a computer-based game that requires the player to fit the geometric pieces in the appropriate places to fill the empty spaces. The transfer effect for this training was assessed after one month using tasks similar to those used in training. It was found that there was a trend towards the improvement in successive training sessions. The two groups that received training for spatial abilities showed better improvement than that of the control group and also exhibited a transfer effect. There was a linear increase in the response time as the angular parameters were varied in the mental rotation task. This showed that older adults benefited from specific training that encourages them to utilize the approach based on imagery and definitive manipulation and a positive outcome of rotation training.

Interpretation of Body Schema – Head and Holmes (1911) first coined the term “body scheme” to describe the notion that a person has about his or her own body. The term is alternatively used with “orientation” or “pattern,” which implies the picture of the body that is created in the individual's mind. This act was found to be one of the sensory activities of the human cortex. Individuals with Gerstmann syndrome were found to have disrupted body schemes (Coslett, 1998). Acalculia, or poor arithmetic abilities, finger agnosia, or inability to distinguish fingers, left/right confusion, and agraphia are the four typical symptoms of Gerstmann syndrome. A lesion in the angular gyrus of the dominant parietal lobe is generally attributed to this condition (Milstein et al., 2016). Left-right disorientation is an inability to identify right and left in a person's own body and others. The disorientation implies difficulties in the application of spatial concepts in the body's lateral orientation. This is not only described as a linguistic deficit but also as deficits in spatial orientation (Ardila et al., 2010). Ardilla also states that finger agnosia and left-right discrimination can be found independently in cases with autotopagnosia, where a patient presents with an impaired interpretation of body scheme, deficits in spatial concepts and language.

Coslett (1998) investigated to study whether the impairment in the body schema can be attributed to the unilateral neglect seen in patients. If neglect was associated with disruption of interpretation of the body schema, patients might also exhibit difficulty discriminating between right and left, which was the hypothesis made. Part of this experiment included the identification of hands in different positions. This experiment was conducted on individuals with right hemisphere damage and was asked to indicate if the visually presented images of hands corresponded to the right or left hand. Three individuals with right hemisphere damage with left and three individuals with right hemisphere damage without neglect were recruited. The stimuli presented to them included color prints depicting a single hand in one of the four possible conditions – the right hand with palm up, the right hand with palm down, the left hand with palm up, and the left hand with palm down. These photographs were presented to the individuals by placing them on the table in a manner where the fingers are pointing away from the individual. Results showed that those subjects with neglect identified pictures of left but not other subjects with brain lesions who demonstrated significantly less reliable response for the images of the right hand. They also stated that identifying pictured hands involves matching the stimuli to an ongoing mental schema of their own body, which suggested that neglect can be associated with failure to attend to the body schema.

The efficacy of activities used for online cognitive training was studied and examined by Croisile et al. (2008). The activities used in this study also included an activity to train the left-right disturbance and the disruption of body schema as part of training for visuospatial skills. This particular activity used images of either the left hand or the right hand. These images had variations like palm up or palm down and either of hand holding an object or performing a task. This was conducted on 85 normal individuals, and the training period took place over a month through online mode. Results showed that individuals who participated in this study showed significant improvement in their cognitive skills compared to the baseline done before the training.

Acquired brain injury is one of the most common causes of disability in adults (Feigin et al., 2010) and among which stroke (Strong et al., 2007) and Traumatic Brain Injury (TBI) are the two most common causes of acquired brain injury (Feigin et al., 2010). It is also evident from the studies seen so far that visuospatial skills are one of the most commonly seen impairments in these patients, and impaired visuospatial skills can affect day-to-day activities to a great extent in individuals with brain damage. They often suffer from anosognosia, lack of awareness of having a disability or a disorder, which indeed makes it difficult to identify the impairment in patients. In the review till now, we have observed that targeting a single cognitive process in intervention can improve other processes as well. These studies are either solely paper-pencil or technology-based tasks. There is a need to combine these different modes of activities in a more convenient form to implement them in a virtual platform for tele-intervention services and in offline clinical setups. It is also seen that training neuro-typical individuals and those individuals with brain damage for visuospatial skills have improved overall cognitive skills and generalization of them in day-to-day activities (P. Chen et al., 2012; B Croisile et al., 2008; Nemoto et al., 2020). Hence, it is crucial to target visuospatial skills, which can allow them to gain some functionality back and help to improve the quality of living. Here is an attempt to develop a manual in an electronic format for telerehabilitation, which includes activities to improve visuospatial skills in persons with brain damage.

The aim of this study is to develop a treatment manual containing activities that target visuospatial skills for persons with brain damage. The objectives of the study are to construct a treatment manual to treat visuospatial skills in persons with brain damage, to determine the content validity of the constructed treatment manual using a questionnaire developed by Goswami et al. (2012), and finally to conduct a pilot study on persons with brain damage by using the constructed manual.

Chapter 3

Method

Visuospatial dysfunctions are present in the majority of individuals who suffer from brain damage. The present study aimed to construct a manual to train visuospatial skills in persons with brain damage and to conduct a pilot study of the manual on individuals with brain damage for a better understanding of the manual in terms of its administration.

3.1 Research Design

This study was on the development of a manual following application-based research.

3.2 Participant

An individual with brain damage diagnosed as Anomic Aphasia with Neurogenic Stuttering by a certified Speech-Language Pathologist in the Department of Clinical Services, All India Institute of Speech and Hearing, Mysuru was considered as a participant for the present study and hereafter named as Participant M. The Participant M, a 35-year-old male, acquired this condition after an incident of Middle Cerebral Artery (MCA) infarct confirmed through Computerized Tomography (CT scan) neck angiogram revealing an abrupt cut-off of the proximal M1 segment of the left MCA territory infarct as described to secondary M1 occlusion. Magnetic Resonance Imaging (MRI) results had shown that there was an acute left MCA territory infarct secondary to M1 occlusion. He obtained a score of 90 as Aphasia Quotient (AQ) on the administration of Western Aphasia Battery (WAB) (Kertesz, 1982) and was diagnosed as Anomic Aphasia. Apart from the linguistic assessment, the cognitive assessment using Montreal Cognitive Assessment (MoCA) (Nasreddine et al., 2005) revealed a score of 22. MoCA being a language-dependent assessment tool, the participant's naming difficulties and word-finding difficulties explain low scores. The details of the scores for WAB and MoCA are mentioned in Table 1 and Table 2.

Table 1

Score of Participant M on the Administration of WAB

WAB Subtest	Participant Score	Maximum Score	Total for Aphasia Quotient
Spontaneous Speech			
a) Information content	9	10	17
b) Fluency	8	10	
Total	17	20	
Auditory verbal comprehension			
a) Yes-No questions	60	60	
b) Word Recognition	60	60	10
c) Sequential commands	80	80	
Total	200	200	
Repetition	92	100	9.2
Naming			
a. Object Naming	58	60	
b. Word Fluency	12	20	8.8
c. Sentence completion	8	10	
d. Responsive Speech	10	10	
Total	88	100	
		Aphasia Quotient	90
		Diagnosis based on AQ	Anomic Aphasia

Table 2

Scores of Participant M on Montreal Cognitive Assessment

Montreal Cognitive Assessment (MoCA)	
Visuospatial/Executive	4/5
Naming	1/3
Attention	6/6
Language	2/3
Abstraction	0/2
Delayed Recall	3/5
Orientation	6/6
Total score	22/30
Impression	Mild cognitive impairment

On Physiotherapist consultation, the clinical impression was hemiparesis post-stroke and recovered with physiotherapy, which did not hinder any functional needs. On a general observation, participants did not exhibit any signs of neglect or hemianopia. Pertaining to the associated problems, the participant did not exhibit any behavioral deficits like aggressiveness or temper tantrums. The participant would attend 2-3 hours of work every day and would adapt good communication strategies. However, the speech fluency was affected, and the participant had to refrain from the nature of work/official correspondence. The participant showed good motivation in attending regular speech-language therapy and was receiving speech-language training sessions five days a week, with each session of 45 minutes per day for about two months. The other detailed demographic information of Participant M is summarized in Table 3.

Table 3

Demographic Details of the Participant M

Variables	Participant detail
Name	Participant M
Sex	Male
Age	35 years
Native language	Kannada
Languages known	Kannada, English
Years of education	12 years
Present/former occupation	Receptionist
Number of days post-morbid	4 months
Handedness	Right
Neglect	Absent
Hemiparesis	Absent
Hemianopia	Absent
Site of lesion on CT and MRI	Left MCA territory

The participant's consent was obtained for his participation in the present study through virtual mode. The participant was verbally informed about the purpose, procedure, and estimated duration of the administration of the training module, and the instructions were read to the participant in the Kannada language. An e-copy (softcopy) of AIISH informal consent (Appendix A) was taken from the participant. The participant had to follow specific inclusionary and exclusionary criteria to participate in the present study as listed below.

Inclusionary Criteria for Individuals with Aphasia (Participant M)

- Participants had been diagnosed with Anomic Aphasia with neurogenic stuttering.

- The participant obtained a score between the range of 25 – 21 on the administration of MoCA (Montreal Cognitive Assessment) (Nasreddine et al., 2005).
- The participant's native language is Kannada.
- Participants completed a minimum 10 of years of formal education (high school).
- The participant with a history of a single episode of brain stroke due to cerebral vascular accident (CVA) and left Middle Cerebral Artery infarct confirmed with a Neurologist.
- The participant with a post morbid duration of at least 1 – 4 months during the time of administration of assessment tools and at the time of testing the manual.

Exclusionary Criteria for Individuals with Aphasia (Participant M)

- Participants with age-related vision problems, abnormal or uncorrected visual acuity, and poor dexterity.
- Participants with a known history of pre-morbid psychological, neurological, and other cognitive deficits.
- Participants not willing to provide consent for participation in the study

3.3 Materials

The study was conducted in two phases; Phase 1: Construction of the treatment manual and, Phase 2: Field test the treatment manual on a person with brain damage.

3.3.1 Phase 1: Construction of the Treatment Manual

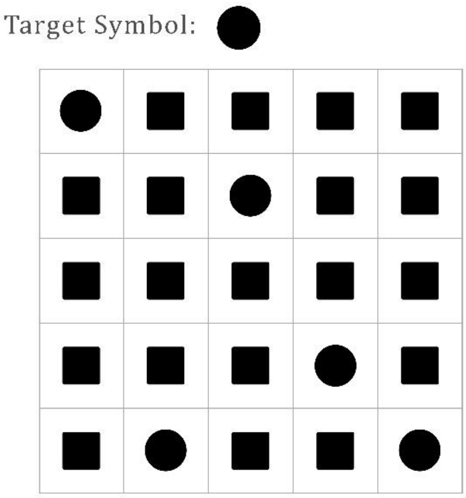
3.3.1.1 Adaptation of Categories for Visuospatial Skills. The categories used in the manual are adapted from an evidence-based resource material of a study by Croisile et al. (2008) to train visuospatial skills. The present study is an attempt to construct a manual with activities to train visuospatial skills. The categories that were adapted are – (1) Symbol Cancellation, (2) Symbol Trail, (3) Pattern Matching, (4) Mental Rotation, and (5) Interpretation of Body. Each of these categories was thoroughly reviewed for the construction of the stimuli. Each category targets different aspects of visuospatial skills like visuospatial perception, visuospatial attention, visuospatial working memory, and many more. The complexity level in each category of tasks is attempted to vary by changing symbol features, increasing the number of target symbols to competing symbol ratio, an increasing number of overall symbols used, or in case of mental rotation, changing the axis of rotation in the stimuli. The variation in complexity was decided after a thorough review of the literature.

3.2.1.2 Preparation of the Stimulus Material. As specified prior, five categories were taken for the construction of the manual. Each category consists of five levels of stimuli that vary in complexity, including one stimulus as the trial.

The first task is the "Symbol Cancellation Task", here the matrix of symbol 5 X 5 was constructed, and it is filled with five target symbols in each row and column and rest with competing symbols. The symbols vary from simple single-lined two-dimensional symbols to 8-10 sided 2-dimensional symbols. These symbols are monochromatic, that is, in black color on a white background. The hierarchy of the symbols used in each stimulus is constructed based on the psycho-anatomy logic and the visual hierarchy as given by Ahissar and Hochstein (2004). Each matrix which is one level of stimulus, is placed in the visual field, which is in A4 page size, and the target symbol for that stimulus is also placed on the same page above the matrix. For the manual, a total of five matrices were made with an additional one matrix as the trial stimulus, as shown in Figure 1.

Figure 1

Example of a Stimulus of Symbol Cancellation Task



The second task was the “Symbol Trail Task”, one trial stimulus and five training stimuli were constructed for this category. The construction of this stimulus was adapted in a similar way as to the tool that is developed by Barncord and Wanlass (2001). For the Symbol Trail Task, a square work field consisting of a total of twelve symbols in a circle is equally distributed in all four quadrants of the field in white background. Among the twelve symbols, four are target symbols, and nine are distractors. The four target symbols are specified above the field as target trail. In each stimulus, the number of total symbols was increased, along with the number of symbols in the target trail. The ratio of total symbols to target symbols used by Barncord and Wanlass (2001) study was 3:1, and the same is adapted in the preparation of tasks for the present study. Therefore, the total count of symbols and target symbols starts from twelve and four, fifteen and five, eighteen and six, twenty-one and seven, and finally twenty-four and eight. The symbols used are unfilled symbols with black outlines. The work field, along with the target trail is placed on an A4-sized page, and an example is shown in Figure 2.

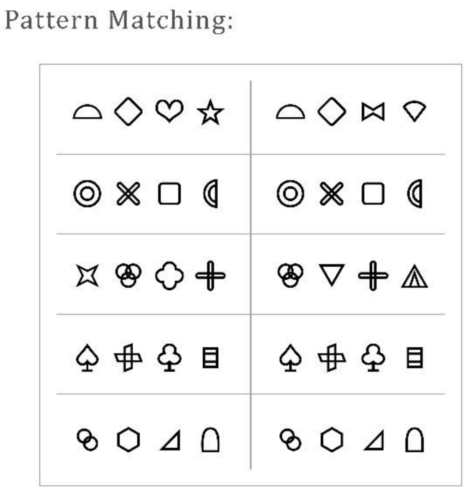
Figure 2

Example of a Stimulus of Symbol Trail Task

The third task is the "Pattern Matching Task", an adaptation from Croisile et al., (2008) study. The symbols used for the pattern are unfilled symbols with black outlines. Each level of stimuli has 5 pairs of patterns (arranged in a horizontal manner) that have to be matched with each other. The reference pattern is in the left column, and the target pattern is in the right column. The number of symbols used in the pattern starts from four numbers and gradually increases to seven symbols across the five levels of stimuli to vary the complexity in each level. These are placed on an A4-sized page with white background. An example of a stimulus is shown in Figure 3.

Figure 3

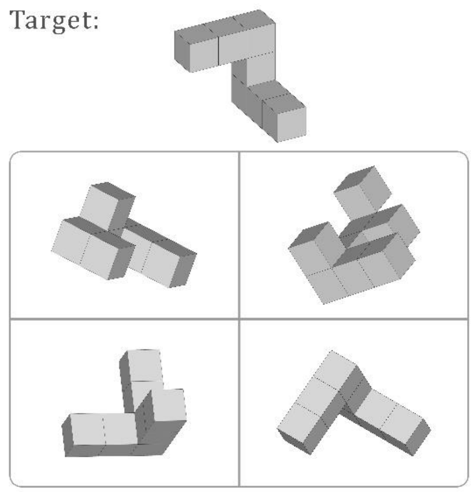
Example of a Stimulus of Pattern Matching Task



The fourth task is the “Mental Rotation Task”, which has a two-dimensional target drawing of a three-dimensional figure as the target figure. The task is to identify the target figure among the options provided. Like the other tasks, this also has 5 levels of stimuli, and each level has five figures with four response options for each along with one figure as the trial stimulus. Each level of stimuli has three figures that are constructed using seven blocks with two bends in the construction and two figures that are constructed using ten blocks with two bends in the construction. The construction of the blocks has been adapted from Vandenberg and Kuse (1978). The rotation angle of the figure that is to be identified is increased across each level of stimuli in order to vary the complexity (Liesefeld et al., 2014; Liesefeld & Zimmer, 2013) of the task. The rotation of the figure has been changed in 30° steps starting from the 30° rotation of the figure from its original axis. Each page of A4 size consists of the target figure and four response figures which are placed on white background, as shown in Figure 4.

Figure 4

Example of a Stimulus of Mental Rotation Task



The fifth task was the “Interpretation of Body Schema”, unlike the other tasks, this has only two variations. The first kind is photographs of hands in different ways, for example, left-hand palm up, left-hand palm down, right-hand palm up, and right-hand down. This stimulus was adapted from the study done by Coslett (1998). The latter kind has either the left hand or the right hand holding an object. These pictures were taken with a white background, cropped to an equal dimension of length and breadth, and placed on an A4-sized page. Each variation has 5 photographs each and additionally one photograph as the trial stimulus. One example is shown in Figure 5.

Figure 5

Example of a Stimulus of Interpretation of Body Schema

Each stimulus was made by a professional illustrator using Adobe Photoshop (Version 2018), and the stimuli were arranged and organized in the manual using Microsoft Office Word 2016 and Microsoft Office Powerpoint 2016. The final complete manual (Appendix B) was rendered in .pdf format, and the entire set of stimuli for the constructed manual is shown in Appendix C.

3.3.1.3 Instructions and scoring. The instructions for the task are presented in Kannada and English in written form in the manual and should be instructed verbally to the participant while using the manual. The scoresheet (Appendix D) for the same was devised to record the scores of the participant.

Verbatim instructions for the "Symbol Cancellation Task" are – "*I will be giving you a card containing different symbols. Among those symbols, one will be mentioned as the target symbol. You have to identify all such symbols by either striking across/circling them using a pen/pencil or using your index finger."*

The scoring for the symbol cancellation task has been described in detail in the manual. For the “symbols cancellation task”, every correctly marked/identified target symbol was scored “1”, and the incorrect response was marked “0”. Each stimulus had a total score of 5, and the overall score of the task is 25.

Verbatim instructions for “Symbol Trail Task” are – *“I will give you a stimulus card containing different symbols and a key containing a sequence of symbols. You have to draw a line connecting the symbols in the same sequence as given in the key on the stimulus card.”*

In the case of the symbol trail task, every correct trail between two symbols was scored “1”, and incorrect was scored “0”. The total score of stimuli started with 3 and increases gradually as the number of symbols increase. The overall score for this task is 25.

Verbatim instructions for “Pattern Matching Task” are – *“I will give you a stimulus card containing a sequence of symbols in two columns. You have to mention whether the sequence on the left side column matches or not with the other sequence of symbols on the ride side column.”*

Pattern matching task provides a score of “1” when correctly identified if the patterns match or not and “0” in case there is an incorrect response. Each level of stimuli has five pairs of patterns; hence, the total possible score for each level was 5, and the overall score of this task is 25.

Verbatim instructions for the “Mental Rotation Task” are – *This particular stimulus card has one target image and four other different images. One of these four images matches with the target image when rotated. Which one is that?”*

In the mental rotation task, every correctly identified rotated figure of the target figure was awarded a score of "1", and incorrect identification was scored "0". The possible score for each level of stimuli was 5, and the overall score for this task is 25.

Verbatim instructions for the 'Interpretation of Body Scheme' task are – *"I will be giving you pictures of a hand, and you will have to tell me whether it is the left hand or the right hand."*

With reference to this task of interpretation of body schema, when the left/right orientation of the hands are correctly identified, a score of "1" was awarded, and an incorrect response was given "0". Each variation of this task has a total possible score of 5 and an overall score of 10.

3.3.1.4 Content validity. The constructed treatment manual with activities of visuospatial skills was given to a Speech-Language Pathologist and a Clinical Psychologist for validating its content in terms of checking its familiarity, complexity, and scoring procedure suitable for persons with brain damage. A feedback rating questionnaire developed by Goswami et al. (2012) was used for this purpose. This questionnaire contained twenty parameters, consisting of a 5-point rating scale, ranging from "very poor" to "excellent" to rate the stimuli in a google form and the overall constructed manual. The parameters used to judge the content of the manual were "simplicity", "familiarity", "size of the picture", "color and appearance", "relevance", "iconicity", and "flexibility". The overall manual on the parameters (Appendix – E) was also rated by the validators on the same 5-point rating Likert scale as mentioned prior. The definitions of the parameters were given at the beginning of the google form for better understanding and implementing them appropriately while rating the manual. The validation form and the manual were incorporated in a google form and were mailed to the validators for rating the content of the manual. Post validation, the responses were reviewed, and the suggestions put across by the validators were incorporated in the manual.

3.3.2 Phase 2: A pilot study of the manual on persons with brain damage

The constructed manual was administered on an individual with brain damage through virtual mode with caregivers' assistance. The manual was administered over five individual sessions for Participant M, and scores for each task were documented. The general guidelines followed commonly among all the tasks such as seating, lighting, alertness, and placement of the stimulus were similar for all the categories of visuospatial skills. Instructions for the examiner were clearly stated for each category in the manual. Verbatim instruction was written in both English and Kannada language in order to make native Kannada participants understand the procedure of each task. The same instructions were given to the participant while administrating the manual. Responses for trial tasks were not scored, and only the target stimuli were scored. Responses for training tasks were considered either correct or incorrect and were scored "1" or "0" respectively and tabulated the scores. A combined score sheet was used to scores each category, and the examiner entered the scores and kept track of the participant's responses.

The examiner used progression criteria, where the participant had to complete one level of stimulus in a specific category successfully in order to progress to the next level of stimulus, for which the participant should achieve at least 90% of the expected responses in each level of stimuli. Requisites, that is, the scores/criteria required to achieve for progression to the next level of the stimulus in each category. The same is provided at the beginning of the examiner's manual.

3.4 Scoring and Analysis:

The noted responses of Participant M for all the categories of visuospatial skills were subjected to quantitative and qualitative profiling. For better understanding and interpretation, the same is described in detail in the following chapter.

Chapter 4

Results

The present study aimed to construct a treatment manual for visuospatial skills and conducting a pilot study by administrating the manual on an individual with brain damage. The categories used for constructing the tasks in the manual have been adapted from the resource material used by Croisile et al. (2008), and tasks for adapted five categories of visuospatial skills were constructed for the treatment manual. The results of the present study are documented under two headings, 1) The content validation of the constructed treatment manual and 2) The pilot study in terms of administration of the treatment manual on individuals with brain damage.

4.1 Content Validation of the Constructed Treatment Manual

The constructed treatment manual was subjected to content validation by a Psychologist and a Speech-Language Pathologist. The responses of the validators were recorded by following the guidelines in the questionnaire developed by Goswami et al. (2012). The overall majority rating obtained for the activities of the manual was considered as final for the content validation, as shown in Table 4. Further, the entire manual was rated for parameters such as presentation, trainability, generalization, feasibility, volume, the scope of practice, and coverage of parameters where the majority ratings of the validators were found to be similar, which have been considered as validated response as shown in Table 5. The recommendations and suggestions given by the validator have also been incorporated into the manual.

Table 4

The Majority Rating of The Validators for The Tasks Of "Manual for Visuospatial Organization Activities for Persons with Brain Damage"

Parameter	Symbol Cancellation Task		Symbol Trail Task		Pattern Matching Task		Mental Rotation Task		Interpretation of Body Schema	
	Validator 1	Validator 2	Validator 1	Validator 2	Validator 1	Validator 2	Validator 1	Validator 2	Validator 1	Validator 2
Simplicity	Good	Fair	Excellent	Good	Good	Fair	Good	Good	Excellent	Good
Familiarity	Excellent	Good	Excellent	Good	Good	Good	Good	Good	Excellent	Good
Size of the picture	Excellent	Fair	Fair	Good	Fair	Good	Good	Good	Excellent	Good
Colour and appearance	Good	Good	Excellent	Good	Fair	Fair	Good	Fair	Excellent	Good
Arrangement	Good	Fair	Excellent	Good	Fair	Good	Good	Fair	Excellent	Good
Relevance	Excellent	Good	Excellent	Good	Good	Good	Good	Good	Excellent	Good
Iconicity	Excellent	Good	Excellent	Good	Good	Good	Good	Good	Excellent	Good
Flexibility	Excellent	Good	Excellent	Good	Good	Good	Good	Good	Excellent	Good

Table 5

Validators Rating for The Manual

Parameters	Validator 1	Validator 2
Presentation	Excellent	Fair
Accessibility	Good	Good
Trainability	Good	Good
Stimulability	Good	Good
Generalization	Good	Fair
Feasibility	Good	Good
Scope of Practice	Excellent	Good
Scoring Pattern	Good	Good
Publications, outcomes, and developers (Professional Background):	Yes	Yes
Coverage of parameters (Reception & Expression):	Excellent	Fair
Remarks of the validators	Modification in the number of target symbols to be made in one of the stimuli in the symbol cancellation task.	Change in the size of the symbols in the first three tasks. Simplification of the instructions given in the Kannada language.

4.2 Performance of Participant M on the Administration of Manual for Visuospatial Organization Activities for Persons with Brain Damage

Participant M underwent five sessions of training for visuospatial skills using the newly constructed treatment manual for visuospatial skills. Each session lasted for 45 minutes a day for two days a week. The training involved the categories of visuospatial activities like 1) Symbol cancellation task, 2) Symbol trail task, 3) Pattern matching task, 4) Mental rotation task, and 5) Interpretation of body schema. In each category, the participant was initially given a trial stimulus after instructing to ensure that the participant understood the task and familiarise with the rules and regulations of the task. The participant was allowed to take reattempts for the stimuli (task) in which he went wrong, and the participant was given verbal cues if necessary to elicit correct responses; however, these were scored zero, and only the responses for the first attempt was considered for scoring. The responses that were obtained in each domain have been described in detail under respective sections.

4.2.1 Symbol Cancellation Task

Participant M exhibited good responses for the trial stimuli by showing the target symbols for the symbol cancellation task. Following the trial, training stimuli were given to the participant. The participant performed without any difficulty by showing accurate responses by identifying the target symbol among the competing symbols in Stimulus-1, Stimulus-2, and Stimulus-3. The responses were similar for all the target symbols where they were arranged in a matrix of 5 X 5 (rows and columns), which gives a score equivalent to five for each correctly identified target symbol and the total score of twenty-five (5 symbols X 5 matrices) for the symbol cancellation task. However, in the case of Stimulus-4 and Stimulus-5, the responses observed from the participant were accurate. Participant M exhibited some confusion in identifying the target symbol among the competing while carrying out the symbol cancellation task. In addition, the participant required more duration to complete the task, and there was insufficient attention paid towards the task. The total score for the symbol cancellation task was 100% accurate for all the selected symbols. Table 6 shows the response summary of Participant M obtained in the task. The total score obtained by the participant for the symbol cancellation task was 25 out of 25.

Table 6

Response and Scoring of the Participant for Symbol Cancellation Task

Stimuli		Symbols	Target response	Score of one row	Score of five rows	Remark
Trial	Stimulus-T		Correct	-	-	-
Training	Stimulus-1		Correct	1	5	Understood instructions; task completed successfully
	Stimulus-2		Correct	1	5	
	Stimulus-3		Correct	1	5	
	Stimulus-4		Correct	1	5	Confusions between target symbols and competing symbols. Relatively longer duration to complete the task
	Stimulus-5		Correct	1	5	
				Total Score	25	

4.2.2 Symbol Trail Task

Participant M performed well for the trial stimulus by showing accurate responses by making all the trails in the same sequence as shown in the key sequence in the symbol trail task. Similar responses were observed for Trail-1 (four symbols trail with three connections), Trail-2 (five symbols trail with four connections), and Trail-3 (six symbols trail with five connections). On observation of responses of Trail-4 (seven symbols trail with six connections) and Trail-5 (eight symbols trail with seven connections), the participant completed the task with a relatively increased time duration compared to the earlier symbol trails given to the participant. The participant did not exhibit any confusion, inattention, or signs of unilateral neglect. The participant provided accurate responses for all the stimuli in the symbol trail task and obtained a total score of 25 out of 25. Table 7 shows the response summary of the symbol trail task, correct responses obtained for the simple trails to the complex trails with similar observations for the same (no missed connections of symbols in the trail or mismatch in the sequence of the trail connections) noticed in all the symbol trails.

Table 7

Response and Scoring of the Participant for Symbol Trail Task

Stimuli		Symbol Trail (No. of connections)	Target response	Score	Remark
Trial	Stimulus-T	3	Correct	-	-
Training	Stimulus-1	3	Correct	3	Understood instructions; task completed successfully
	Stimulus-2	4	Correct	4	
	Stimulus-3	5	Correct	5	
	Stimulus-4	6	Correct	6	Relatively longer duration to complete the task
	Stimulus-5	7	Correct	7	
			Total Score	25	

4.2.3 Pattern Matching Task

Participant M showed good performance for the trial stimuli by showing accurate responses by matching the reference pattern to the target pattern that is arranged in the horizontal plane in the pattern matching task. A similar response was seen for the pair of reference patterns and target patterns given in the Matching Task-1, Matching Task-2, and Matching Task-3. For the Matching Task-4, there was an incorrect response, and it was observed that the participant attempted to self-correct and could perform with an accurate response on the second trial. The response for the Matching Task-5 was correct, and it was observed that the participant's duration taken to identify the match gradually increased with an increase in number symbols in the pattern, that is, the complexity of the task. The total score for the Pattern Matching task was 100% accurate for all the selected sequential patterns and obtained a score of a total of 25 out of 25. Table 8 depicts the response summary of the five patterns for each stimulus of five, in total, twenty-five stimuli.

Table 8

Response and Scoring of the Participant for Pattern Matching Task

Stimuli		Pattern Match (No. of symbols in the pattern)	Target response	Score	Remark
Trial	Stimulus-T	3	Correct	-	
Training	Stimulus-1	3	Correct	5	
	Stimulus-2	4	Correct	5	
	Stimulus-3	5	Correct	5	Took a relatively longer duration to complete the task Corrected on the second attempt after receiving feedback.
	Stimulus-4	6	Correct	5	Took a relatively longer duration to complete the task
	Stimulus-5	7	Correct	5	
			Total Score	25	

4.2.4 Mental Rotation Task

For the mental rotation task, the stimuli were five three-dimensional target figures which have to be matched to its target figure among the choice of four options for each of the target figures. The target figures are rotated in their axis in different degrees forming the rotated figures as one of the choices for the participant to identify correctly. The participant performed with an accurate response to the trial stimulus. For Stimuli-1, the participant performed accurately for four of the target figures and with one incorrect response to one target figure. Examiner gave feedback for the incorrect response, and on the second trial, the participant was able to give the correct response. The participant was given verbal cues whenever there was an incorrect response by asking him to look into the number of blocks and their angle/orientation, which facilitated an accurate response. A similar response was seen for Stimuli-2, Stimuli-3, Stimuli-4, and Stimuli-5. The participant was able to identify four of the rotated figures out of five for all five stimuli. On comparing the duration taken to respond to all five stimuli, the duration taken to respond to Stimuli-4 and Stimuli-5 were relatively long and indicated that the difficulty level increased as the participant progressed through each stimulus. Table 9 shows the response summary of this task, and the participant scored a total of 20 out of 25 for the mental rotation task.

Table 9

Response and Scoring of the Participant for Mental Rotation Task

Stimuli		No. of target figures	Target response	Score	Remark
Trial	Stimulus-T	1	Correct	-	-
Training	Stimulus-1	5	Correct	4	For the figures for which the wrong response was given, the participant gave a wrong response on the first trial. Examiner gave feedback, and on the second trial, the participant was able to identify the correct figure.
	Stimulus-2	5	Correct	4	
	Stimulus-3	5	Correct	4	
	Stimulus-4	5	Correct	4	Similarly, for the figures for which the wrong response was given, the participant gave a wrong response on the first trial. Examiner gave feedback, and on the second trial, the participant was able to identify the correct figure. However, a longer duration was taken
	Stimulus-5	5	Correct	4	
			Total Score	20	

4.2.5 Interpretation of Body Schema

There were two sets of stimuli with five pictures (5 pictures X 2 sets) of the hand, which required the participant to identify if the picture depicted the left hand or the right hand. The participant could accurately identify the stimulus (right or left) shown for the trial. Stimuli-1 consisted of five pictures of hand (either palm up/palm down of right/left hand) where each one had to be identified whether it was right-hand or the left-hand. The participant could give a correct response, and it was observed that the participant glanced at his hand to identify the target picture. The participant could complete a set of Stimuli-1 without any confusion, errors, or revisions and obtained a score of 5 out of 5. Stimuli-2 were again five pictures of; however, here it was depicted as holding an object, and the participant was required to identify the hand accurately for all the five target stimuli without any confusion, errors, or revisions and obtained a score of 5 out of 5. The total score obtained by the participant was 10 out of 10 for the task of interpretation of body schema. Table 10 shows the response summary for the task of interpretation of body schema.

Table 10

Response and Scoring of the Participant for Interpretation of Body Schema

Stimuli		No. of pictures	Target response	Score	Remark
Trial	Stimulus-T	1	Correct	-	-
Training	Stimulus-1	5	Correct	5	The participant was able to identify correctly however glanced at his own left initially to determine if it was left or right.
	Stimulus-2	5	Correct	5	The participant was identifying correctly without any confusion, errors, or revisions
			Total Score	10	

The summary of the results suggests that Participant M could perform more accurately without the investigator's assistance for the “Symbol Cancellation task” whereas for the other tasks like “Symbol Trail Task”, “Pattern Matching Task”, “Mental Rotation Task”, and “Interpretation of Body Schema”, the participant required assistance in terms of repeated instructions, simplification of instruction, rehearsal strategies with repetition of the task, self-corrections, extended duration to complete the task and an accurate response was obtained for the second trials. However, in the present study, the response for the second trial was not considered for scoring. The summary of the total scores for each task is shown in Table 11.

Table 11

Summary of Response and Score for All Tasks

Sl No.	Task	Participants Score	Expected Score
1.	Symbol Cancellation task	25	25
2.	Symbol Trail Task	25	25
3.	Pattern Matching Task	25	25
4.	Mental Rotation Task	20	25
5.	Interpretation of Body Schema	10	10

To conclude, the participant showed difficulty in the ‘mental rotation task’ and however did not exhibit any signs of spatial neglect. To comment on the visuospatial skills like visuospatial perception, visuomotor tracking, visuospatial attention, and working memory were found to be intact. The positive responses of the participant indicate good comprehension of the instructions and smooth administration of the manual on an individual with brain damage. However, the manual has to be standardized on neuro-typicals and validated on a large clinical population with various brain damages for routine therapeutic and counseling purposes.

Chapter 5

Discussion

The present study aimed to construct a training manual for visuospatial organization activities for individuals with brain damage, conduct content validation of the manual, and perform a pilot study by administering the newly constructed manual on an individual with brain damage.

The said manual was administrated on an individual diagnosed with Anomic aphasia with neurogenic stuttering. In “Symbol Cancellation Task” and in “Symbol Trail Task”, the participant was able to produce accurate responses for all stimuli in the manual, implying the absence of any sort of neglect, good visuomotor tracking, visuospatial perception and, attention. To date, the literature has stated there is very less incidence of unilateral neglect in individuals with left hemisphere damage. Beis et al. (2004) has also reported observing *neglect* in left-brain damage, in which case it affects the right side of the space, although it is of lesser degree and often less long-lasting. In their study, among the seventy-eight participants who had left hemisphere stroke, each task to assess neglect revealed 10 – 13.2% right neglect in the participants. However, the performance of such tasks on individuals with aphasia has also been reported to be one of the easiest tasks while assessing for non-linguistic skills in such individuals.

Eight out of thirteen participants in the study conducted by Helm-Estabrooks (2002) achieved scores above the normal levels for the cancellation task. Symbol cancellation requires visual attention, visual scanning, discrimination, and moreover, it also calls upon the ability to *inhibit* stimulus attraction to symbols similar to the target and avoid distractions within the four quadrants.

In another study by Ehrenstein et al. (1982), even though both the group of brain-damaged individuals, aphasics and non-aphasics, showed a correlation between trail-making tests outcomes and other cognitive tests, it was concluded that aphasics use *different cognitive strategies* when compared to other non-aphasic brain-damaged individuals.

There are few conceptualizations that language impairments may arise from or be magnified by *dysfunction in cognitive skills* other than language (Murray, 2012). Among other cognitive skills, *attention* was also found to be affected in individuals with aphasia. Each function of the attention, such as auditory and visual mode of sustained and selective attention, visual and auditory attention switching, and visual attention, was found to be vulnerable in individuals with aphasia. It is also known that spatial attention is generally attributed to the right hemisphere. However, the left hemisphere also plays a role in spatial attention. Evidence of lesion studies suggests that the left frontal lobe is involved in spatial attention, but clinical manifestations are found to be less severe and more transient (Friedrich et al., 2007). Hence, the study supports the explanation of the difficulty faced by Participant M to pay attention while doing the final two complex stimuli of cancellation task and trail task.

Dexterity and impeding hemiparesis post-stroke have also been one of the factors affecting the performance in paper-pencil tasks like cancellation tasks and trail-making tasks. The study by Bonini and Radanovic (2015) showed outcomes of poor performance in the trail-making task by individuals with aphasia which is in variance to that of the outcome obtained in the current study. The participant in the current study did not exhibit hemiparesis and or any other weakness in their limbs.

Hence, it could be one of the multiple factors explaining good performance in the tasks.

Lesion site for unilateral neglect was mostly found in the inferior parietal cortex, medial temporoparietal junction, and superior temporal cortex, and similarly, lesion site at the temporoparietal region of the right hemisphere has shown to cause issues in visual attention (Karnath & Rorden, 2012). The integrity of the lateral superior parietal and parieto-occipital cortices was revealed to be important in visual location estimation, and the encoding of spatial location has been shown to include the posterior parietal cortex (Von Cramon & Kerkhoff, 1993), which all play an active role in carrying the functions required for the said tasks. Conversely, the participant in the current study suffered from the stroke due to occlusion in the M1 branch of the medial cerebral artery. The medial cerebral artery is known to supply the lateral frontal lobe, inferior frontal lobe, and anterior lateral areas of the parietal lobe.

Individuals with left hemisphere damage diagnosed with aphasia who present with a very low incidence of visuospatial deficits are better explained with the "crowding hypothesis" – where the functions left hemisphere begin to reorganize in the right hemisphere leading to "crowding" of functions. Studies also show that the occurrence of cortical reorganization of functions post early unilateral brain damage is better clarified on mechanisms of reorganization of the networks (Lidzba et al., 2006). However, the observations of the participant's responses in this study have led to understanding that the reorganization has facilitated improvements in language skills and cognitive skills to a large extent, and in contradiction to the crowding hypothesis, the participant did not exhibit any deficits in visuospatial skills.

In the task of "Pattern Matching", Participant M was able to produce correct responses for all the stimuli but also demonstrated to face difficulty as the number of symbols in the pattern increased. Difficulty in matching with a higher level of stimuli can be attributed to the number, and it is known that *visual perception tends to get complex* as the crowding of stimuli occurs. Belleza et al. (1979) conducted a study using visual matching test where the patients with left hemisphere damage consistently showed good performance, whereas patients with right hemisphere damage committed frequent errors. Supporting this result, Bottini et al. (1991) found that there is a correlation between right hemisphere damage and perceptual discrimination in a visual matching task, and the left hemisphere had a semantic association to this impairment has the language centers of the brain are often found to be in the left hemisphere. However, the author also found a concomitance that there is a superior performance of the right hemisphere when it comes to meaningless shape identification. This can be associated with the output obtained from the current study, where symbols with lower semantic load were used hence demanding superior performance from the right hemisphere. The participant, however, had suffered from damage to the left hemisphere he did not show any difficulty in matching the meaningless symbols used in the pattern matching task.

In "Mental Rotation Task", Participant M was able to identify the rotated figure of the reference; however, in five of the twenty-five figures, the participant required a second attempt to identify them correctly. Johnson (2016) states the process by which an individual performs a mental rotation task is like the participant first forms a *mental representation* of the entity, following which he rotates it in its axial orientation mentally which allows him to compare with the reference, then he makes the judgment and finally the decision regarding the rotation is reported.

According to Shepard and Metzler (1971), the *reaction time* for the performance of the mental rotation task was a linear function of the degree of rotation to increase the similarity of the same hence assisting in understanding the excess time taken to complete the task as the participant progressed through the stimuli. Participant M took increased processing time as the task became more complex. Evidence is also found that older adults have shown to perform poorly in mental rotation tasks and hypothesized that *hemispheric differences* are present in older adults based on their poor performance in the mental rotation task (Clancy Dollinger, 1995). Age could be another factor contributing to the requirement of second attempts for few stimuli in this current study.

There has been clinical evidence from lesion studies that *right hemisphere involvement* is present for mental rotation based on the poor performance of the patients for right hemisphere damage in mental rotation tasks (Ratcliff, 1979). The mental rotation has been identified to show increased activity in the intraparietal sulcus and its adjacent regions and medial superior precentral cortex, especially when the conditions seem to favor motor simulation (Zacks, 2008). There is also activation in the subcortical structures such as basal ganglia during mental rotation tasks, and the basal ganglia and motor cortex work hand in hand during this process for motor planning and execution (Alivisatos & Petrides, 1997). Mental rotation also requires the significant contribution of *executive functioning skills*. Studies were so far done to understand cognition and language impairment in individuals with aphasia have led to an understanding that cognitive skills are also impaired, and here, in this case, can explain the reason for the participant in the current study to face difficulty in this task. Mild impairment in executive functioning is frequently seen in individuals with anomic aphasia, which further supports the findings in the current study (Murray, 2016), and the site of lesion of the participant does not correlate with the activation areas of mental rotation.

With reference to the “Interpretation of Body Scheme”, disturbance in body schema and left/right disorientation is a classic example that is often seen in Gerstmann syndrome. Gerstmann syndrome also presents with agraphia, acalculia, and finger agnosia. Lesion site in this condition was found to the angular gyrus, and it is occasionally termed as the "angular gyrus syndrome" (Ardila, 2020). The clinical symptoms usually appear in association with aphasia, alexia, and other cognitive disorders. However, the Participant M of the current study did not exhibit symptoms as that of Gerstmann syndrome, and the *site of lesion did not correspond* to that of this syndrome explaining the good performance in the task of interpretation of body schema and absence of left/right disorientation.

A speech-language pathologist predominantly sees individuals with left hemisphere damage more frequently than those with right hemisphere damage, and often an assessment of unilateral neglect in left hemisphere damage itself is foreseen during evaluations. Evidence has also been found that non-linguistic cognitive skills like attention, executive functions, working memory, and aphasia were often found to co-exists in patients who suffered from strokes, and the less amount of literature to explain the correlation could be mostly due to the difficulty of assessing non-verbal cognitive skills with the impaired language skills (Lee & Pyun, 2014). Typically, visuospatial organization and processing are associated with right hemisphere functioning (Heilman et al., 2004), but other researchers have also found that visuospatial functions like visuospatial working memory and visuospatial memory have shown lateralization towards the left hemisphere (Cowan et al., 2011) hence, it can be assumed that there is a significant bilateral involvement for the functioning and processing of visuospatial skills. Hence the developed manual can be clinically used in the management of visuospatial skills in individuals with brain damage.

This manual of visuospatial organization activities for persons with brain damage is an initial attempt to create activities that aim to improve visuospatial skills. This manual has been shown to explicitly target visuospatial skills. It has five different categories of tasks to target as many operations as possible under visuospatial skills. These tasks allow the patient to explore those skills at a different level of complexity and allow them to improve their skills in specific sub-domains of visuospatial skills such as visuospatial scanning, visuomotor tracking, visuospatial perception, visual attention, visuospatial working memory, and executive functioning. The stimuli used in the manual are not language-dependent and have a less semantic load which allows the clinician to use them on all patients with visuospatial deficits and does not require the patient to have very good skills in the semantic parameter of the language as well. The outcomes from the pilot study have shown that the patient who had left brain damage post-stroke provided with good performance; however, different outcomes can be expected when administrated on individuals with right brain damage or traumatic brain injury. Manual has exhibited ease of administration through virtual mode and can be inferred had the same can be expected while using a softcopy on smart devices like tablets.

Chapter 6

Summary and Conclusion

Visuospatial skills are those cognitive operations that allow an individual to determine visual and spatial correlations among objects and their surroundings. This is usually found to be impaired in individuals with brain damage impeding their daily actions. There is a need to target visuospatial skills for such individuals in order to help them to gain some functionality back and help to improve the quality of living.

The objectives of the present study were to construct a manual for visuospatial skills for persons with brain damage, to validate the content of the constructed manual, and to conduct a pilot study on individuals with brain damage using the manual. The categories of visuospatial activities were adapted from Croisile et al. (2007), and further construction of activities was based on a thorough literature review of visuospatial activities. Categories of activities such as symbol cancellation, symbol trail, pattern matching, mental rotation, and interpretation of body schema were majorly selected and incorporated in the manual. Each of these categories has five sets of stimuli with a hierarchy in their complexity. The progression criteria were set based on the completion of each level of complexity of the stimuli. The instructions to be given to the participant were made in both English as well as in the Kannada language, and scoring for each stimulus was also devised for the manual. Correct responses were given a score of “1,” and incorrect responses were scored “0”.

This manual was subjected to content validation by a certified Speech-Language Pathologist and a certified Clinical Psychologist. A feedback rating questionnaire developed by Goswami et al. (2010) was used for the content validation process. The suggestions and recommendations provided by the validators were incorporated in the manual, and the ratings given by them were qualitatively analyzed, and possible changes based on the analysis were also implemented in the manual. This validated manual was used for conducting a pilot study.

The pilot study was performed on an individual with a history of the left hemisphere and diagnosed with anomic aphasia with neurogenic stuttering by a Speech-Language Pathologist. Participant M, a 35-year-old male, revealed good performance in the “symbol cancellation task”, “symbol trail task”, “pattern matching task”, and “interpretation of body schema”. However, it was observed that the participant faced difficulty in the “mental rotation task” as the participant required a second attempt to produce a correct response for few stimuli, and he was given verbal cues by asking to re-analyze the angle and orientation of the figures. It was also observed that as the complexity of the stimuli increased, the duration taken by the participant increased. This led to derive to an inference that the visuospatial skills like visuospatial scanning, visuomotor tracking, visuospatial perception were intact and did not exhibit any neglect. However, it can be commented that visual attention, visuospatial working memory, and executive function have scope for improvement in this participant.

Few theories proposed by the researchers state that language impairments may arise from or be magnified due to underlying dysfunction in the cognitive skills. Implying from this statement, recovery in the same domain of language can assist improvement in the cognitive skills allowing Participant M to show good performance in tasks. Dexterity and impeding hemiparesis post-stroke have also been one of the factors affecting the performance in paper-pencil tasks like cancellation tasks and trail-making tasks; however, this was not the case in the current study. In matching tasks, especially in adults, difficulty in matching with a higher level of stimuli can be attributed to the number, and it is known that visual perception tends to get complex as the crowding of stimuli occurs, which can be attributed to the increased duration taken by the participant in the pilot study.

While looking at the results obtained for the mental rotation task, the reaction time for the performance of the mental rotation task is said to have a linear function of the degree of rotation to increase the similarity of the same hence assisting in understanding the excess time taken to complete the task. It can also be correlated that right hemisphere involvement is present for mental rotation based on the poor performance of the patients for right hemisphere damage in mental rotation tasks. Mental rotation also requires the significant contribution of executive functioning skills. Lack of left/right disorientation is usually seen in the case of Gerstmann syndrome; however, Participant M did not face difficulty in performing the task of "interpretation of body schema" as he did not exhibit symptoms as that of Gerstmann syndrome and the site of lesion did not correspond to that of this syndrome explaining the good performance in the task of interpretation of body schema and absence of left/right disorientation.

The constructed manual was designed for visuospatial skills for those who have visuospatial dysfunction. Adding to this, the manual being a training manual, it turns out to be very useful for speech-language pathologists as part of their clinical resource that targets specific cognitive skills, that is, visuospatial skills. The manual can be paired with other cognitive training programs and rehabilitative programs for persons with brain damage and form a holistic intervention program for the patients, which taps on all possible skills.

6.1 Implications of the Study

The results from the study offer an understanding regarding the performance of the individual with left brain damage on various categories of visuospatial skills. Owing to the COVID pandemic, the manual was constructed in an e-format extending its applicability for tele-rehabilitation sessions for individuals with visuospatial dysfunction. Although the manual requires further field testing on a large population with brain damage, the pilot study on a single subject showed evidence that this manual can be utilized to target visuospatial skills in individuals with visuospatial disturbances. It will aid in understanding the level of functioning of visuospatial skills in impaired individuals and plan a training program based on their baseline of functioning. The manual will be very useful from a research and clinical point of view. The manual has good scope to be used as a home training tool after the caregiver is trained on the use of the manual.

6.2 Limitations and Future Directions

This manual is a handy tool that will allow practicing clinicians to work on visuospatial skills explicitly from the basic level. The activities constructed from this manual were paper-pencil-based tabletop tasks where direct generalization of these activities could be studied in the future. An appropriate baseline assessment protocol for evaluating visuospatial skills prior to the implementation of the manual should be determined in future studies. Thus, there will be scope for refinement in the construction of the stimuli, types of stimuli, and hierarchy of complexity and responses can be more objective by measuring reaction time for each task. The pilot study did not include pre and post-assessment data to study the effectiveness of the treatment manual in detail. The attempted pilot study using this manual on a single subject did not provide sufficient data to generalize the outcome of the manual or anticipate the generalization outcomes of the manual on different lesions sites of brain damage.

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Appendix - A

All India Institute of Speech and Hearing, Naimisham Campus, Manasagangothri, Mysore-570006.

CONSENT FORM

Dissertation on

"Development of a Manual for Visuospatial Organization Activities for Persons with Brain Damage"

You are invited to participate in the study titled "Development of a Manual for Visuospatial Organization Activities for Persons with Brain Damage". This study is conducted by Ms. Thirumanjari K, a postgraduate student of the All India Institute of Speech and Hearing, under the guidance of Dr. Hema. N, Assistant Professor, Department of Speech-Language Sciences, All India Institute of Speech and Hearing. The study aims to develop and validate a treatment manual to treat the visuospatial skills in persons with brain damage and conduct a pilot study to test the utility of the constructed manual. Participant and caregiver will be interviewed to obtain demographic details and necessary medical information prior to confirming eligibility for the study. Once eligible, the participant will be provided therapy sessions for training for visuospatial skills for 5 sessions, 45 minutes each via tele-mode (Zoom app), and sessions will be recorded for further analysis. The identity of the participant will not be revealed at any time, and the videos will be maintained confidential. The data obtained from the sessions will not be disclosed, and the access will be limited to individuals who are working on the project. Participation in this study is voluntary. You can refuse to participate or withdraw at any point in the study without penalty or loss of benefits to which you are otherwise entitled. The procedures of the study are non-invasive, and no risks are associated.

Informed Consent

I have read the foregoing information, or it has been read to me in the language I understand. I have had the opportunity to ask questions about it, and any questions that I have asked have been answered to my satisfaction. I consent voluntarily to participate in this study.

I, ____, consent to be participant of this investigation/study/program.

Name, Email ID, age, and address of the participant | Name of the investigator

Appendix – B

MANUAL FOR VISUOSPATIAL ORGANIZATION ACTIVITIES FOR PERSONS WITH BRAIN DAMAGE

EXAMINER'S MANUAL

INTRODUCTION

What are visuospatial skills?

Visuospatial skills are those with which a person specifies the configuration of an object, analyses its position in space, integrates a coherent spatial framework, and performs mental operations on spatial concepts.

Why are visuospatial skills essential?

Visuospatial skills are one of the important skills that need to be targeted as they play a crucial role in our day-to-day activities; they enable us to estimate the distance between objects, create mental representations to get to the required location, for example, while locating the spot where we parked our car or direct ourselves to the bathroom in the dark.

Purpose of this manual:

This manual is devised to target visuospatial skills in an intervention program for those with impairment in visuospatial skills. It is constructed by keeping those in mind who suffer from difficulties in visuospatial skills post brain damage. Manual includes simple paper-pencil tasks that can be provided to individuals with impaired visuospatial skills in a step-wise manner at a clinical setup. Hence, aid in improving the said skills as part of other cognitive skills training.

1. SYMBOL CANCELLATION TASK

Cancellation tasks are those which are primarily used to evaluating visuospatial skills. The tasks involve correctly identifying the target stimuli in which the individual is encouraged to cancel out the stimuli and using the outcome to evaluate the individual's performance. Mesulam's symbol cancellation test is one of the most common tools used for this task. This task uses the principle of visual scanning therapy, which aims to improve visual scanning behavior by encouraging individuals with hemineglect to actively pay attention to the entire visual field of stimulus.

Task description: A stimulus card containing a set of symbols and one symbol indicated as the target symbol to be presented to the individual. These symbols are formed using black colour (continuous line drawing/filled shapes/dot etc.), and symbols are placed in a 5 X 5 matrix. The individual must be instructed to identify all the target symbols by either striking across/circling them using a pencil/pen or pointing using the index finger wherever it is present on the card.

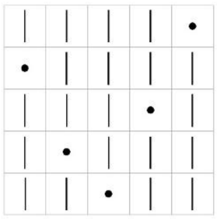
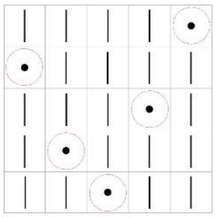
Scoring and administration: Stimulus card is given one at a time in the order followed in the manual. The individual can be given a cue and guided to scan throughout the visual field in search of the target stimuli if they are finding it challenging to complete the task. Multiple trials can be given until they mark all the target stimuli and then only proceed to the following stimuli. There is no specific time limit provided to the individual to complete the task. A trial stimulus can be given to the individual, which can be used to explain the task and make them more familiar with it. The trial stimulus is not scored. In the training stimuli, each correctly identified target stimuli is scored 1; therefore, each card constitutes a total score of 5.

General rules: Necessary steps have to be taken to create an optimal environment for the individual. The individual should be well-rested and alert and should be able to attend to the activity. The individual should be seated comfortably with a provision where the stimulus card can be placed (e.g., table, desk). The stimulus cards should be placed in the center of the visual field of the individual. The room should be well lit and with minimal distractions in the room as well as the on the working surface provided for the individual.

A. Trial stimulus

Instruction: *"I will be giving you a card containing different symbols. Among those symbols, one will be mentioned as the target symbol. You have to identify all such symbols by either striking across/circling them using a pen/pencil or using your index finger."*

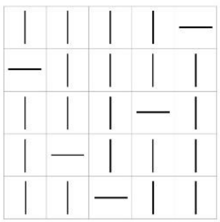
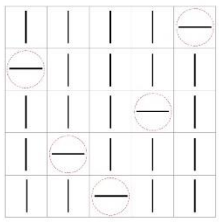
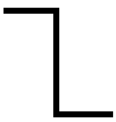
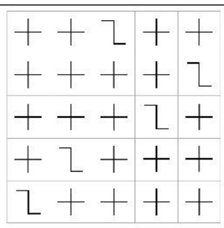
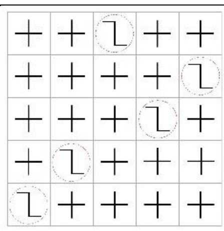
Score: Trail stimulus is not scored.

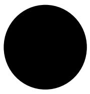
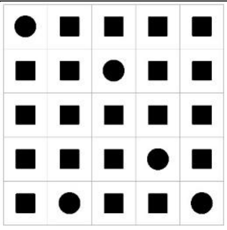
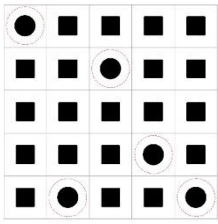
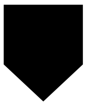
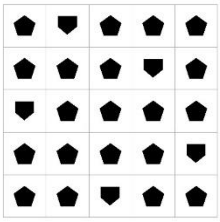
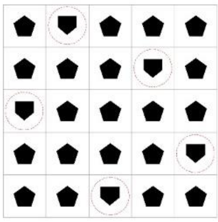
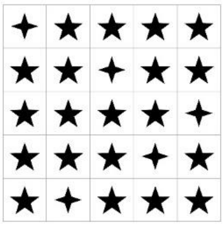
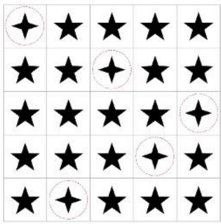
TARGET SYMBOL	STIMULI	EXPECTED RESPONSE	SCORE
			-

B. Training stimuli

Instruction: *"I will be giving you a card containing different* symbols. *Among those symbols, one will be mentioned as the target symbol. You have to identify all such symbols by either striking across/circling them using a pen/pencil or using your index finger."*

Scoring: Score 1 for every correct identification of the symbols.

Sl. No	TARGET SYMBOL	STIMULI	EXPECTED RESPONSE	SCORE
1.				---/5
2.				---/5

3.				---/5
4.				---/5
5.				---/5

2. SYMBOL TRAIL TASK

Trail making test is the second most commonly used task in neuropsychological evaluation. This task is administered as a simple "connect-the-dot" type of sequencing task where the individual must draw lines to connect the consequent elements in the circle as indicated in the key sequence. This task has been described to tap on visuospatial perception, visual scanning, visuomotor tracking, divided attention, and problem-solving.

Task description: A stimulus card containing different symbols on a square field will be presented, and another set of symbols as key on the same card. The square field contains the symbols given in the key as well as competing symbols. The individual must be instructed to draw a line connecting the symbols in the same order as the key using a pencil/pen.

Scoring and administration: Stimulus cards are given one at a time in the same order as followed in the manual. The individual can be given a cue and guided to scan throughout the visual field to locate the next symbol in the key sequence if they are finding it difficult. Overwrites or erasure is not encouraged, and a specific time limit is not imposed. If any errors are made, multiple trials can be given for the same task until the individual completes the task successfully and then move ahead to the next stimulus card. A trial stimulus can be given to the individual, which can be used to explain the task and make them more familiar with it. The trial stimulus is not scored. In the training stimuli, every correctly connected pair of symbols is scored 1, and therefore, based on the number of symbols connected, the total score will vary from 3 to 7.

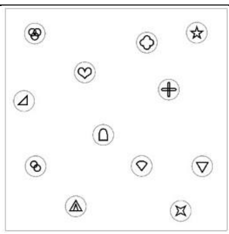
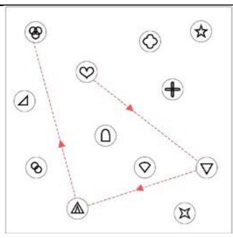
General rules: Necessary steps have to be taken to create an optimal environment for the individual. The individual should be well-rested and alert and should be able to attend to the activity. The individual should be seated comfortably with a provision where the stimulus card can be placed (e.g., table, desk). The stimulus cards should be placed in the center of the visual field of the individual. The room should be well lit and with minimal distractions in the room as well as the on the working surface provided for the individual.

A. Trial stimulus

Instruction: *"I will give a stimulus card containing different symbols and a key containing a sequence of symbols. You have to draw a line connecting the symbols in the same sequence as given in the key on the stimulus card."*

Task: Individual has to connect the symbols on the stimulus card in the same sequence as given in the key.

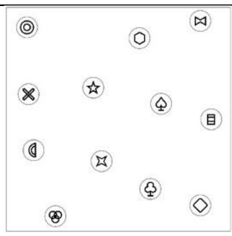
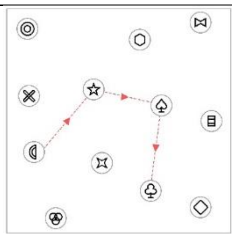
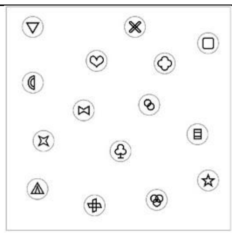
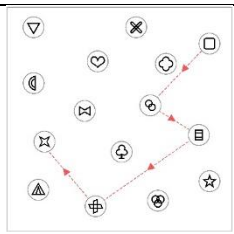
Score: Trial stimulus is not scored.

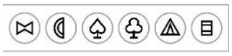
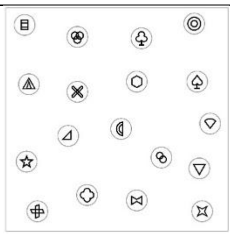
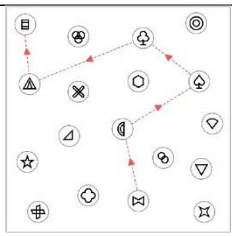
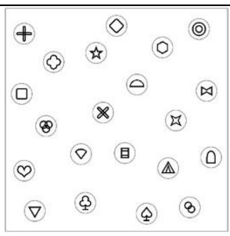
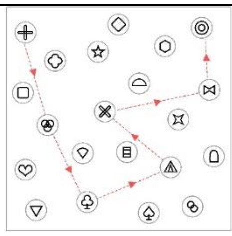
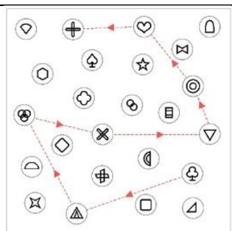
KEY	STIMULI	EXPECTED RESPONSE	SCORE
			-

B. Training stimuli

Instruction: *"I will give a stimulus card containing different symbols and a key containing a sequence of symbols. You have to draw a line connecting the symbols in the same sequence as given in the key on the stimulus card."*

Scoring: Score 1 for every correct connection between the symbols.

Sl. No	KEY	STIMULI	EXPECTED RESPONSE	SCORE
1.				---/3
2.				---/4

3.				---/5
4.				---/6
5.				---/7

3. PATTERN MATCHING TASK

Matching tasks are one of those basic tasks that are used in cognitive evaluation and training. Pattern matching task is adapted from such matching tasks. It is as simple as matching a given sequence of items with another set given parallel to it and identifying if they match or are different. In this manual, the sequence of symbols varies from three in a sequence to seven. This task is based on visual discrimination activities and taps on visual perception, visual attention, and working memory.

Task description: Each stimulus card contains a total of 10 patterns of symbols in 2 columns (5 each in one column). The pattern on the left column has the reference pattern, which may/may not match with the pattern in the corresponding row of the right column, which has the target pattern. Therefore, there are 5 pairs of patterns in each card that needs to be identified if they match with each other or not. These patterns contain symbols starting from 3 to 7 in one pattern.

Scoring and administration: Stimulus cards are given one at a time, and within each card, the individual is asked to match each pair of patterns one at a time. The individual can be given the next card once they can complete the preceding card successfully. The order of the stimulus card has to be followed as given in the manual. There is no specific time limit imposed to complete each stage of the task. A trial card can be given to the individual, which can be used to explain the task and make them more familiar with it. The trial stimulus is not scored. In the training stimuli, every correctly identified match/non-match is scored one, and therefore, each card has a total score of 5.

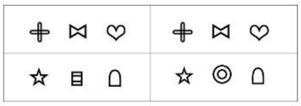
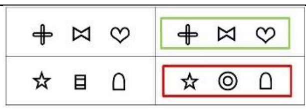
General rules: Necessary steps have to be taken to create an optimal environment for the individual. The individual should be well-rested and alert and should be able to attend to the activity. The individual should be seated comfortably with a provision where the stimulus card can be placed (e.g., table, desk). The stimulus cards should be placed in the center of the visual field of the individual. The room should be well lit and with minimal distractions in the room as well as the on the working surface provided for the individual.

A. Trial stimulus

Instruction: *"I will give you a stimulus card containing a sequence of symbols in two columns. You have to mention whether the sequence on the left side column matches or not with the other sequence of symbols on the ride side column."*

Task: Individual has to state whether the given sequence of symbols on the left column matches the ones given adjacent to it on the right column.

Score: Trail stimulus is not scored.

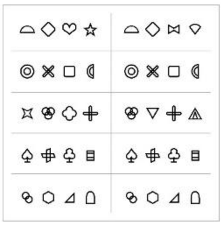
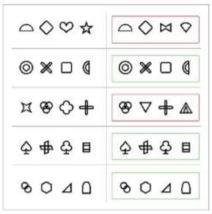
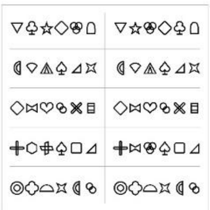
STIMULI	EXPECTED RESPONSE	SCORE
	 Pattern - match/non-match	-

B. Training stimuli

Instruction: *"I will give you a stimulus card containing a sequence of symbols in two columns. You have to mention whether the sequence on the left side column matches or not with the other sequence of symbols on the ride side column."*

Scoring: Score 1 for correct identification of match/non-match.

Sl. No	STIMULI	EXPECTED RESPONSE	SCORE
1.		*Red: Not matching; Green: Matching 	---/5

2.			---/5
3.			---/5
4.			---/5
5.			---/5

4. MENTAL ROTATION TASK

Mental rotation is imaging what an object will look like when it is rotated. Mental rotation is one of the most studied domains in spatial cognition. Vandenberg's and Kuse's Mental Rotation Test is the commonly used tool to measure spatial abilities. Mental rotation tasks usually consist of two-dimensional drawings of three-dimensional geometrical figures. One of them being a reference and four other drawings. These additional drawings include the rotated image of the reference, and the participant has to indicate a reference rotated image. The task devised in the manual is based on Vanderburg and Kuse’s Mental Rotation Test. This task targets the spatial orientation skills of the individual.

Task description: Each stimulus card will contain a total of five two-dimensional drawings of 3-dimensional geometric figures. One will be labeled as the target. Using the “target” image as the reference, the individual has to indicate which among the other four images matches the “target” figure when rotated.

Scoring and administration: Stimulus cards are given one at a time. The individual must be asked to identify the image that matches with the “target” image when rotated in each card. Each group of stimuli has 5 such images in 5 different cards. A total of 5 stimuli groups are included in the manual. There is no specific time limit imposed to complete each card. The order of the stimuli group must be maintained as used in the manual. The individual can proceed to the nest group of stimuli once they complete the preceding group. A trial card can be given to the individual, which can be used to explain the task and make them more familiar with it. The trial stimulus is not scored. In the training stimuli, every correctly identified image is scored one, and therefore, each group of stimuli has a total score of 5.

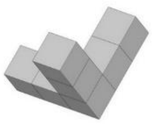
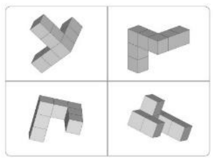
General rules: Necessary steps have to be taken to create an optimal environment for the individual. The individual should be well-rested and alert and should be able to attend to the activity. The individual should be seated comfortably with a provision where the stimulus card can be placed (e.g., table, desk). The stimulus cards should be placed in the center of the visual field of the individual. The room should be well lit and with minimal distractions in the room as well as the on the working surface provided for the individual.

A. Trial stimulus

Instruction: *"This particular stimulus card has one target image and four other different images. One of these four images matches with the target image when rotated. Which one is that?"*

Task: Individual has to identify the rotated image which matches the target image.

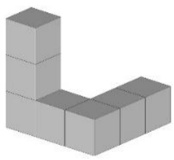
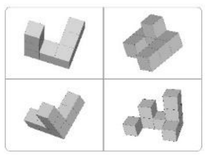
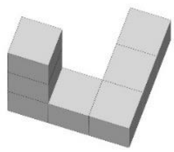
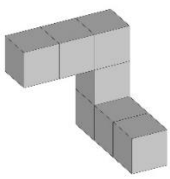
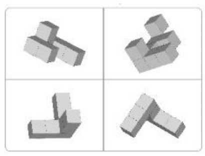
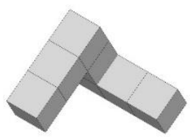
Score: Trail stimulus is not scored.

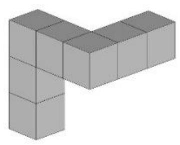
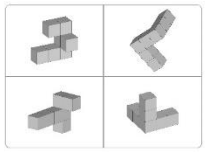
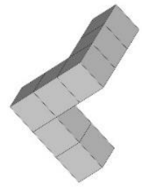
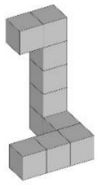
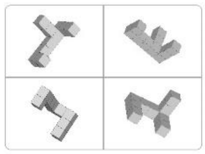
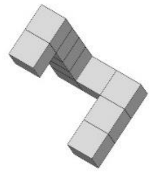
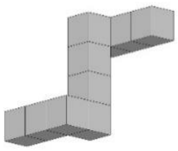
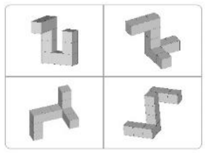
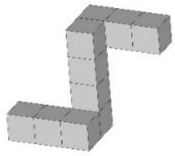
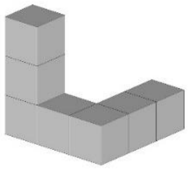
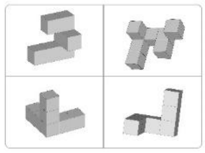
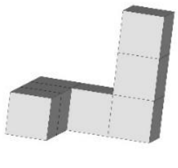
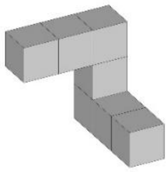
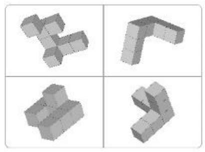
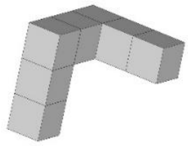
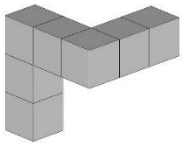
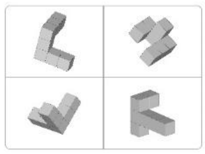
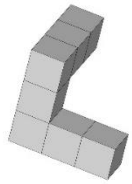
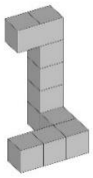
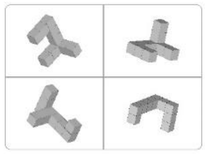
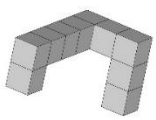
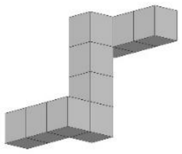
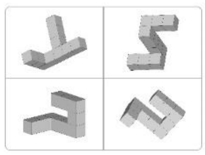
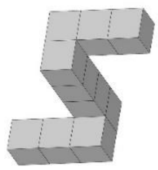
TARGET FIGURE	STIMULI	EXPECTED RESPONSE	SCORE
			-

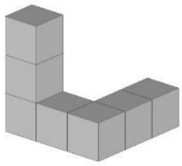
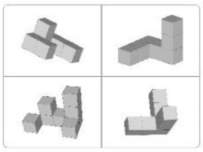
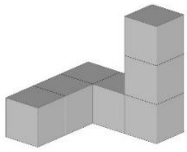
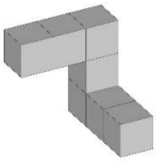
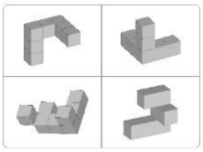
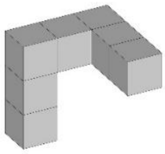
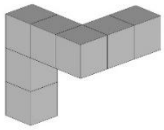
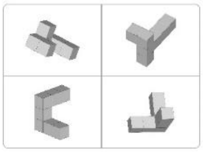
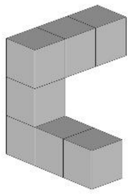
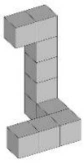
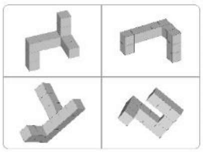
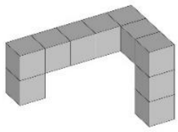
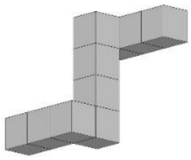
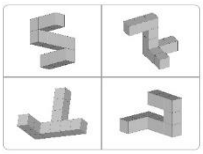
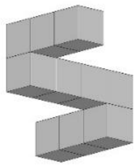
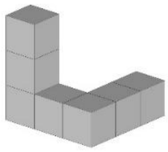
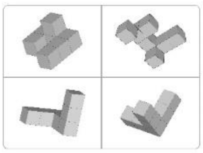
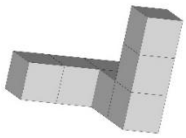
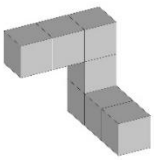
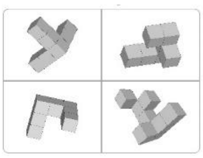
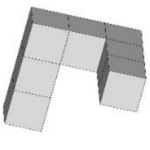
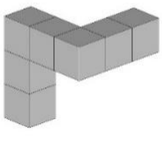
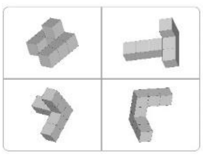
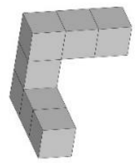
B. Training stimuli

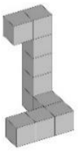
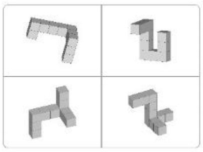
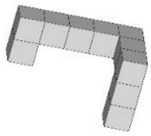
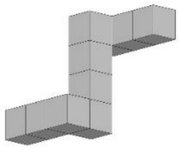
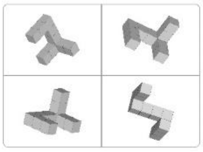
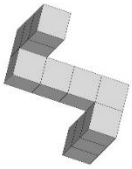
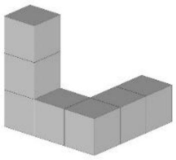
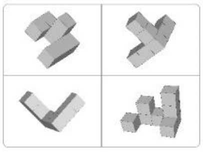
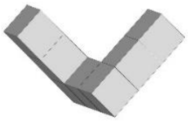
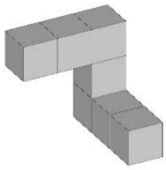
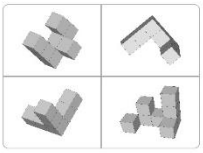
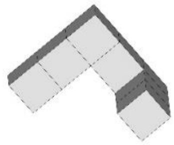
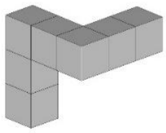
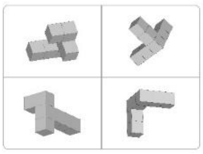
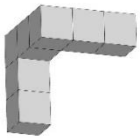
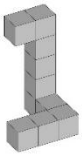
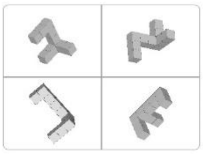
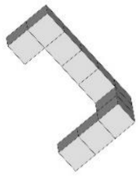
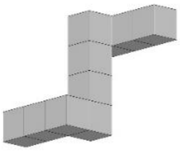
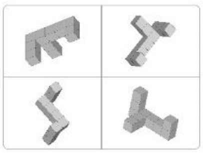
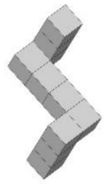
Instruction: *"This particular stimulus card has one target image and four other different images. One of these four images matches with the target image when rotated. Which one is that?"*

Scoring: Score 1 for correct identification of the rotated figure.

Sl. No	TARGET FIGURE	STIMULI	EXPECTED RESPONSE	SCORE
1.				---/5
				

				
				
				
				
				
2.				---/5
				
				

				
				
3.				---/5
				
				
				
4.				---/5
				

				
				
5.				---/5
				
				
				
				

5. INTERPRETATION OF BODY SCHEMA

Interpretation of body schema is a task that is commonly used when an individual experiences disruption in body schema where they have difficulty identifying between left and right on themselves as well as on images. This particular task taps on visuospatial perception and working memory.

Task description: A stimulus card containing pictures of a human hand will be presented to the individual. They will be asked to determine if the visually presented image corresponds to the right hand or the left hand. Stimuli will be presented in colour prints, and each stimulus card will contain a picture of one hand at a time. The pictures can be of two types – one, palm facing up/down with fingers adjacent to each other without holding any object, and second, hand holding an object.

Scoring and administration: Stimulus card is given one at a time in the order followed in the manual. There is no specific time limit provided to the individual to complete the task. A trial stimulus can be given to the individual, which can be used to explain the task and make them more familiar with it. The trial stimulus is not scored. In the training stimuli, each correctly identified image is scored 1; therefore, each group of cards constitutes a total score of 5.

General rules: Necessary steps have to be taken to create an optimal environment for the individual. The individual should be well-rested and alert and should be able to attend to the activity. The individual should be seated comfortably with a provision where the stimulus card can be placed (e.g., table, desk). The stimulus cards should be placed in the center of the visual field of the individual. The room should be well lit and with minimal distractions in the room as well as the on the working surface provided for the individual.

A. Trial stimulus

Instruction: *"I will be giving you pictures of a hand, and you will have to tell me whether it is the left hand or the right hand."*

Task: Individual has to identify from the picture if the hand is a left or right hand.

Score: Trail stimulus is not scored.

STIMULI	EXPECTED RESPONSE	SCORE
	Right	-

B. Training stimuli

Instruction: *"I will be giving you pictures of a hand, and you will have to tell me whether it is the left hand or the right hand."*

Scoring: Score 1 for correct identification of the orientation of the hand.

<table>
<tr><th>Sl. No</th><th>STIMULI</th><th>EXPECTED RESPONSE</th><th>SCORE</th></tr>
<tr><td rowspan="2">1.</td><td></td><td>Right</td><td rowspan="2">---/5</td></tr>
<tr><td></td><td>Left</td></tr>
</table>

		Left	
		Right	
		Right	
2.		Right	---/5
		Left	
		Right	
		Right	

		Left	

Appendix - C

MANUAL FOR VISUOSPATIAL ORGANIZATION ACTIVITIES FOR PERSONS WITH BRAIN DAMAGE

STIMULUS MANUAL

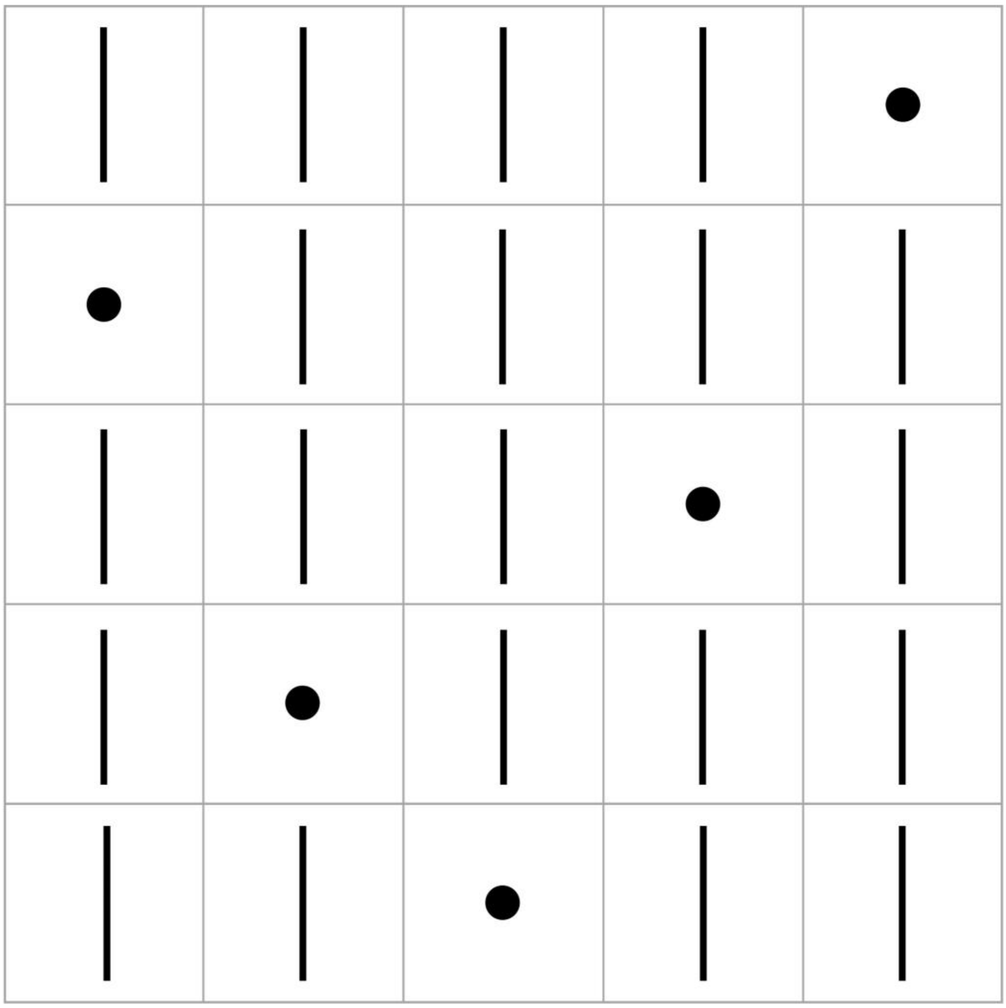
1. Symbol Cancellation Task

Instructions: *"I will be giving you a card containing different symbols. Among those symbols, one will be mentioned as the target symbol. You have to identify all such symbols by either striking across/circling them using a pen/pencil or using your index finger."*

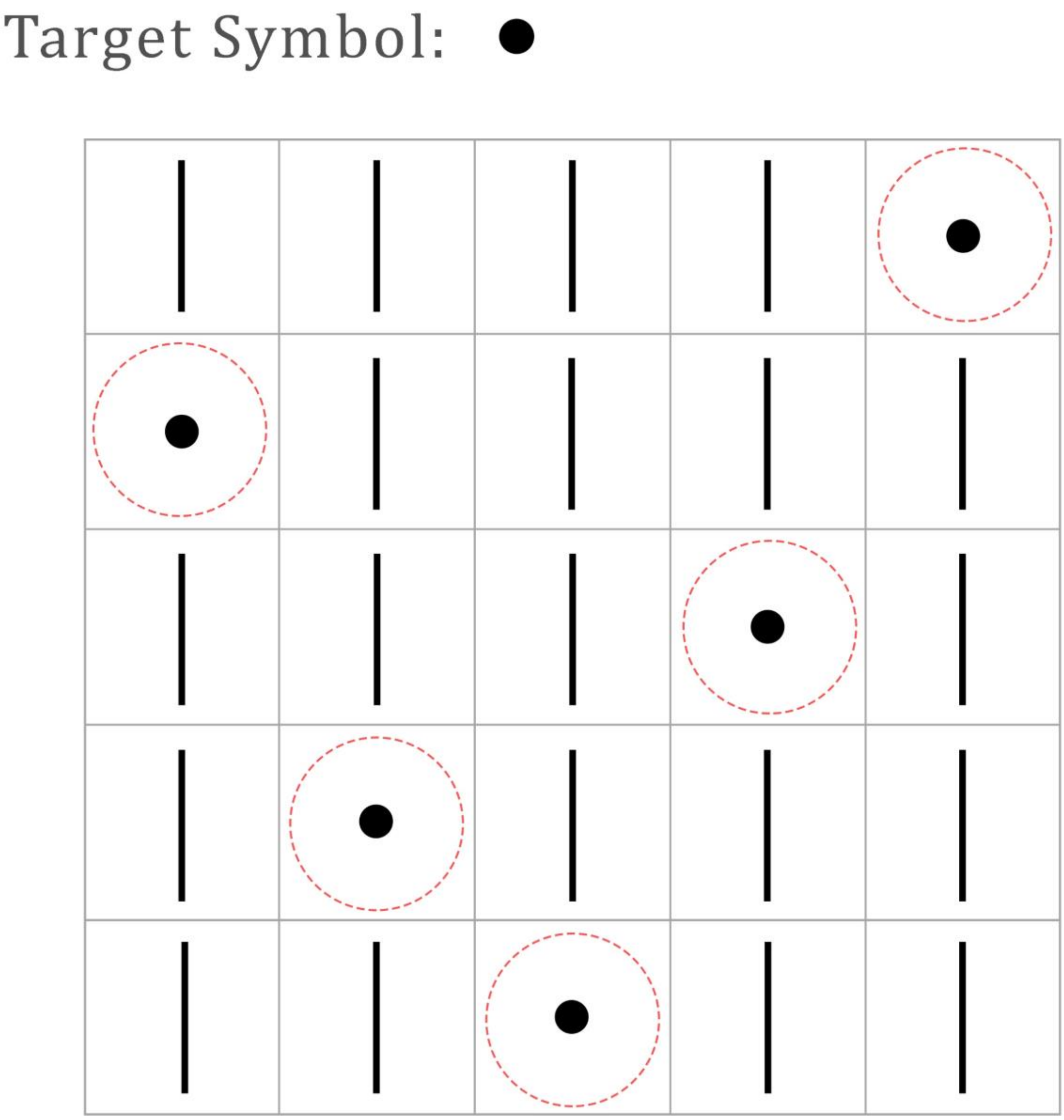
ಸೂಚನೆ: ನಾನು ವಿವಿಧ ಚಿಹ್ನೆಗಳು ಇರುವ ಕಾರ್ಡನ್ನು ತೋರಿಸುತ್ತೇನೆ. ಆ ಕಾರ್ಡ್‌ನಲ್ಲಿ ಮೇಲಿರುವ ಚಿಹ್ನೆಯಂತೆಯೇ ಕೆಳಗಿರುವ ಎಲ್ಲಾ ಚಿಹ್ನೆಗಳನ್ನು ಗುರುತಿಸಿ.

TRIAL

Target Symbol: ●

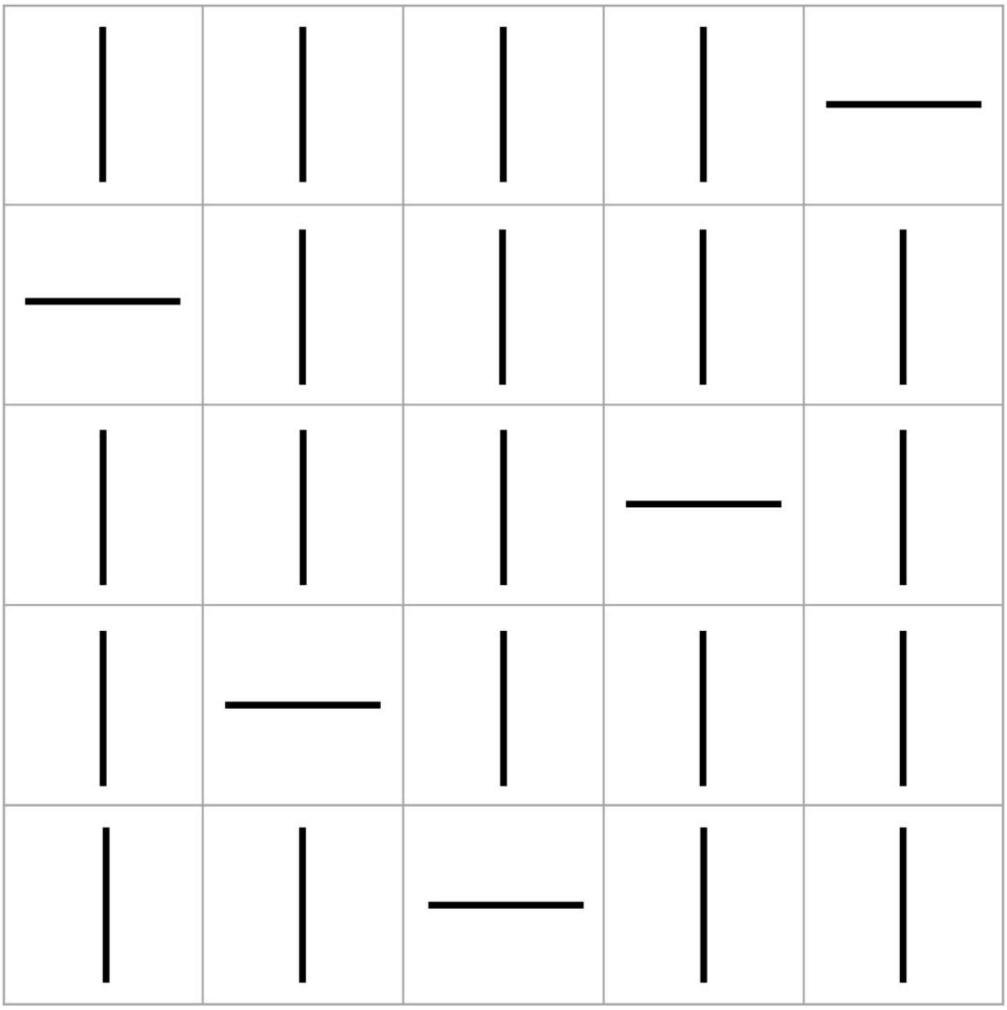


TRIAL - RESPONSE



Stimulus 1

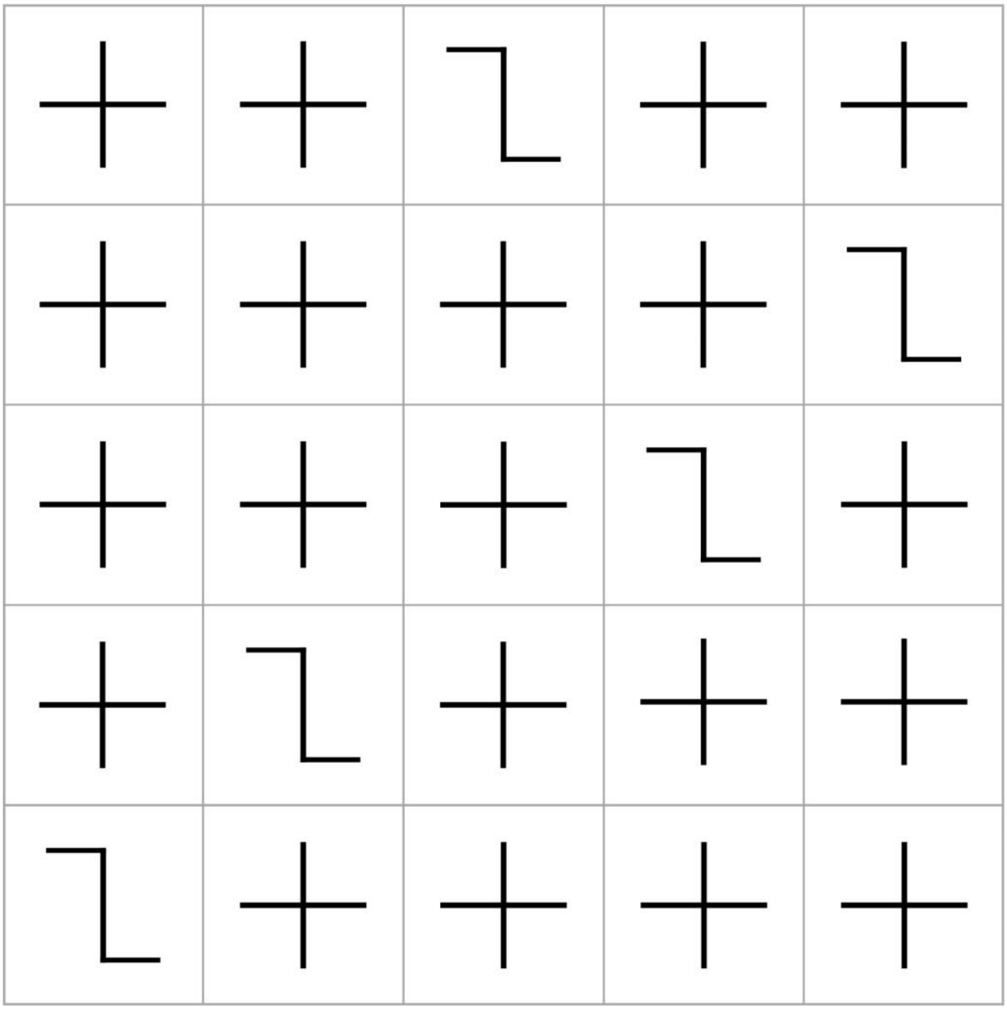
Target Symbol:



Stimulus 2

Stimulus Card -2

Target Symbol: 



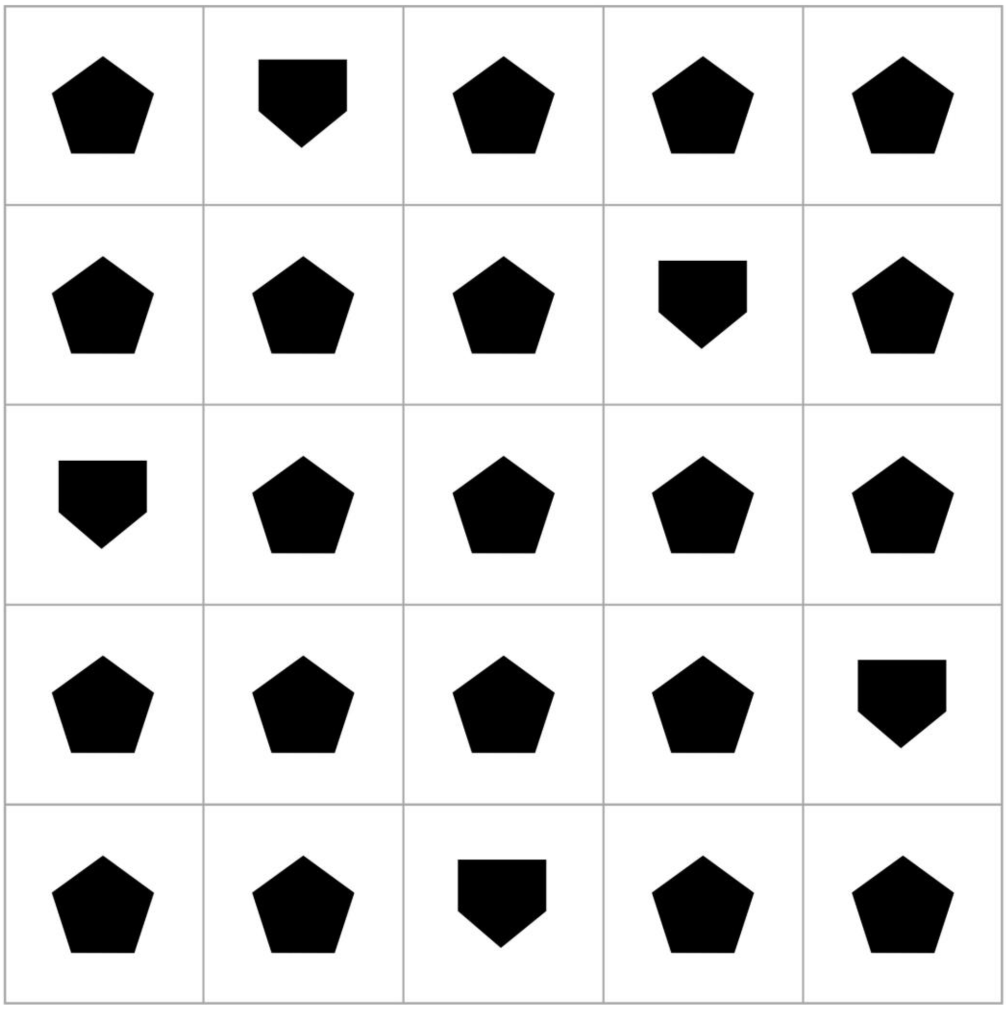
Stimulus 3

Target Symbol: ●

●	■	■	■	■
■	■	●	■	■
■	■	■	■	■
■	■	■	●	■
■	●	■	■	●

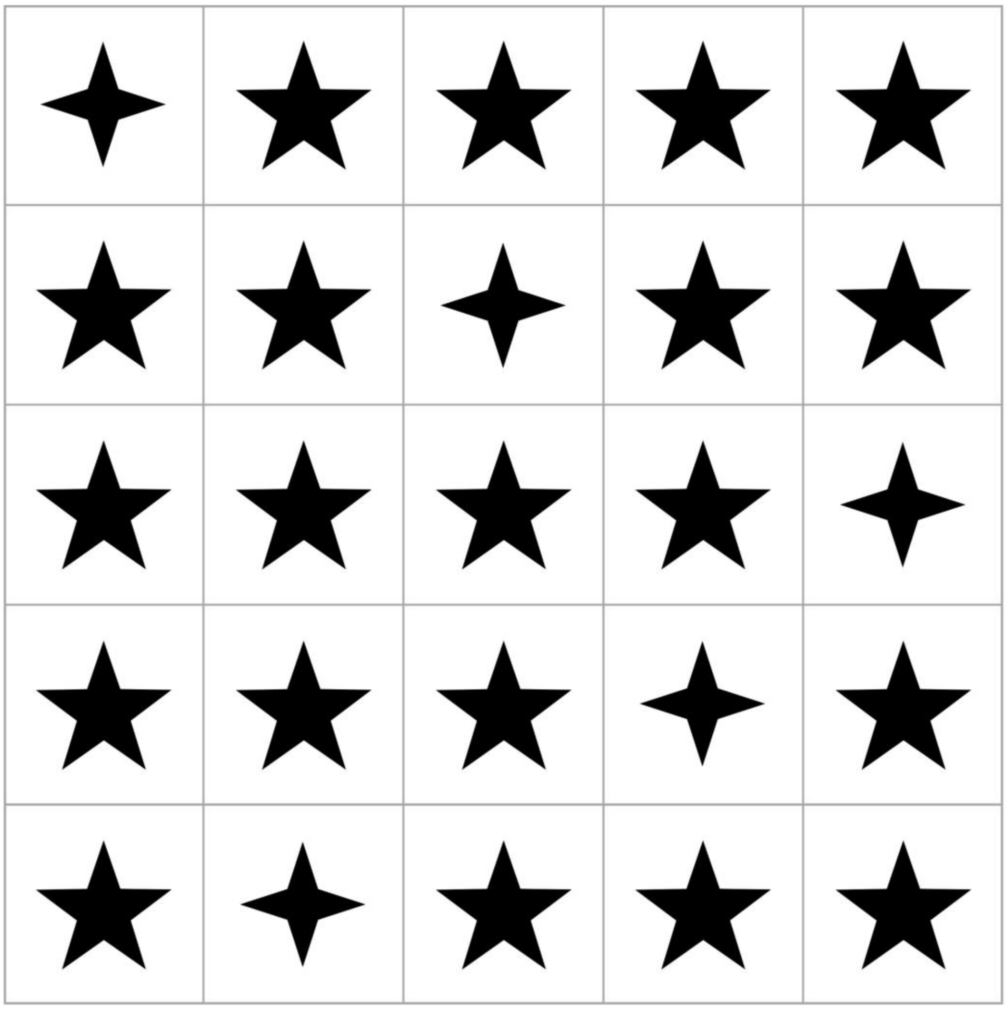
Stimulus 4

Target Symbol: 



Stimulus 5

Target Symbol: 



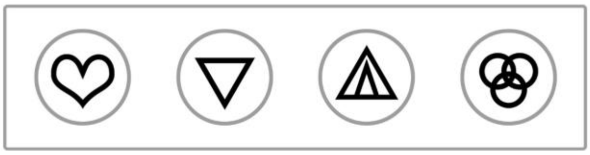
2. Symbol Trial Task

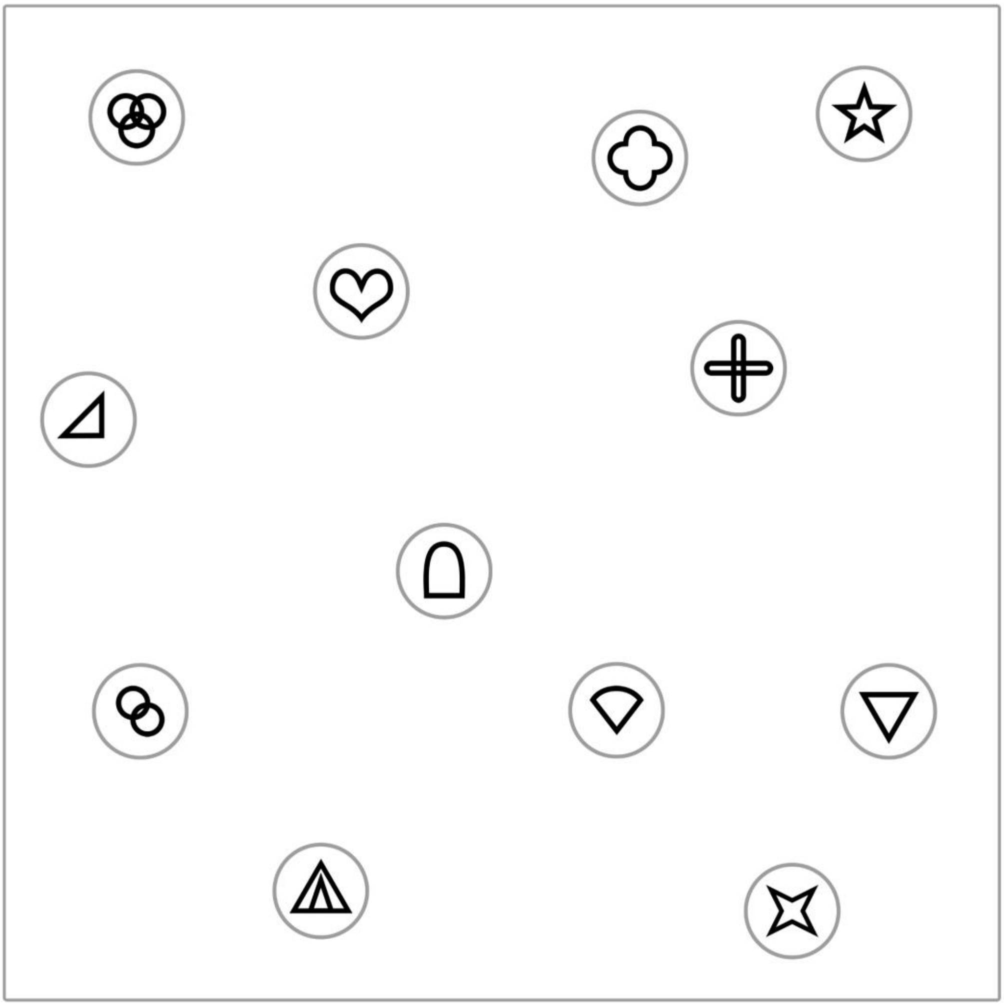
Instruction: *"I will give a stimulus card containing different symbols and a key containing a sequence of symbols. You have to draw a line connecting the symbols in the same sequence as given in the key on the stimulus card."*

ಸೂಚನೆ: ನಾನು ವಿವಿಧ ಚಿಹ್ನೆಗಳು ಇರುವ ಕಾರ್ಡನ್ನು ತೋರಿಸುತ್ತೇನೆ. ಆ ಕಾರ್ಡ್‌ನಲ್ಲಿ ಮೇಲಿರುವ ಚಿಹ್ನೆಗಳನ್ನು ಗುರುತಿಸಿ, ಅದೇ ಅನುಕ್ರಮದಂತೆ ಗೆರೆ ಎಳೆಯುವ ಮೂಲಕ ಜೋಡಿಸಿ.

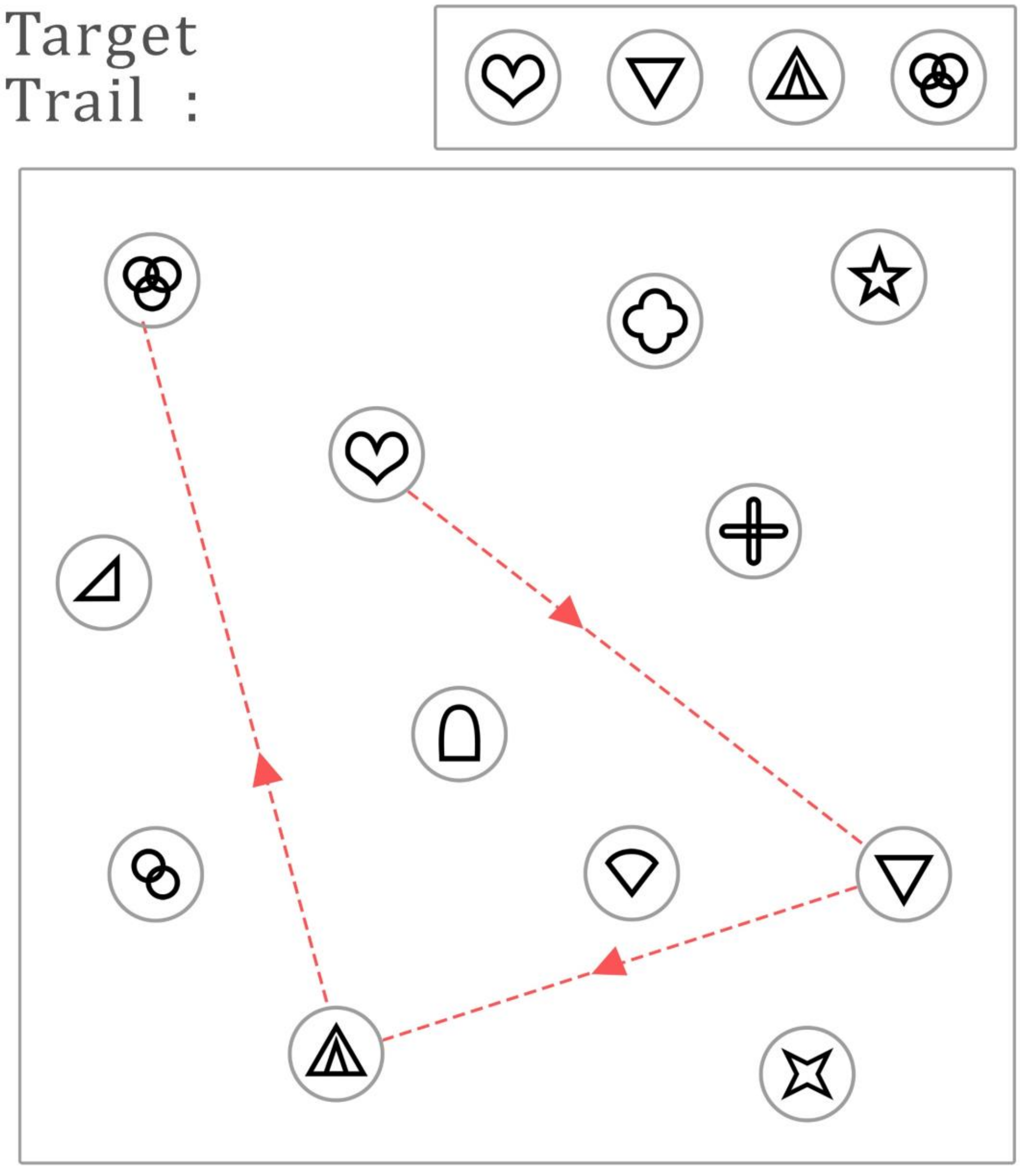
TRIAL

Target Trail :



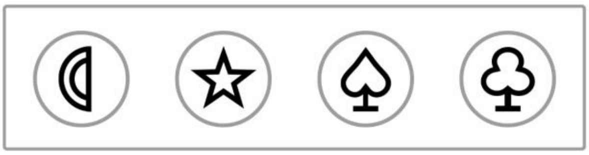


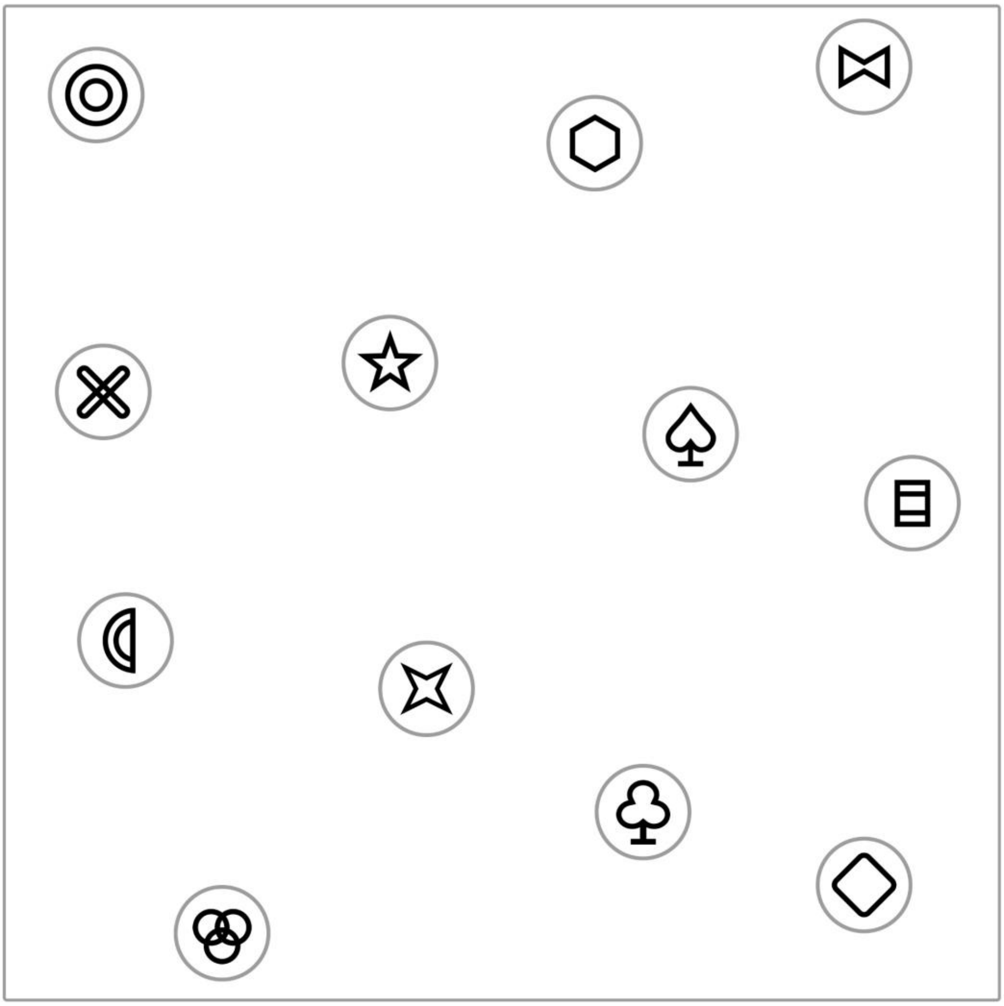
TRIAL - RESPONSE



Stimulus 1

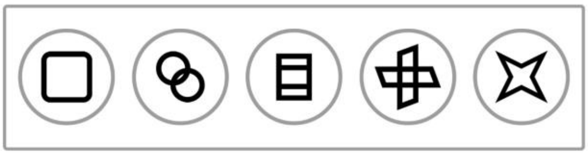
Target Trail :

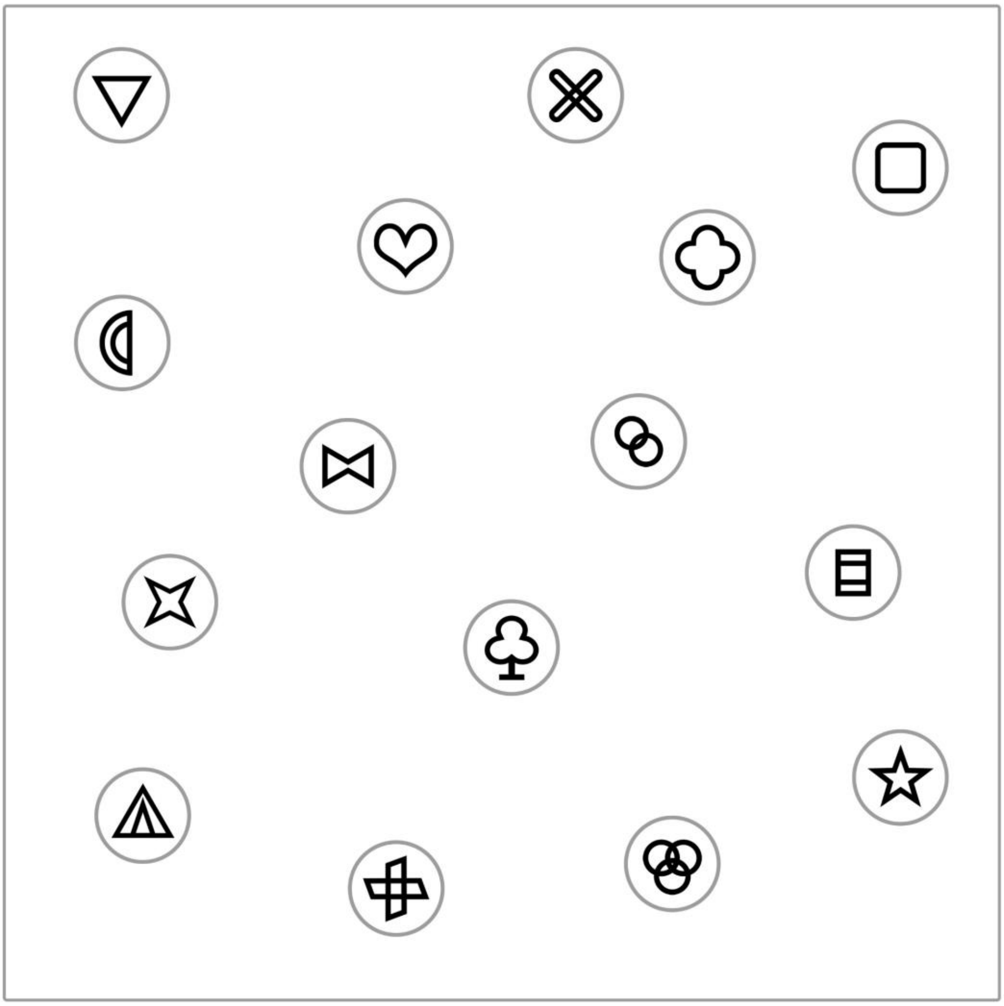




Stimulus 2

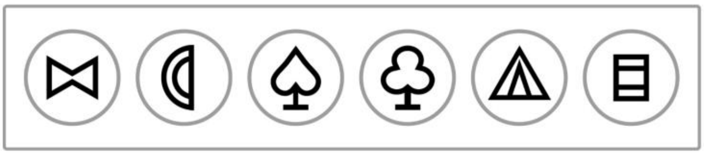
Target Trail :

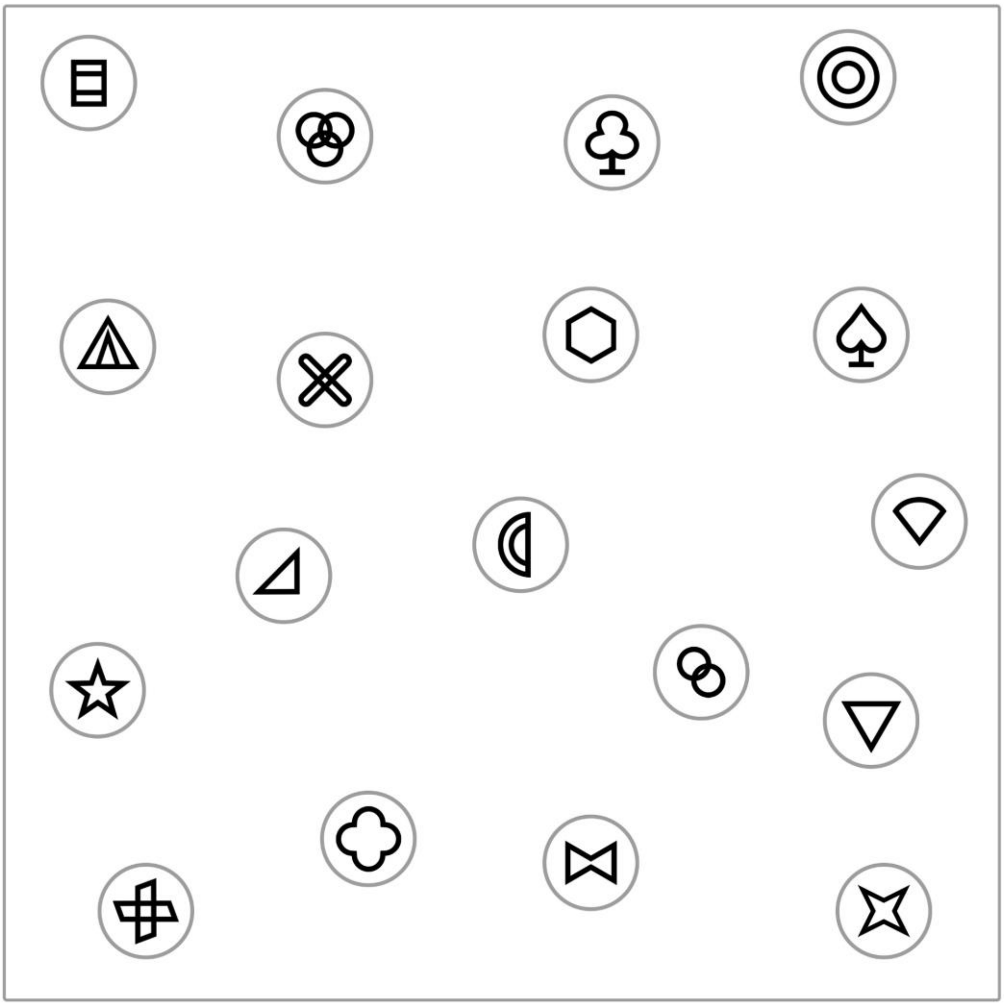




Stimulus 3

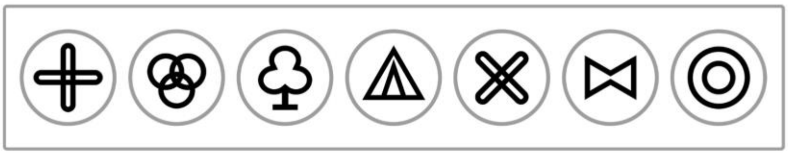
Target Trail :

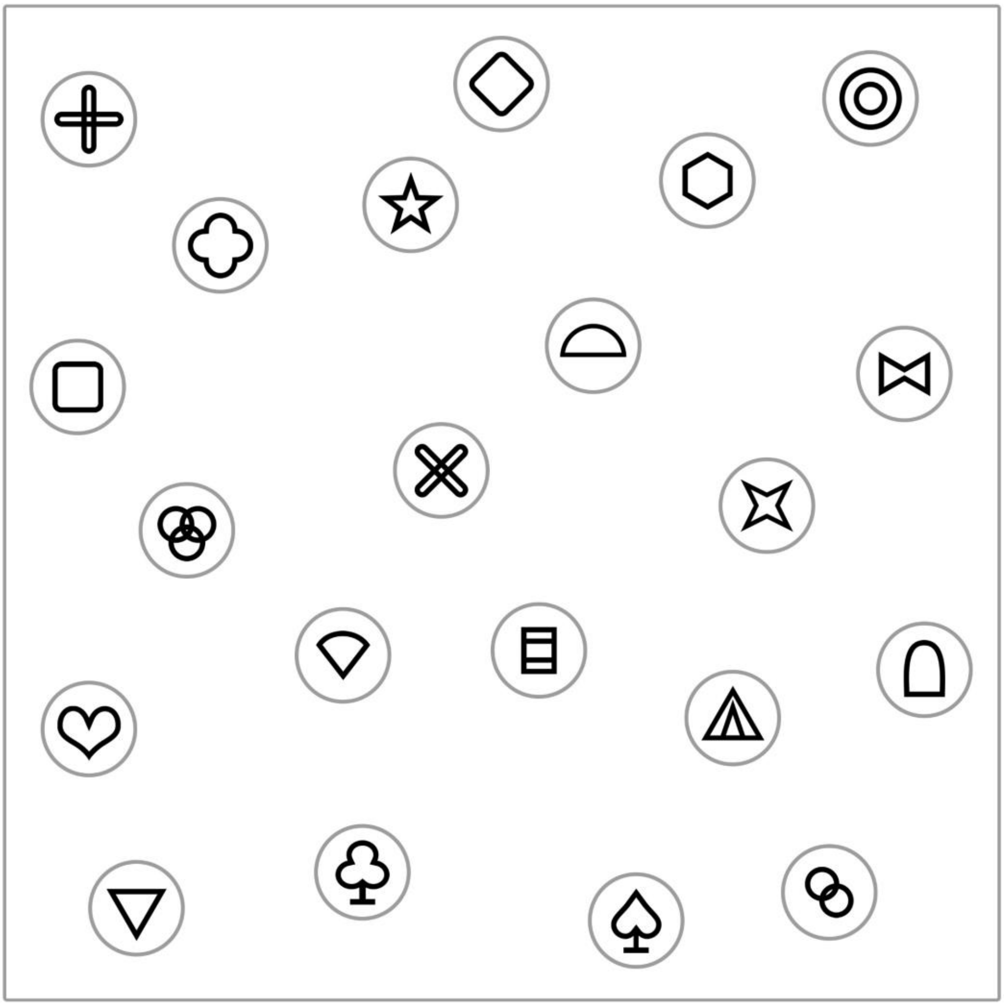




Stimulus 4

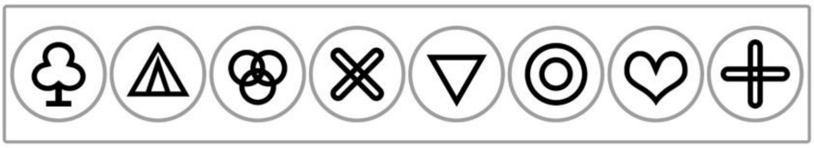
Target Trail :

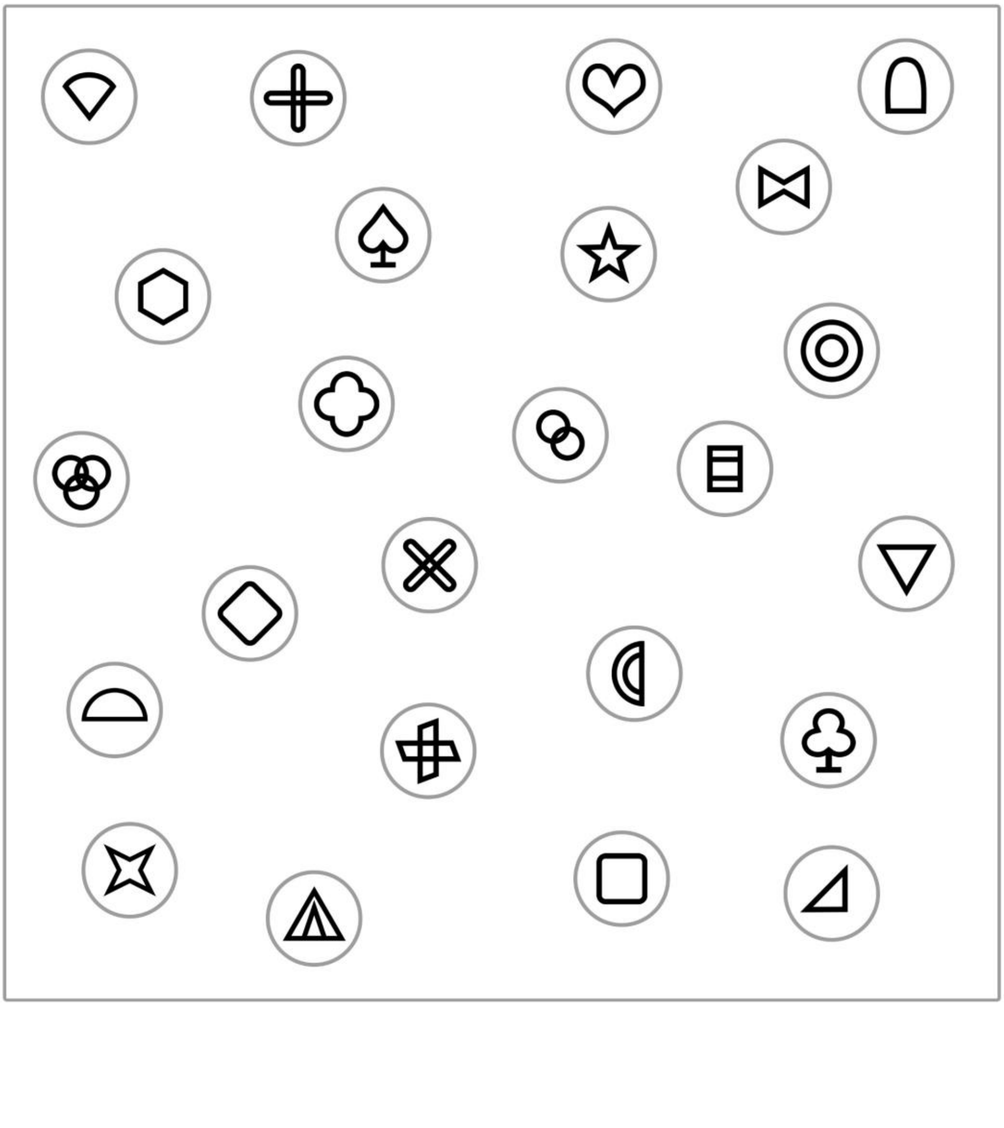




Stimulus 5

Target Trail :





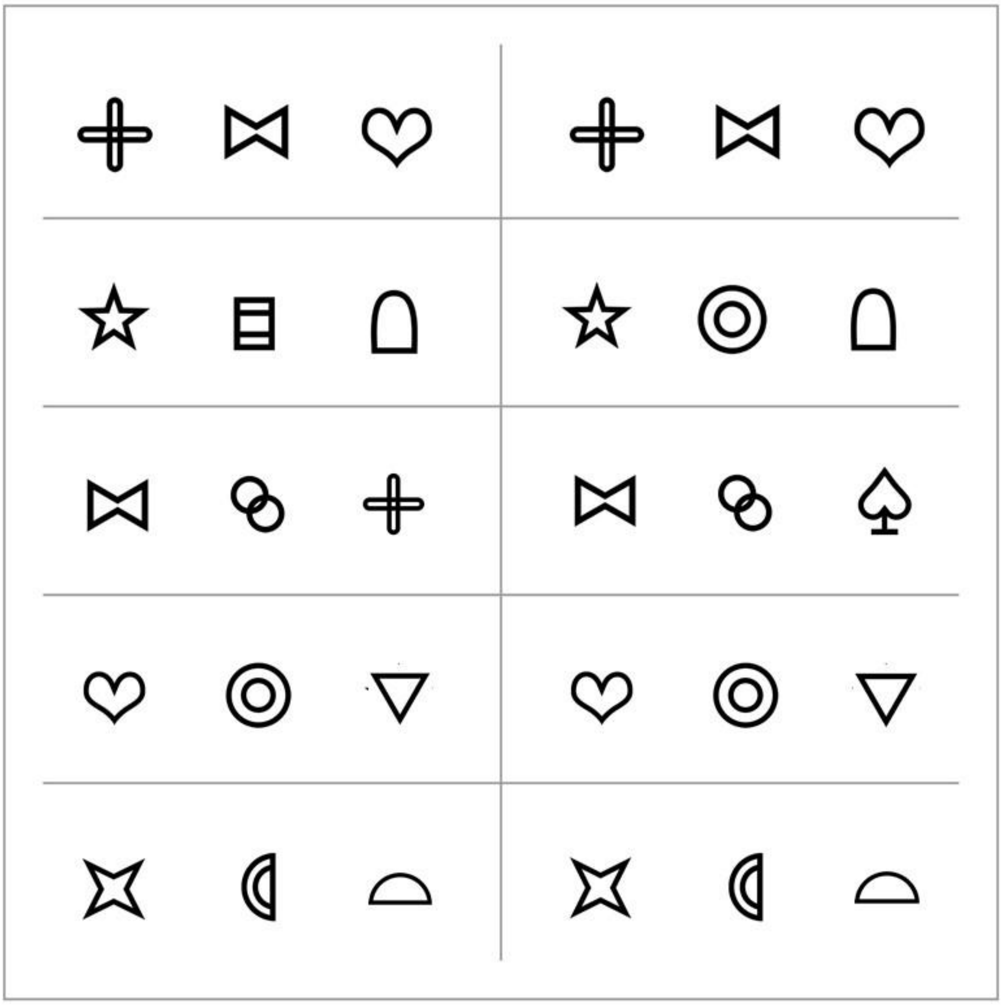
3. Pattern Matching Task

Instruction: *"I will give you a stimulus card containing a sequence of symbols in two columns. You have to mention whether the sequence on the left side column matches or not with the other sequence of symbols on the ride side column."*

ಸೂಚನೆ: ಈ ಕಾರ್ಡ್ ಅಲ್ಲಿ ಒಂದು ಮೂಲ ಚಿತ್ರ ಮತ್ತು ನಾಲ್ಕು ವಿವಿಧ ಚಿತ್ರಗಳು ಇವೆ. ಈ ನಾಲ್ಕು ಚಿತ್ರಗಳಲ್ಲಿ ಒಂದನ್ನು ತಿರುಗಿಸಿದಾಗ ಮಾತ್ರ ಮೂಲ ಚಿತ್ರಕ್ಕೆ ಹೊಂದಿಕೆಯಾಗುತ್ತದೆ. ಅದು ಯಾವುದು?

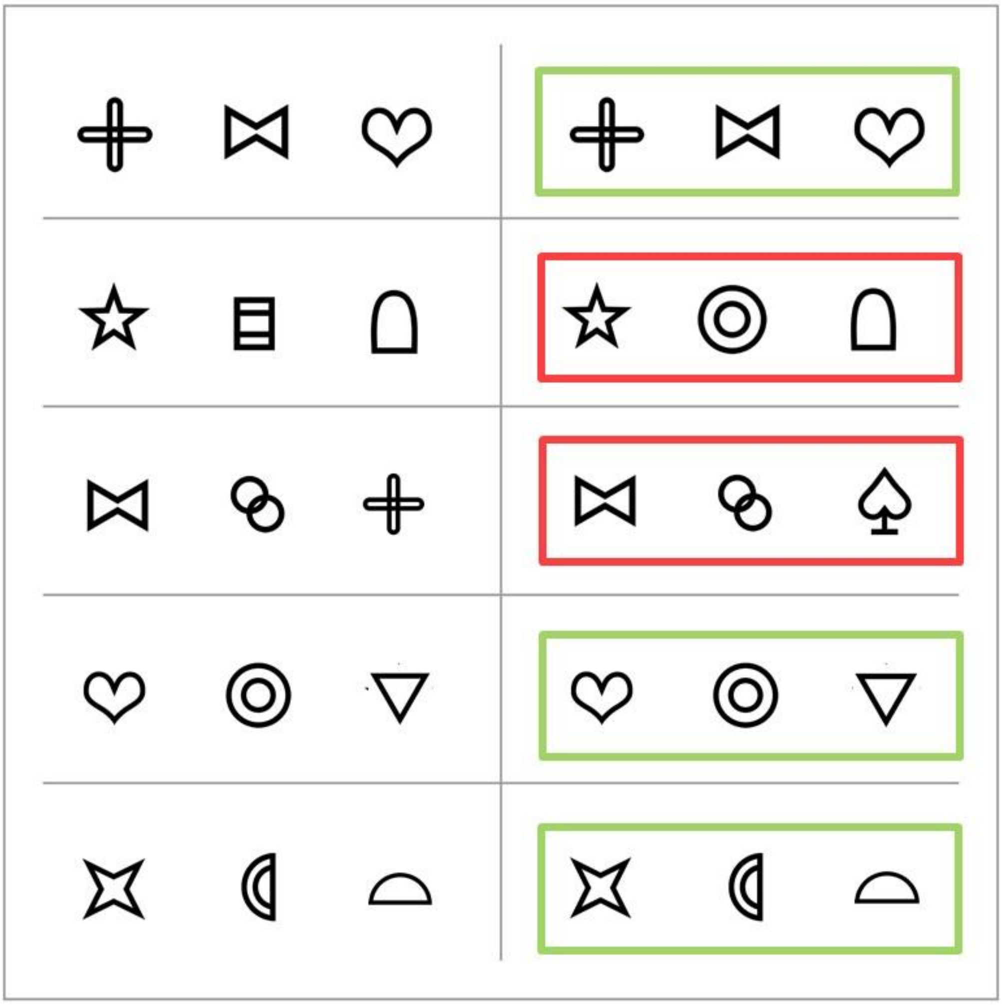
TRIAL

Pattern Matching:



TRIAL - RESPONSE

Pattern Matching:

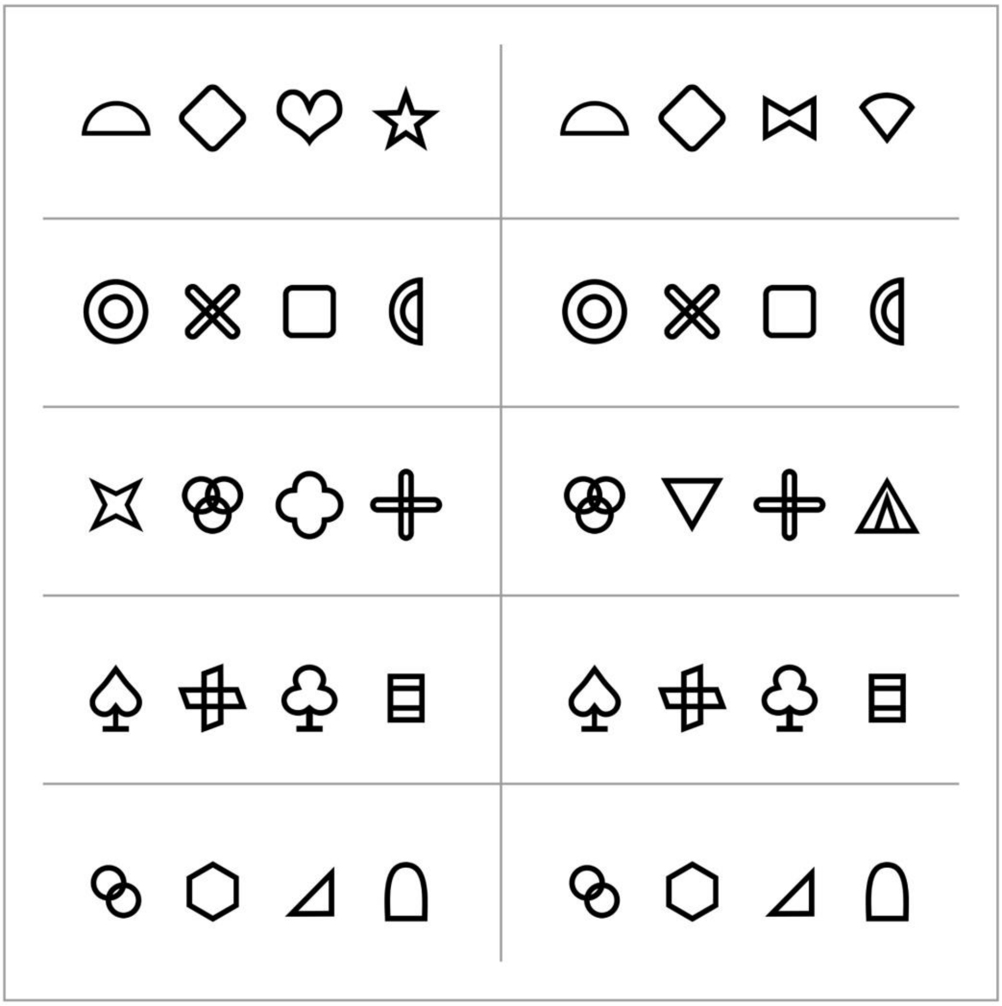


Stimulus 1

Pattern Matching:

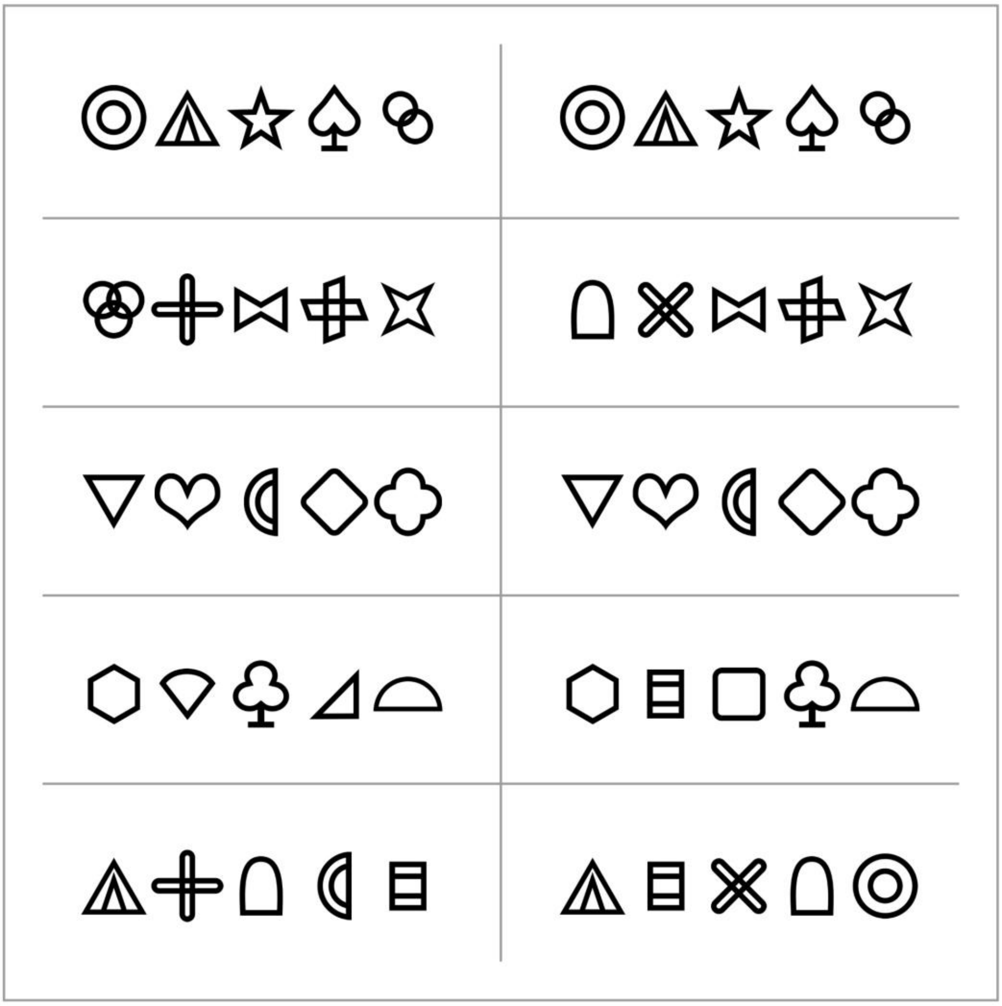
Stimulus 2

Pattern Matching:



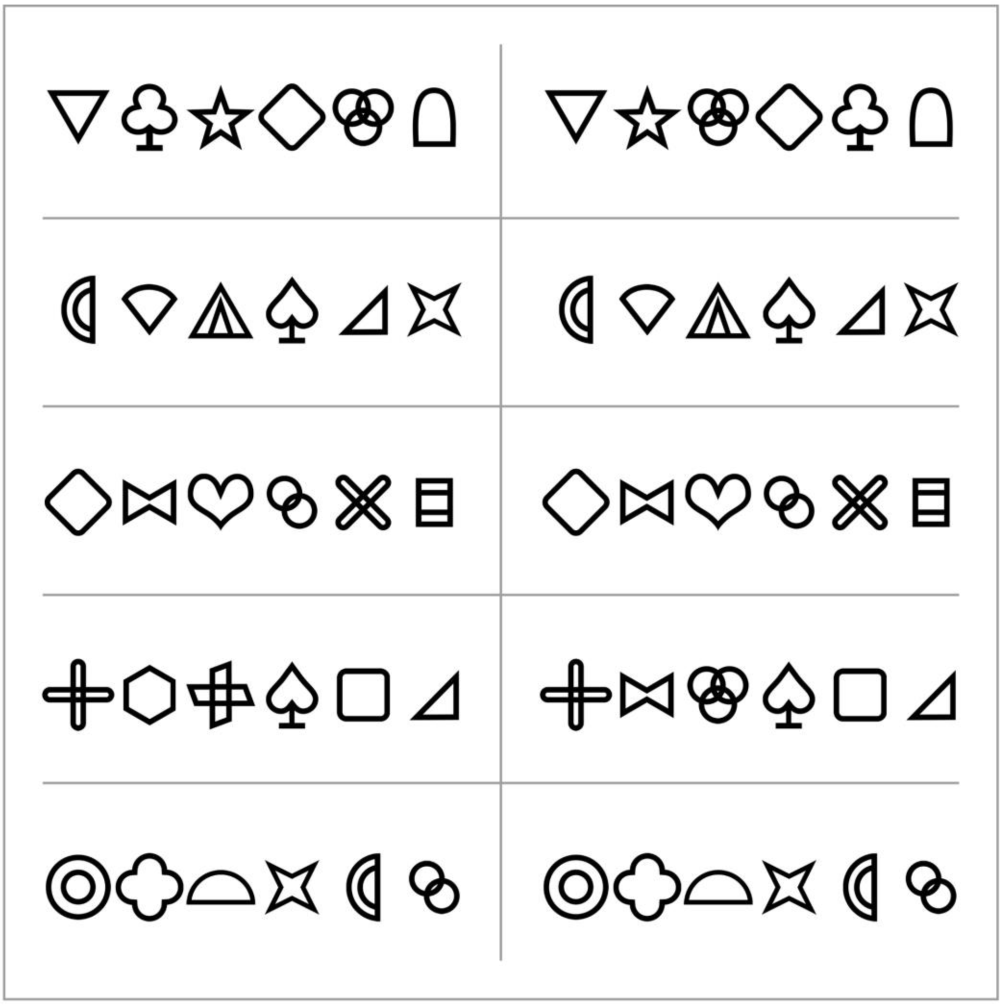
Stimulus 3

Pattern Matching:



Stimulus 4

Pattern Matching:



Stimulus 5

Pattern Matching:

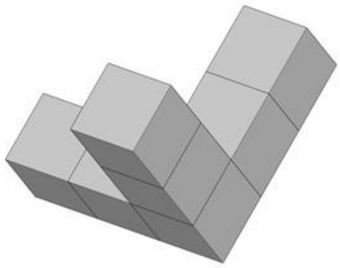
4. Mental Rotation Task

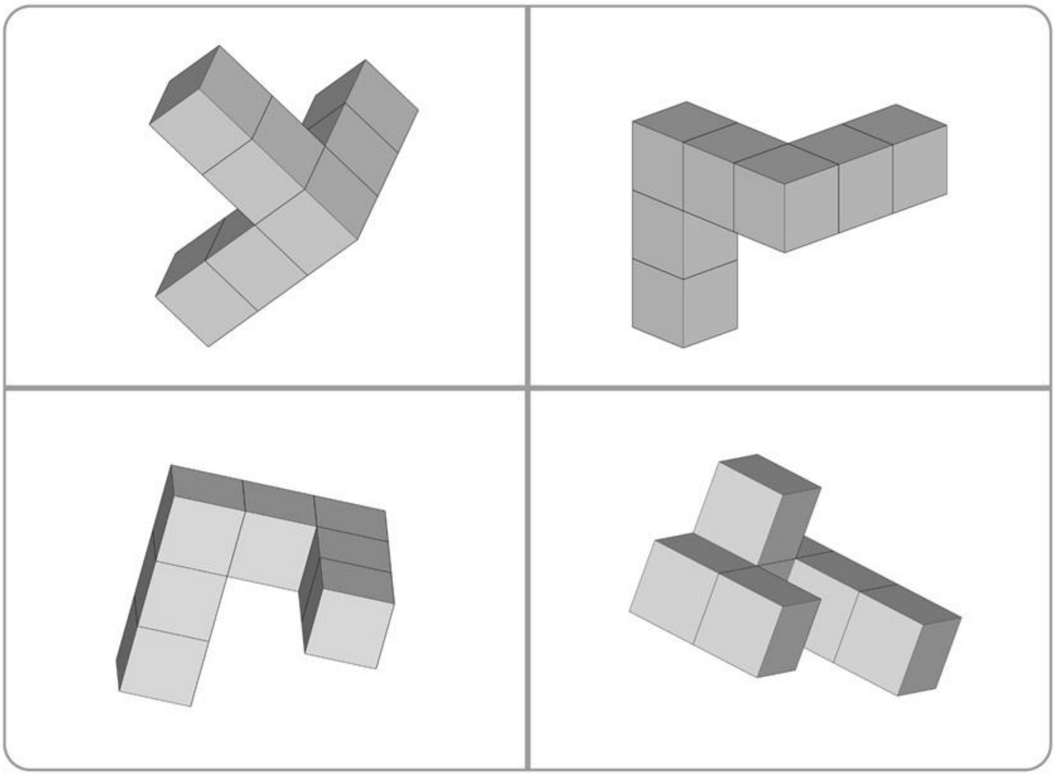
Instruction: *"This particular stimulus card has one target image and four other different images. One of these four images matches with the target image when rotated. Which one is that?"*

ಸೂಚನೆ: ಈ ಕಾರ್ಡ್ ಅಲ್ಲಿ ಒಂದು ಮೂಲ ಚಿತ್ರ ಮತ್ತು ನಾಲ್ಕು ವಿವಿಧ ಚಿತ್ರಗಳು ಇವೆ. ಈ ನಾಲ್ಕು ಚಿತ್ರಗಳಲ್ಲಿ ಒಂದನ್ನು ತಿರುಗಿಸಿದಾಗ ಮಾತ್ರ ಮೂಲ ಚಿತ್ರಕ್ಕೆ ಹೊಂದಿಕೆಯಾಗುತ್ತದೆ. ಅದು ಯಾವುದು?

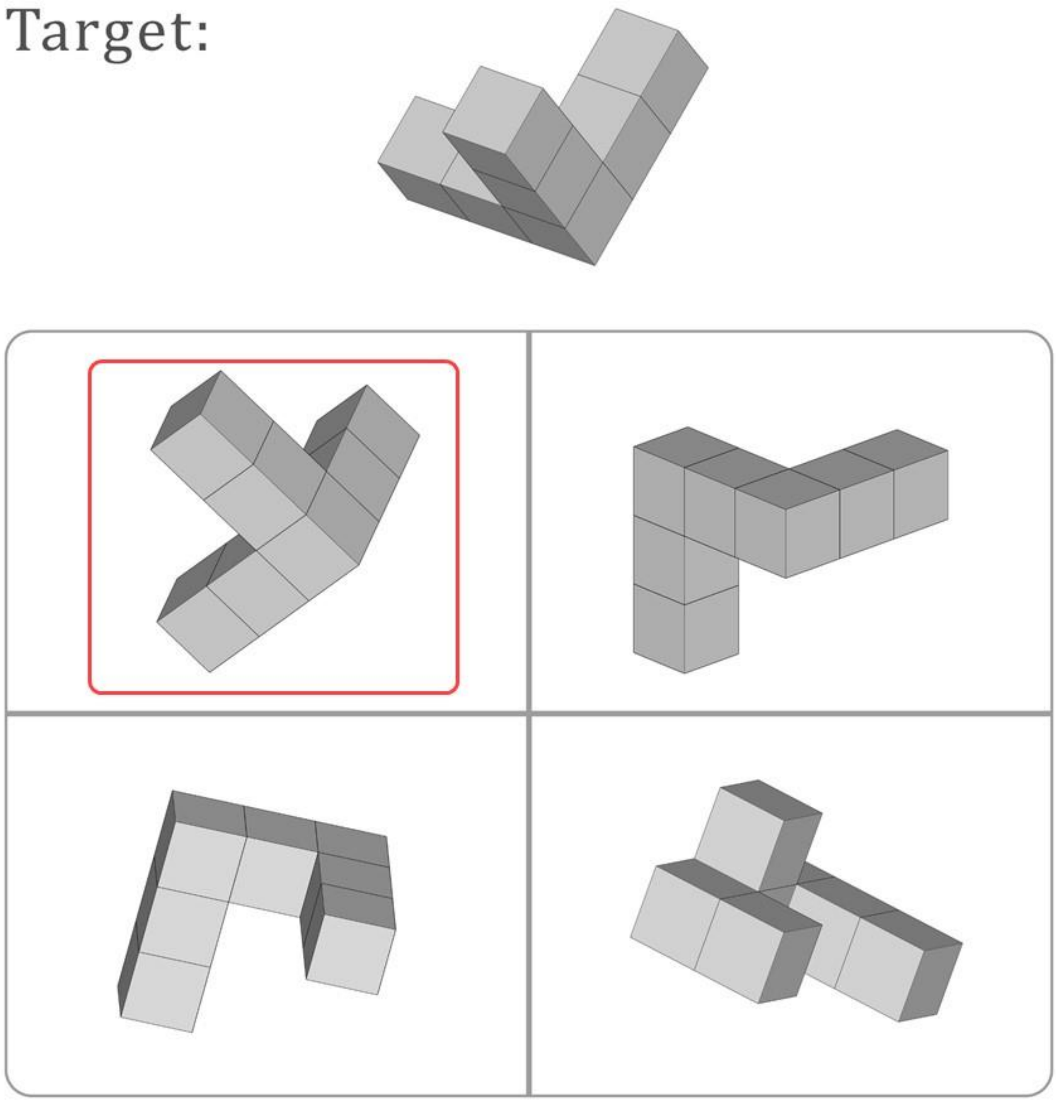
TRIAL

Target:



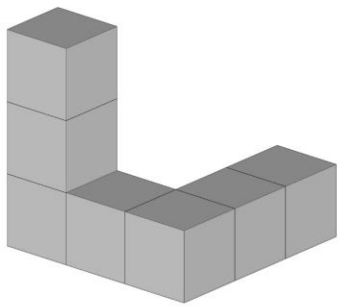


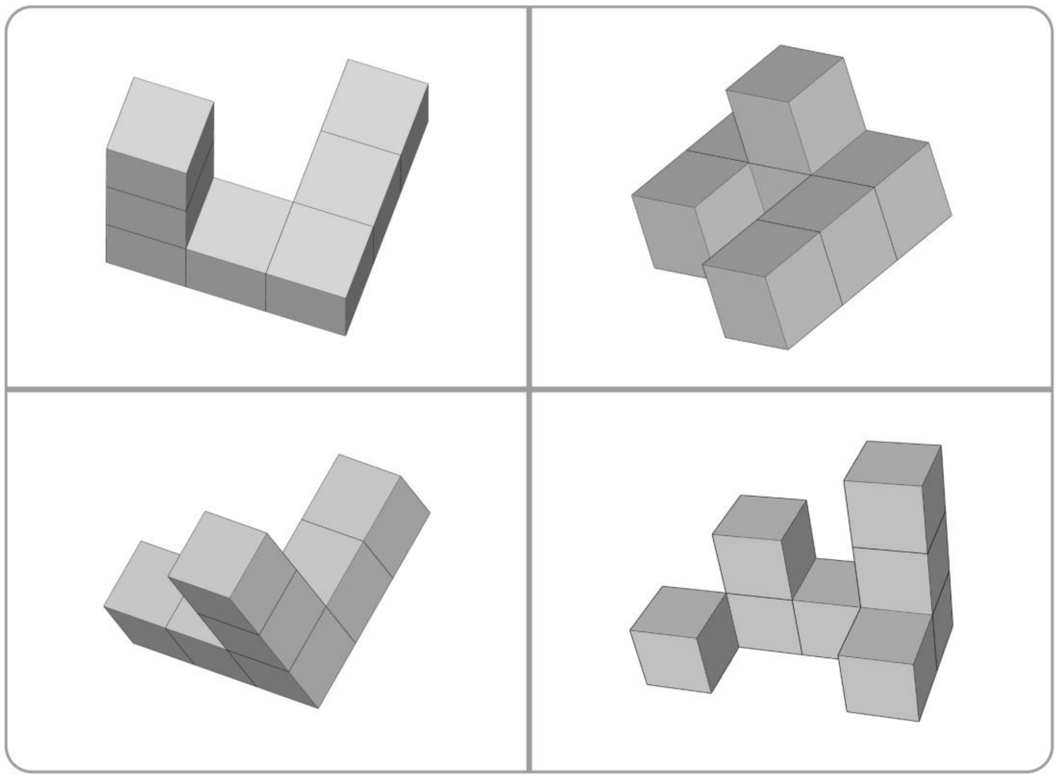
TRIAL - RESPONSE



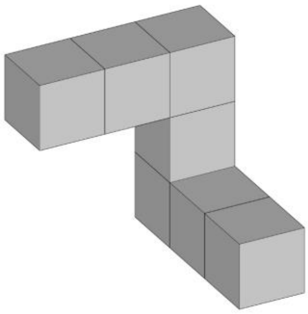
Stimuli 1

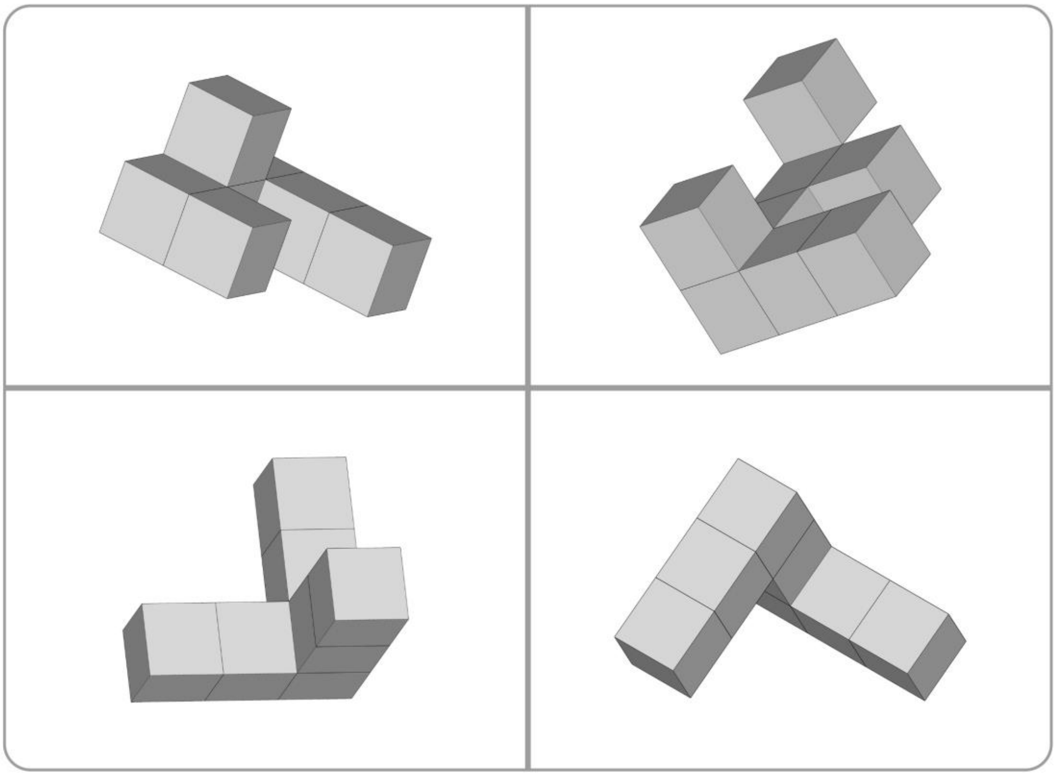
Target:



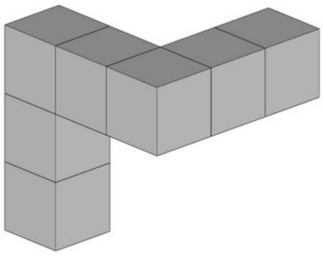


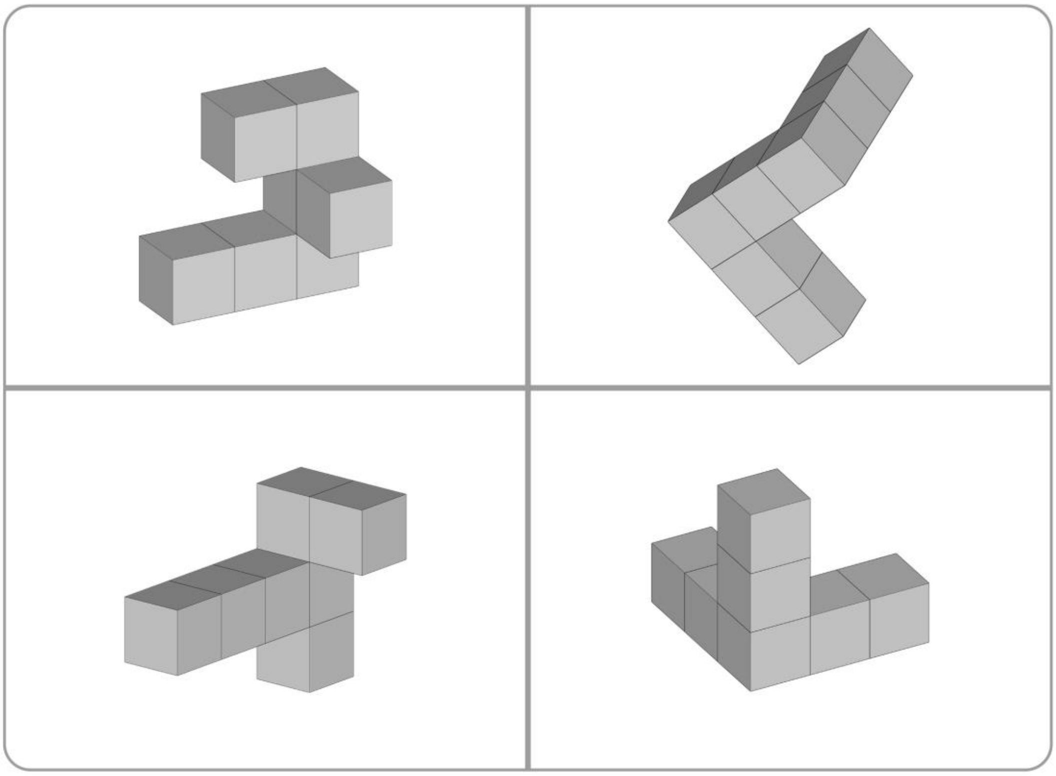
Target:



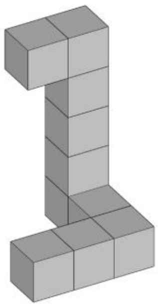


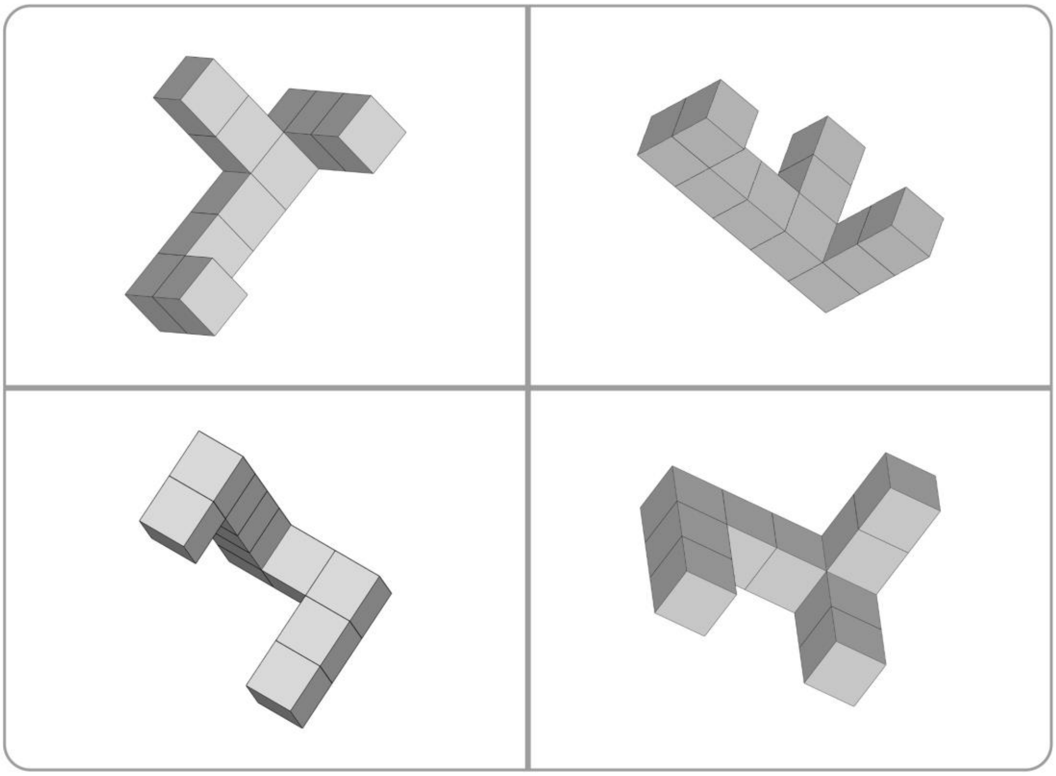
Target:



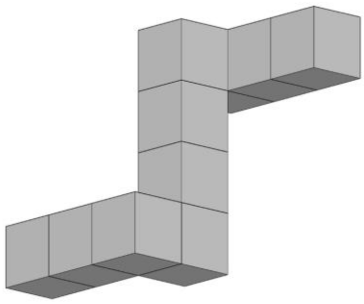


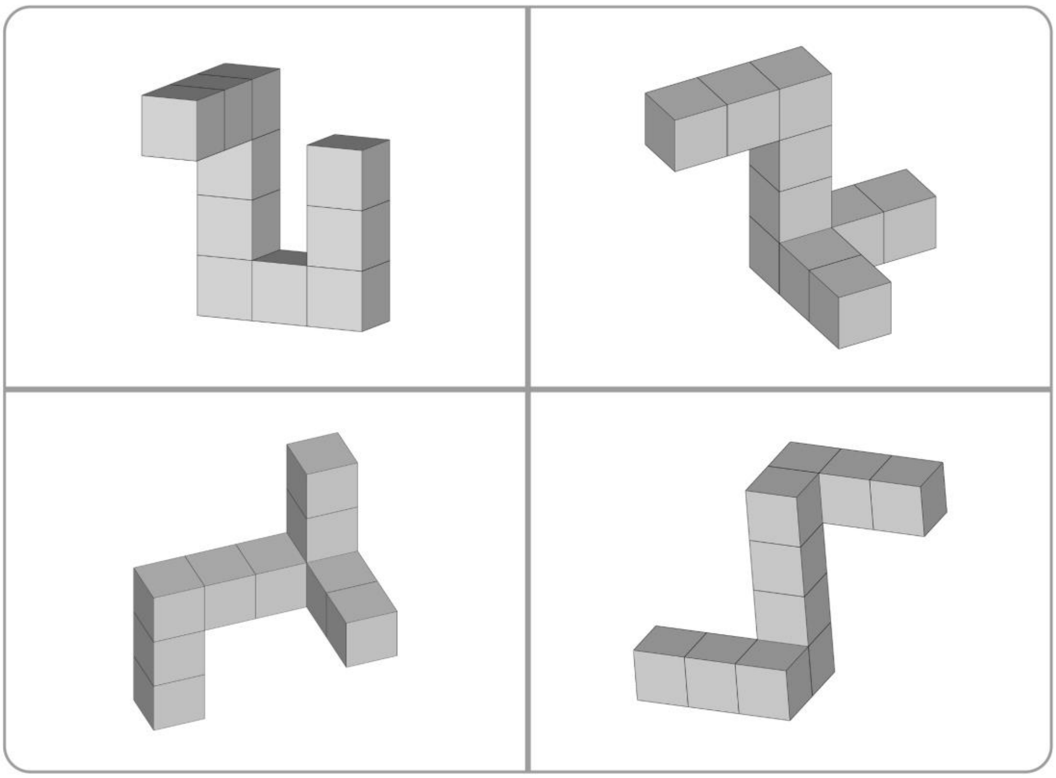
Target:





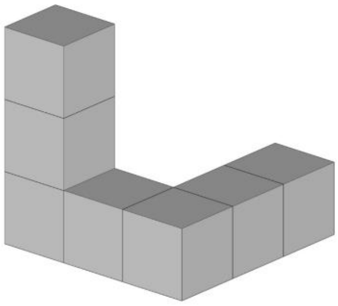
Target:

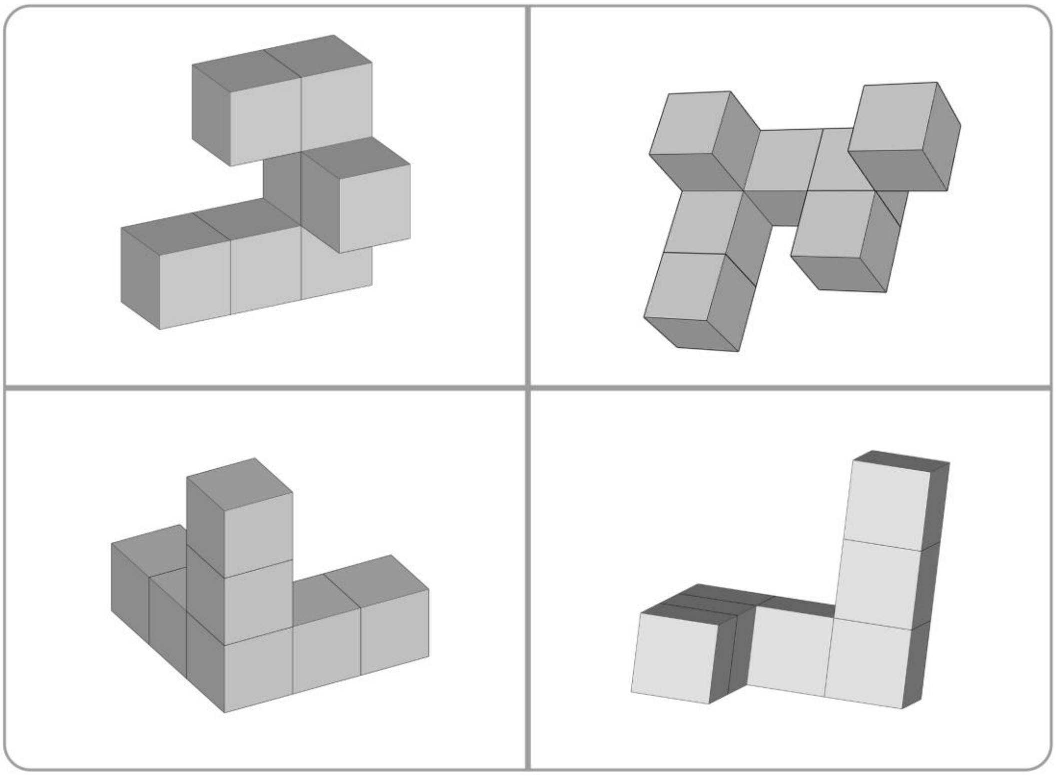




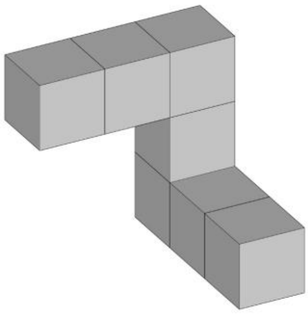
Stimuli 2

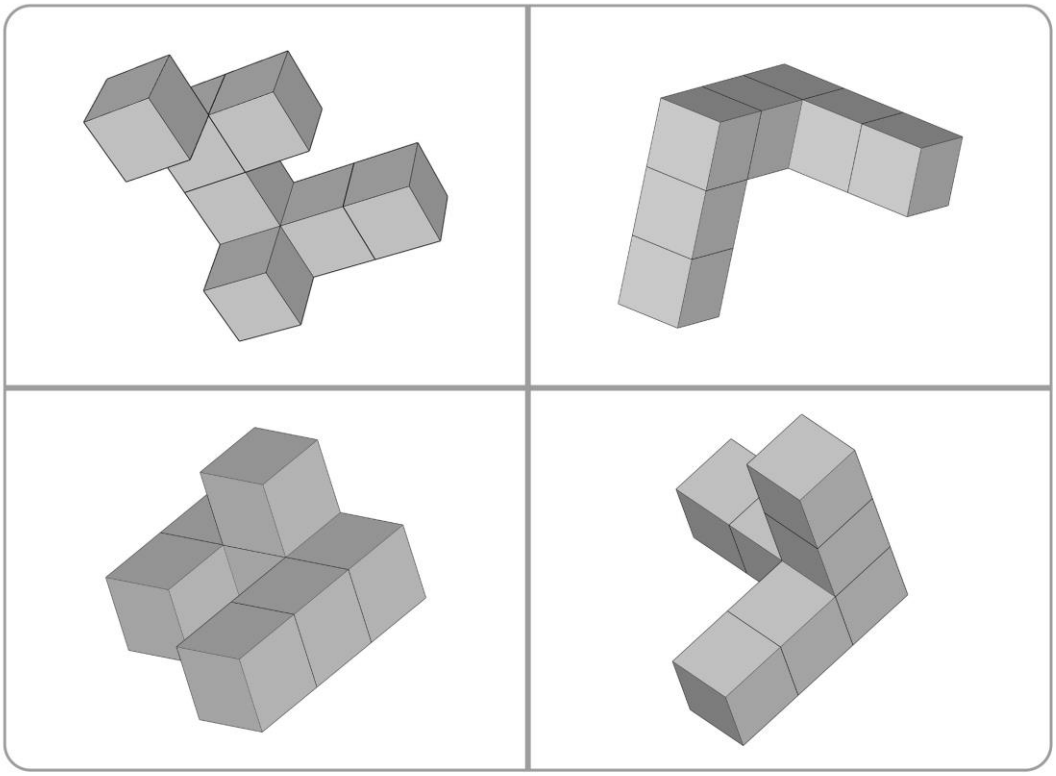
Target:



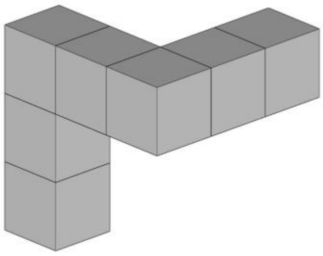


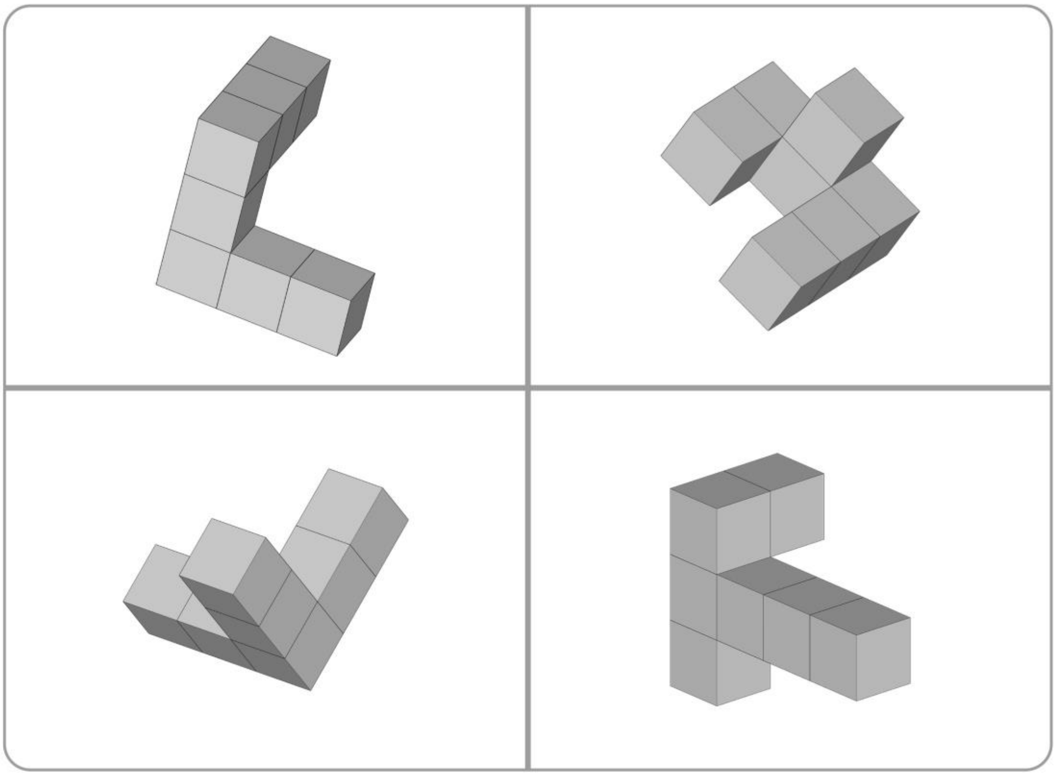
Target:



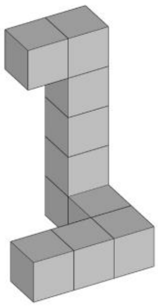


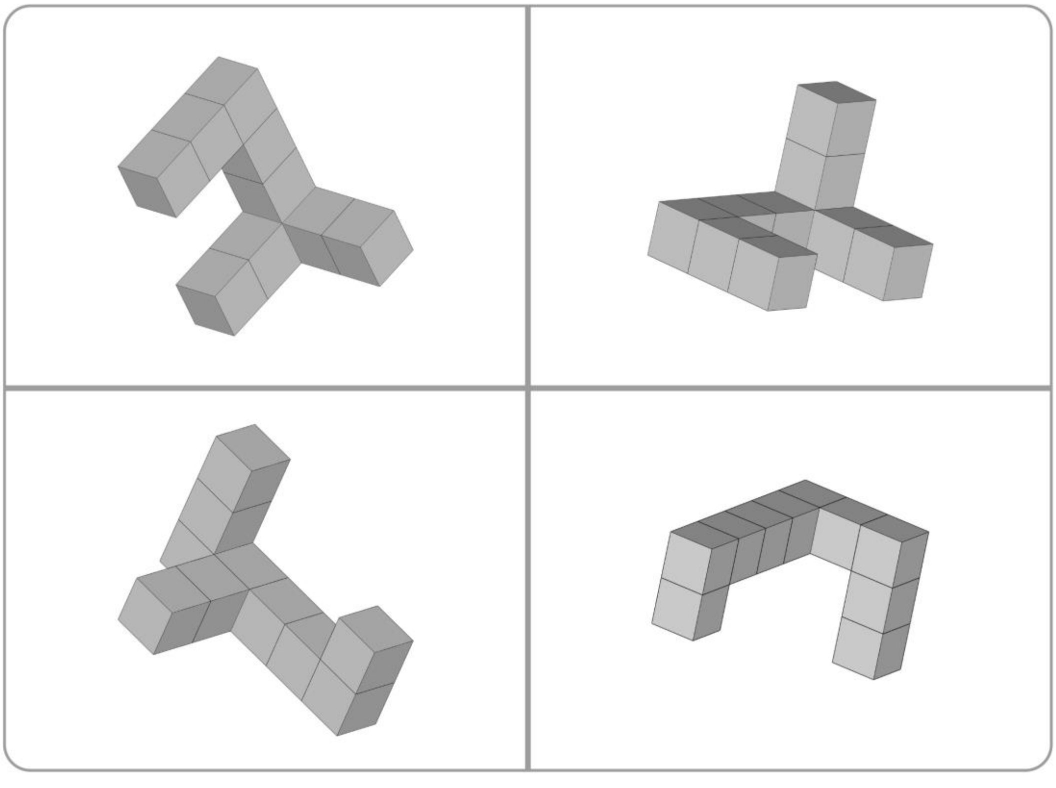
Target:



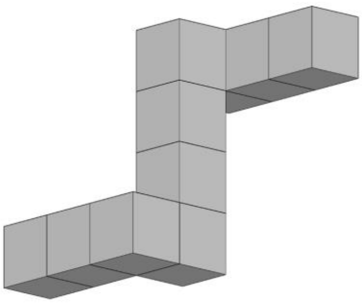


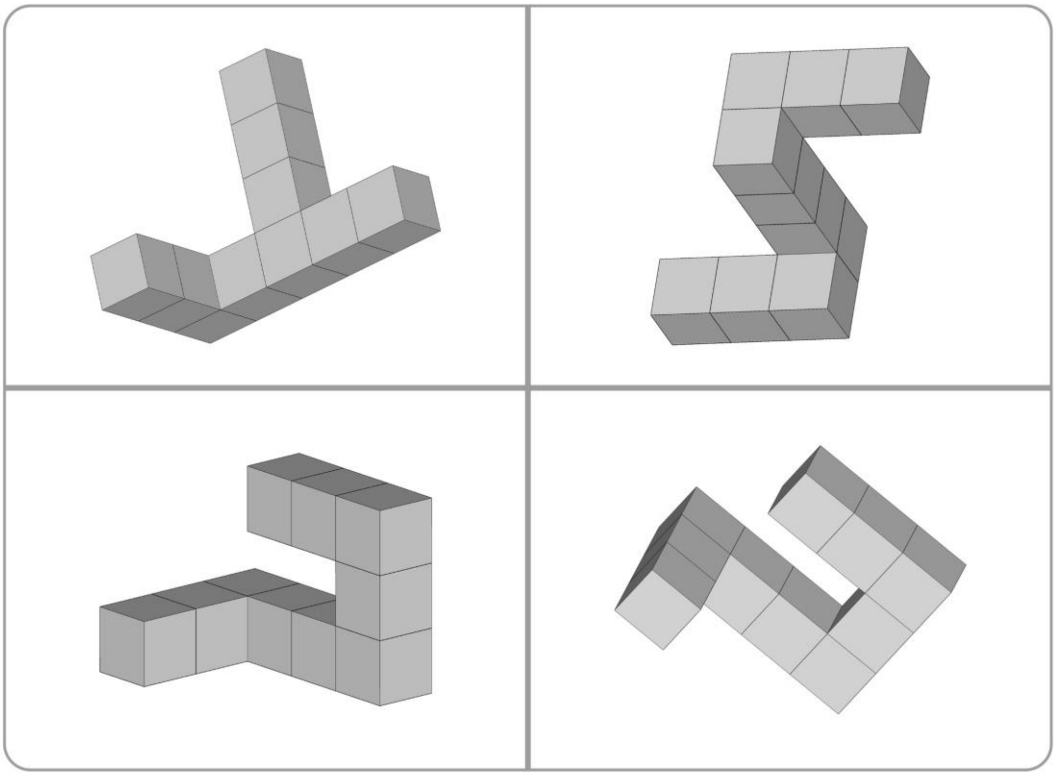
Target:





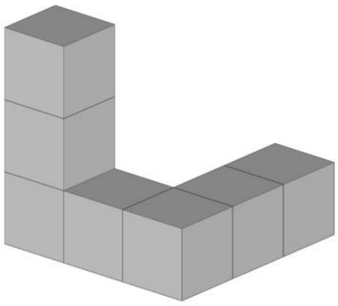
Target:

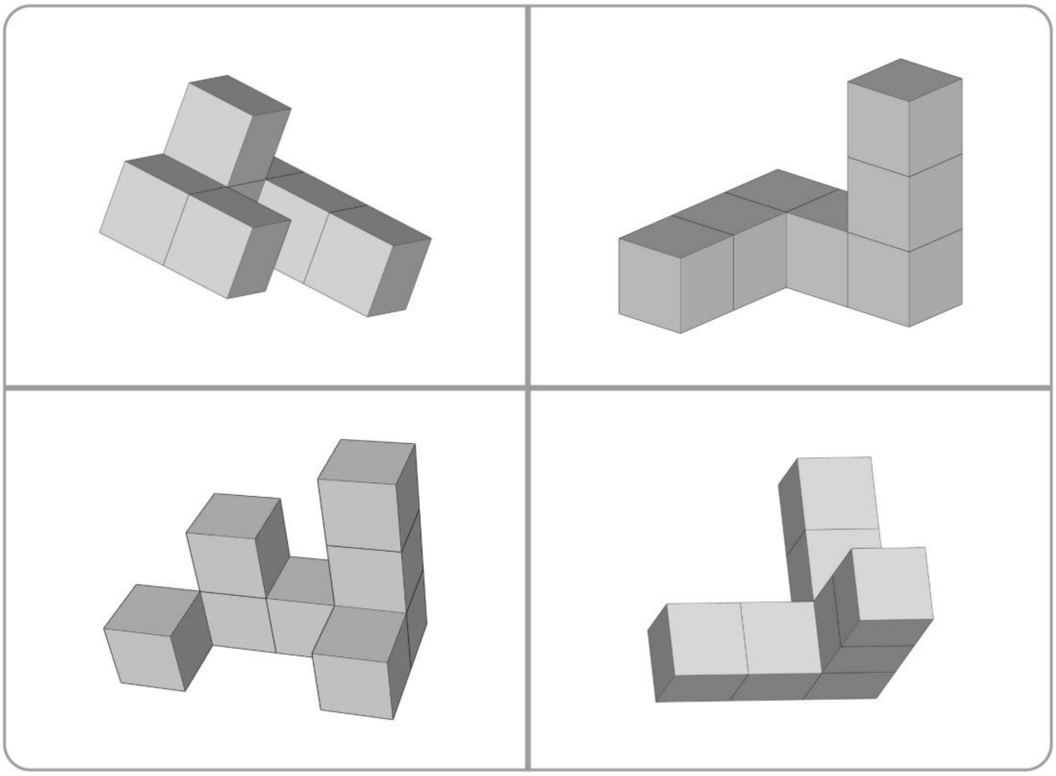




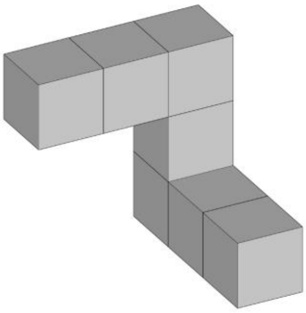
Stimuli 3

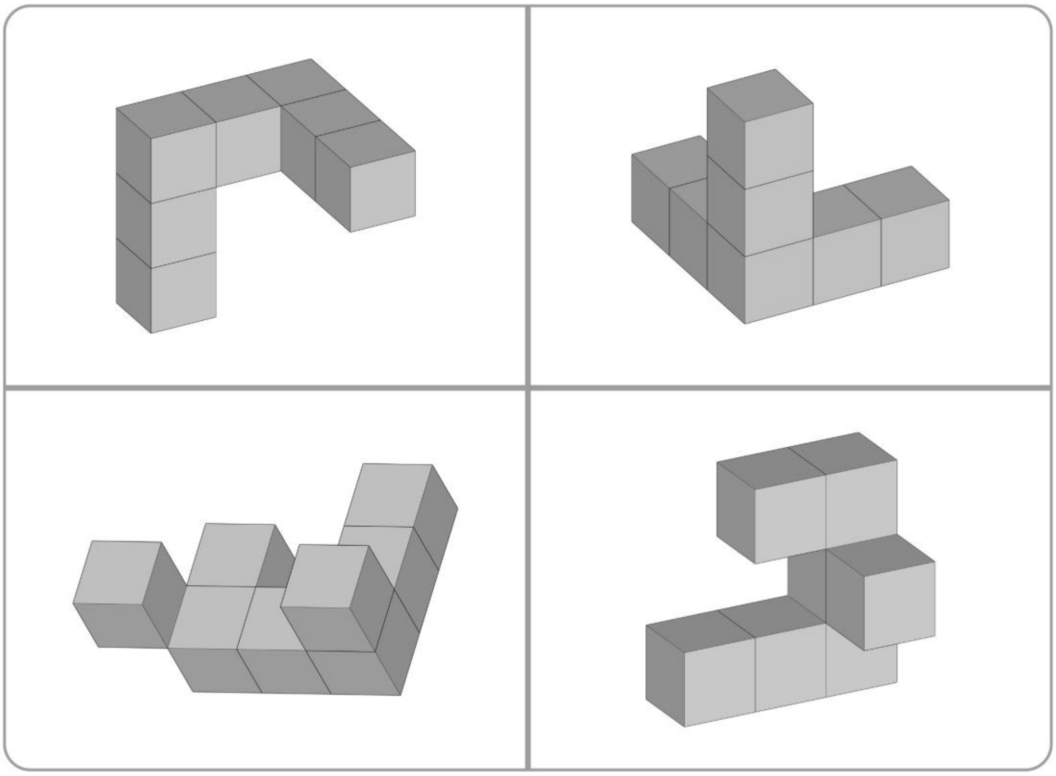
Target:



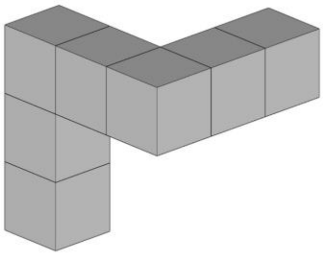


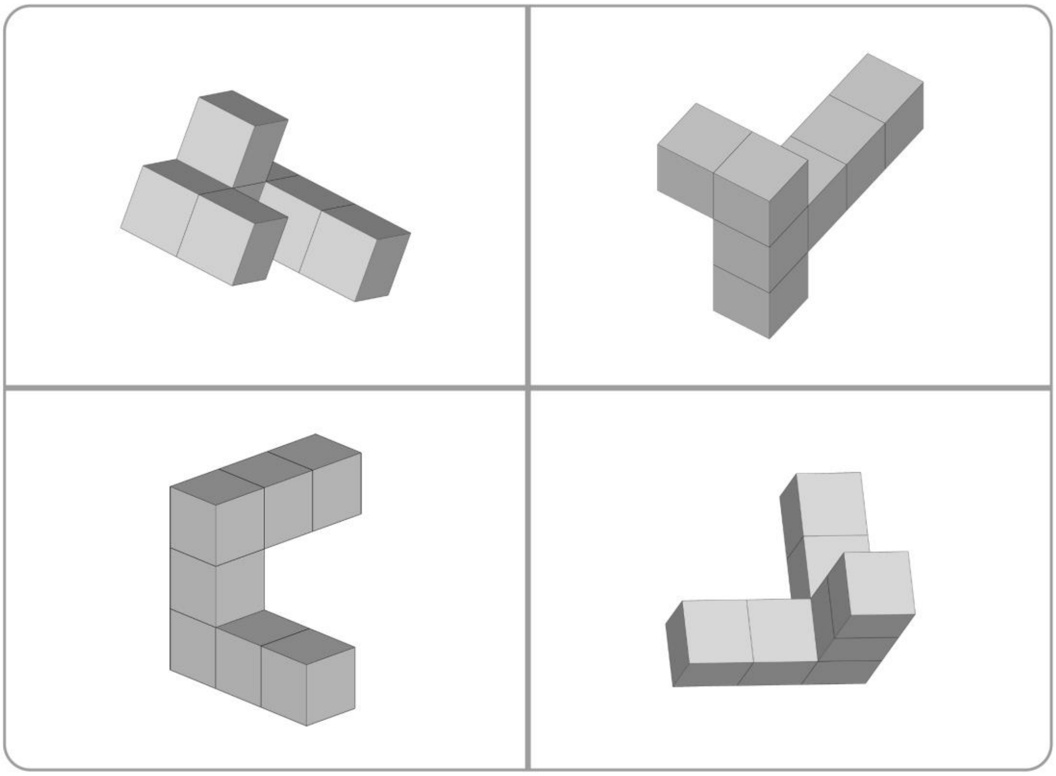
Target:



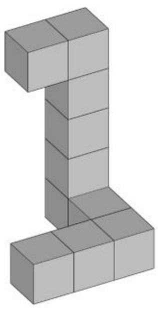


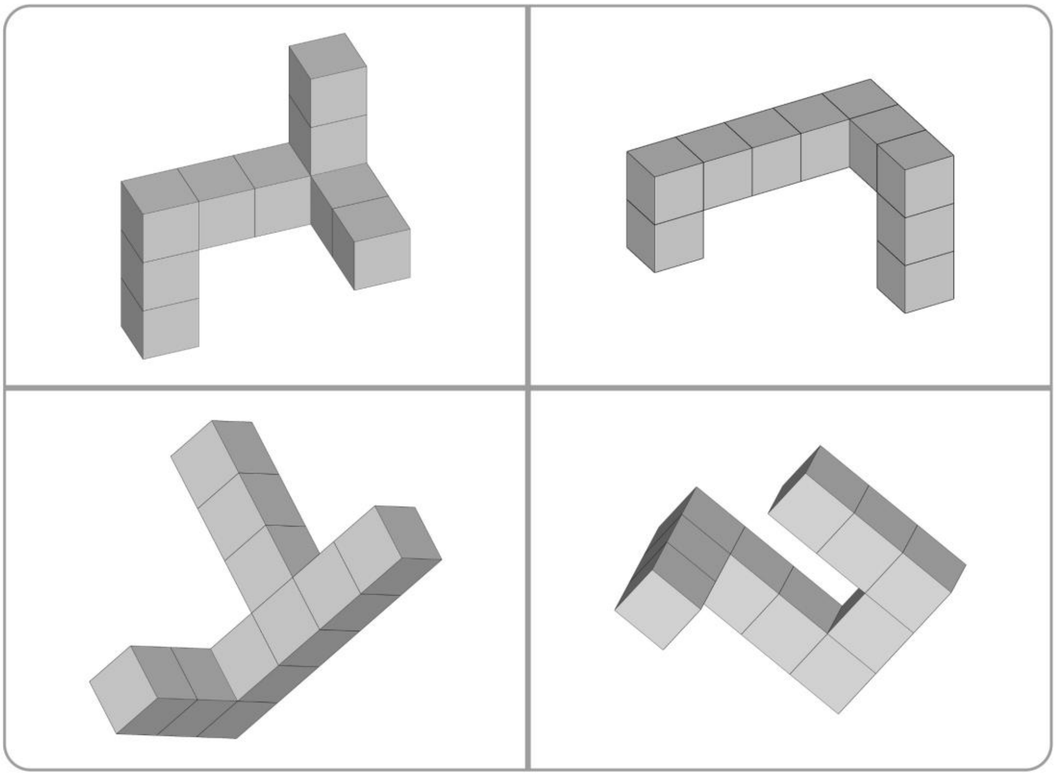
Target:



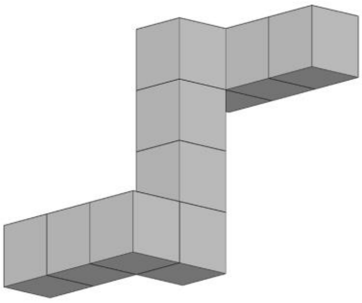


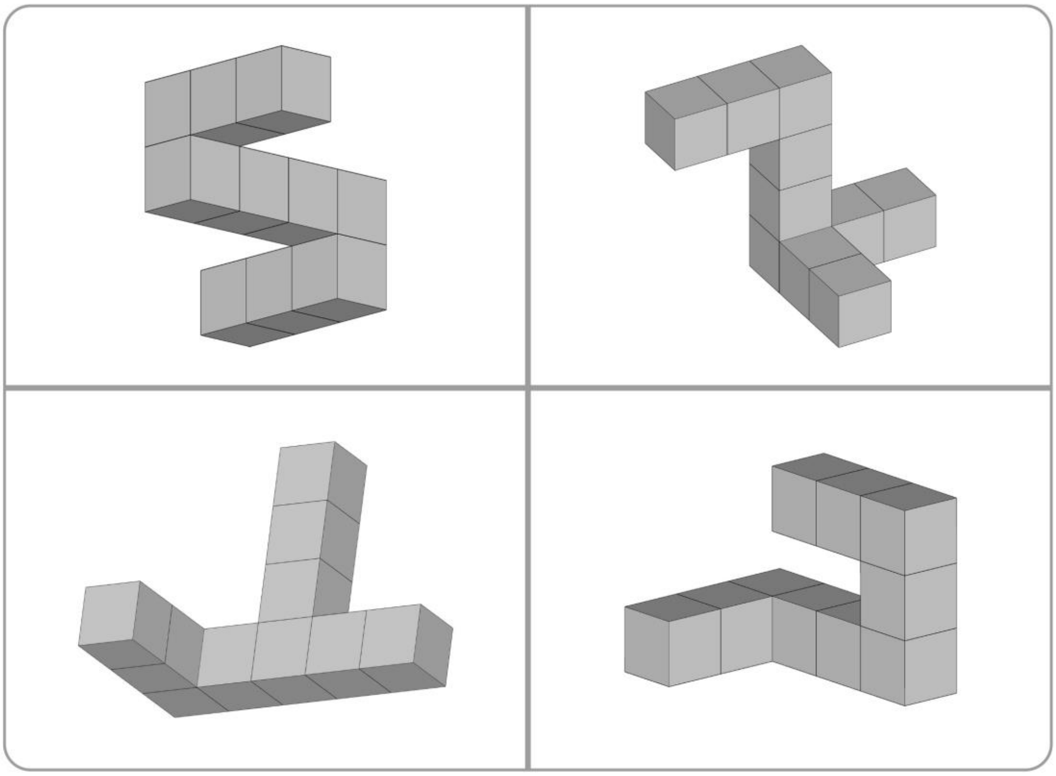
Target:





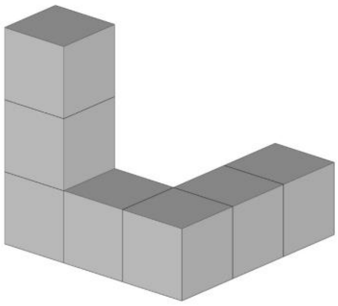
Target:

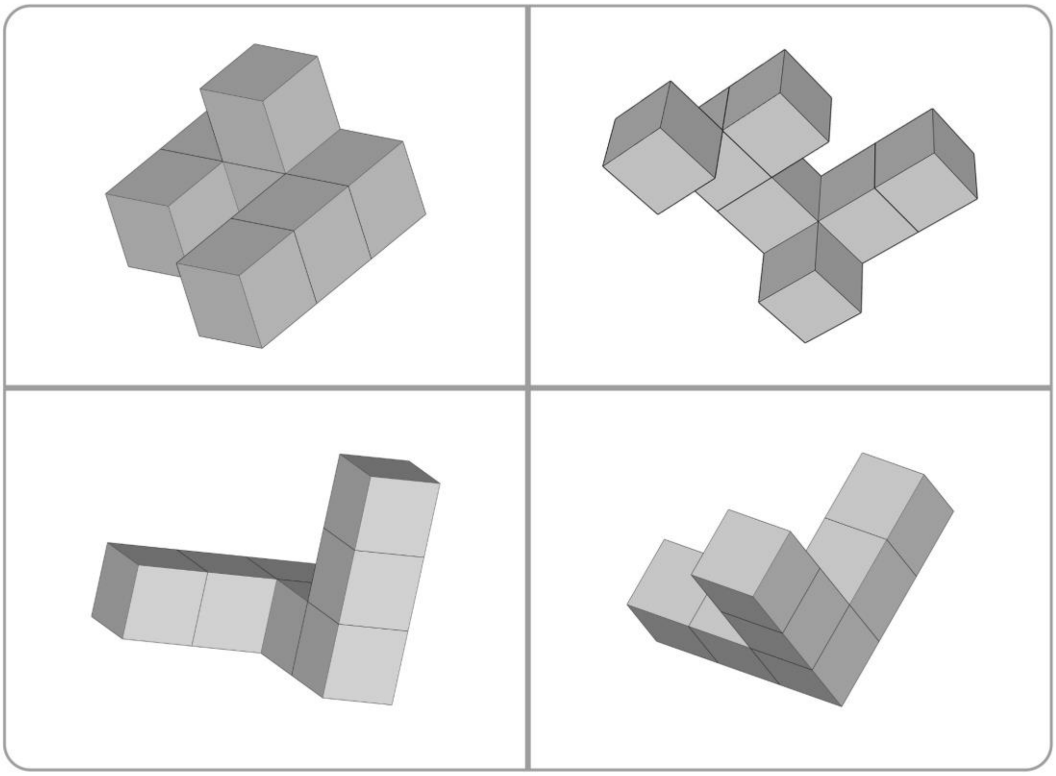




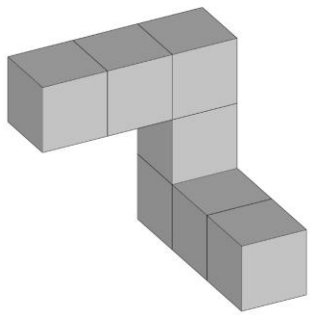
Stimuli 4

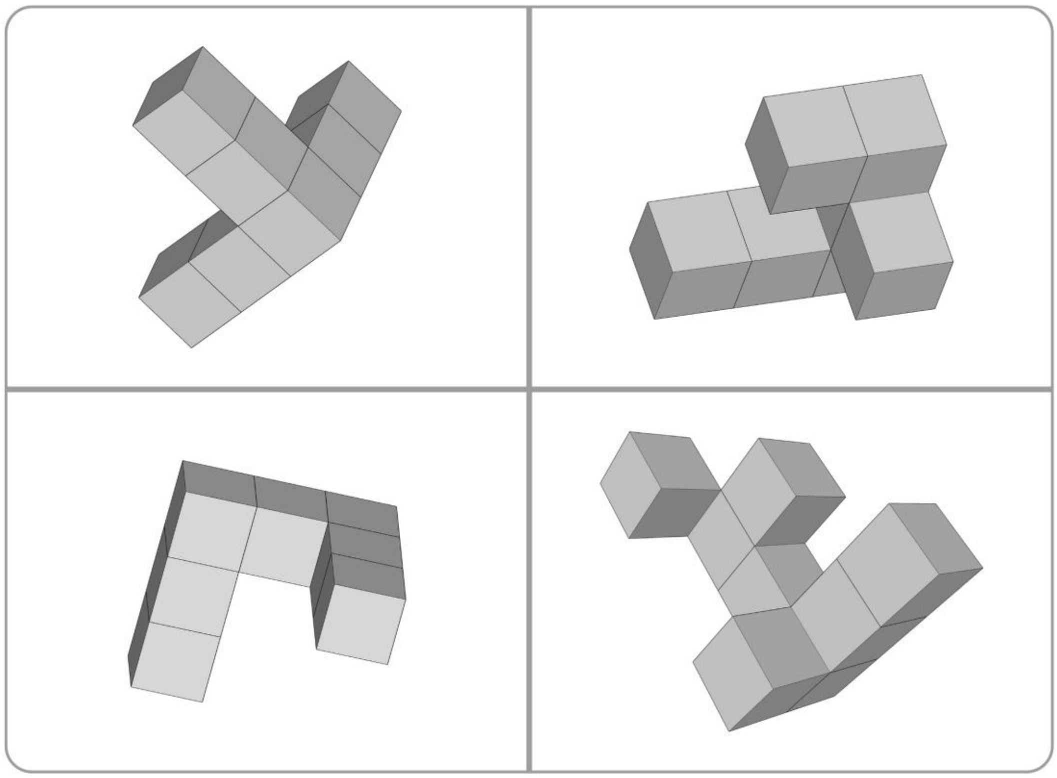
Target:



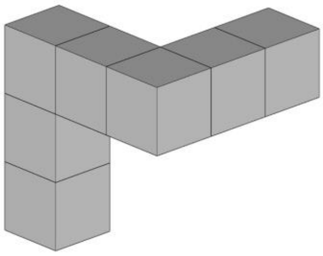


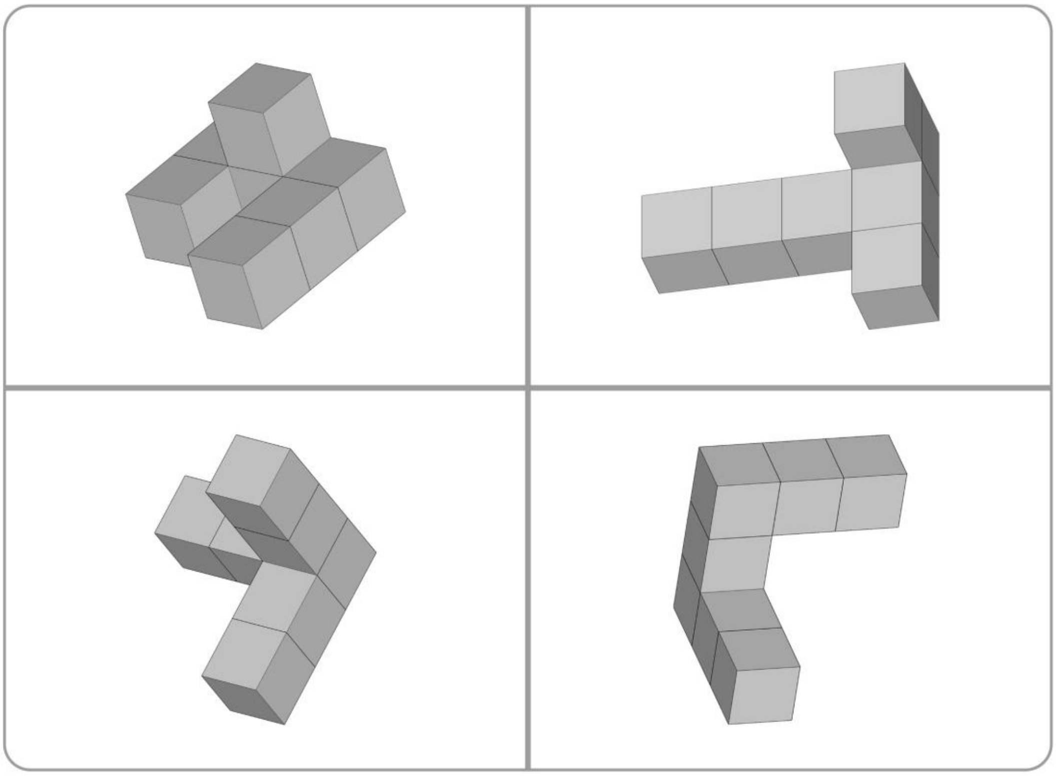
Target:



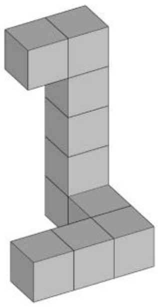


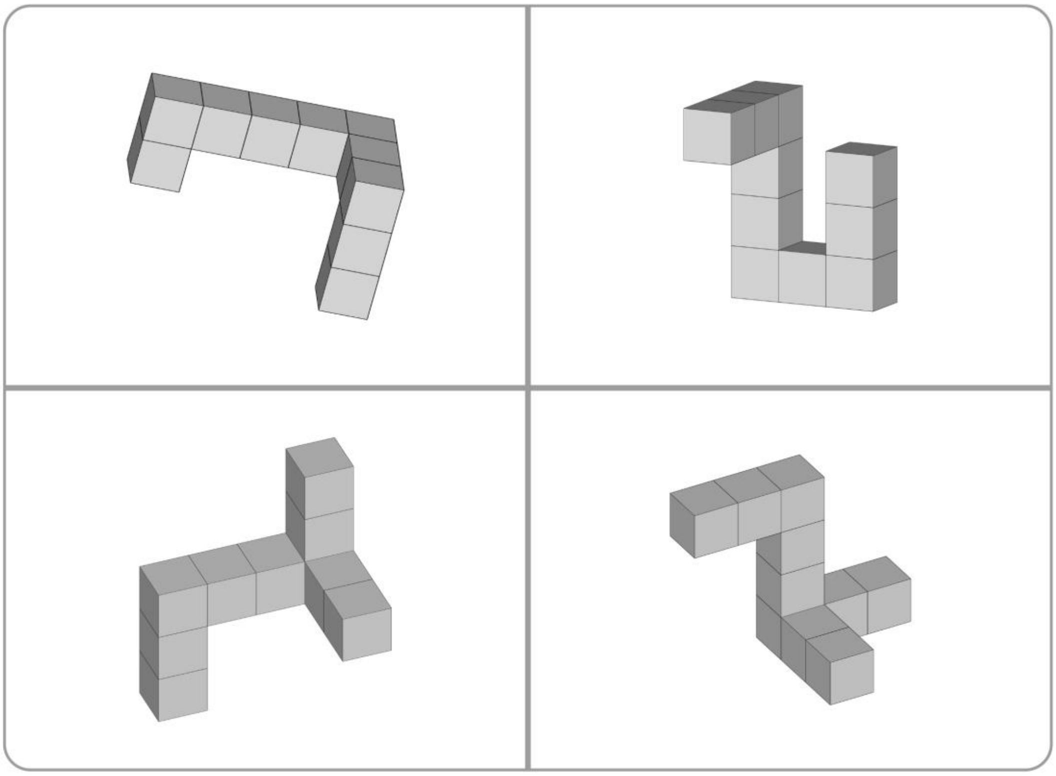
Target:



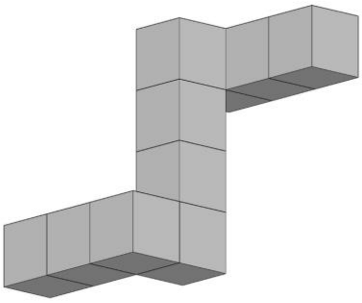


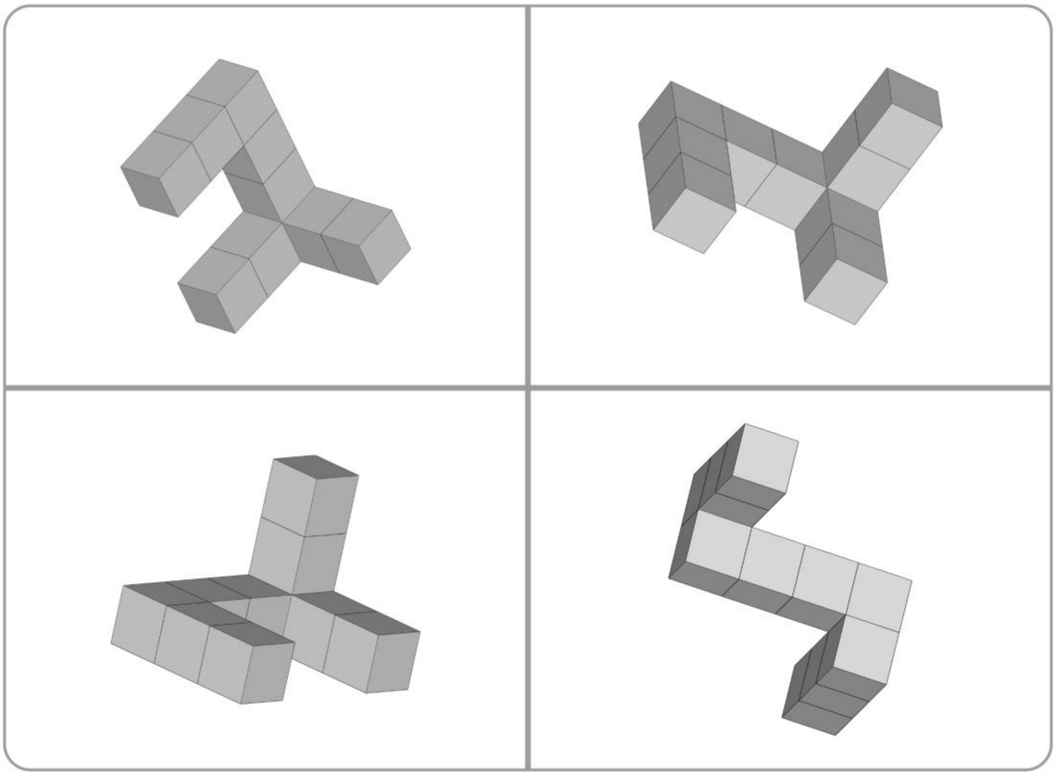
Target:





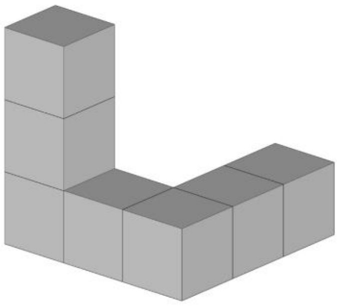
Target:

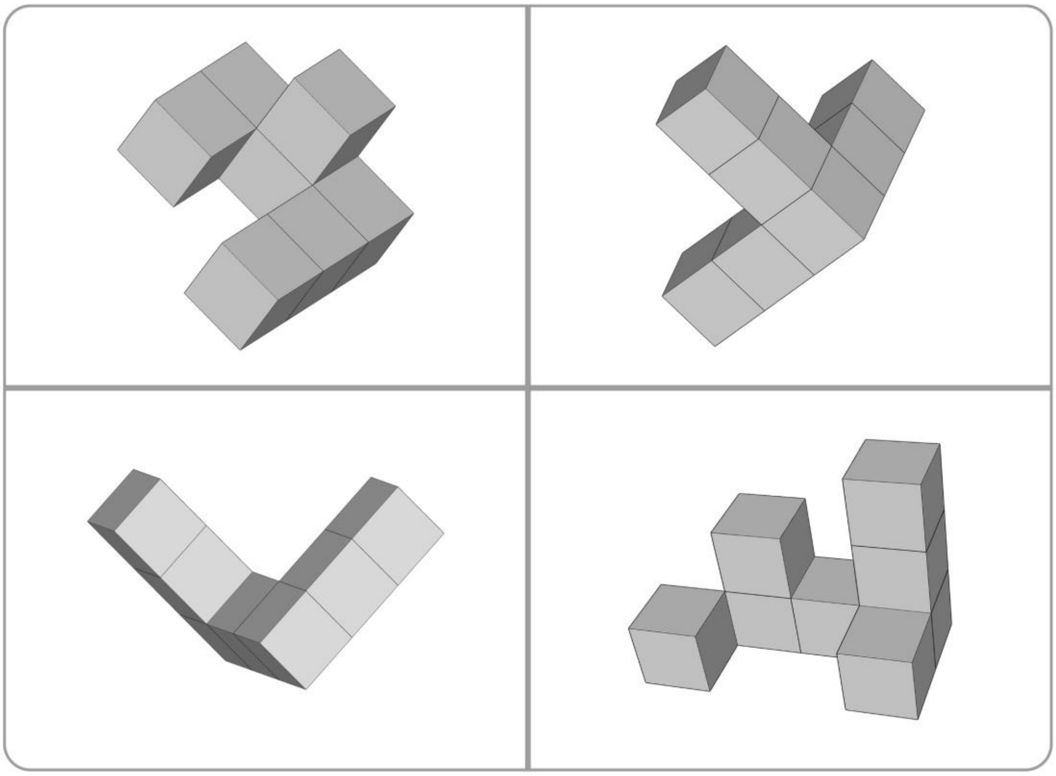




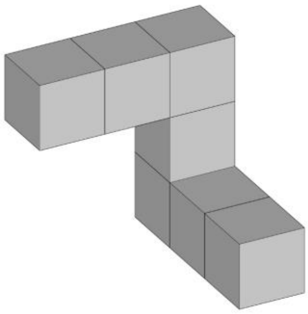
Stimuli 5

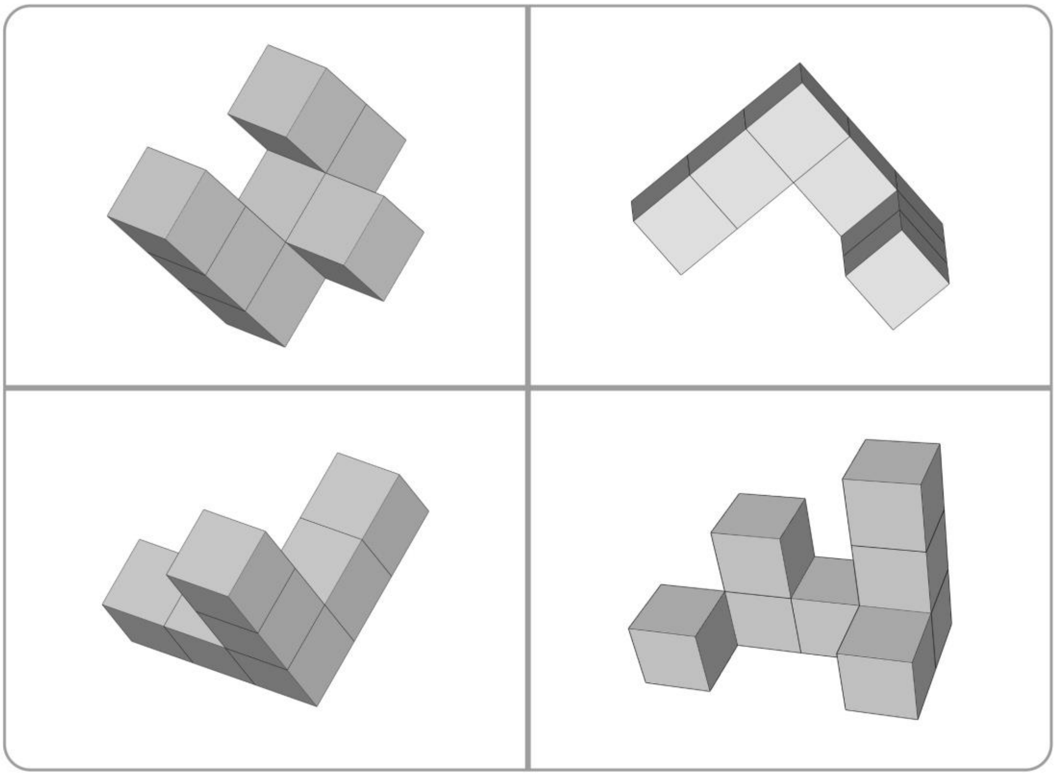
Target:



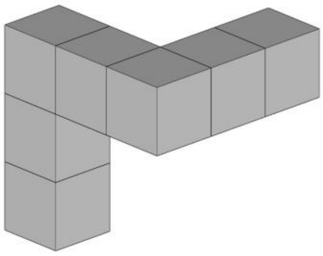


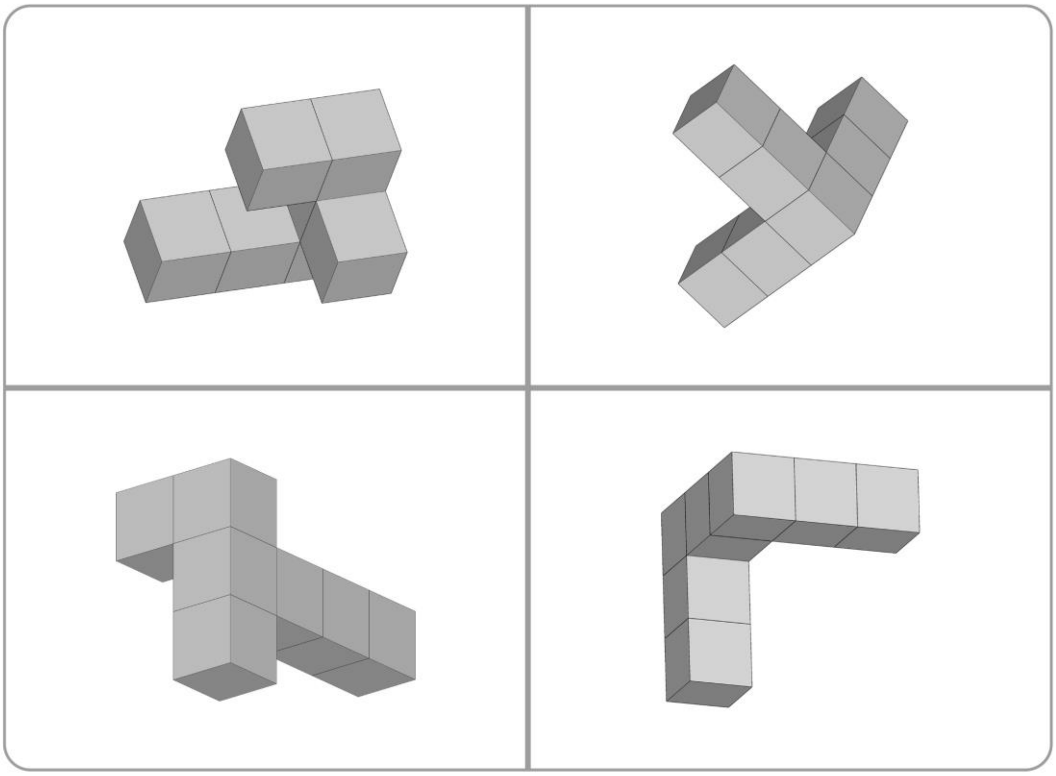
Target:



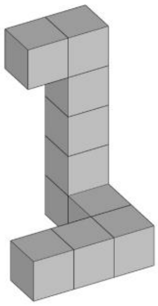


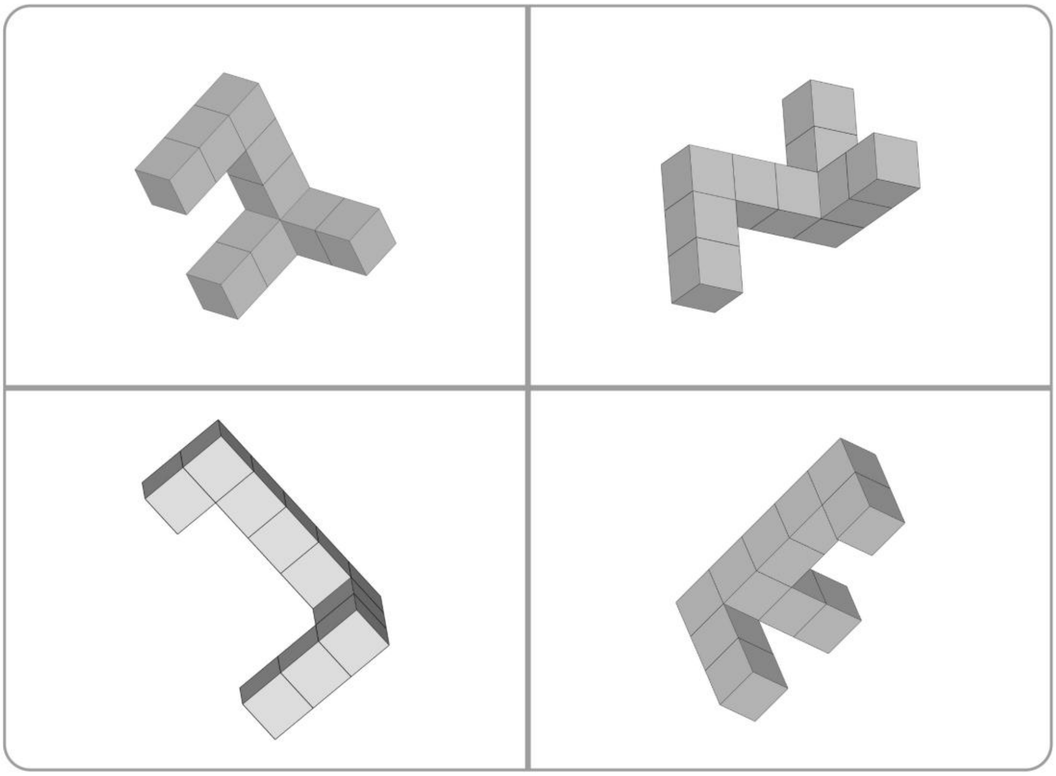
Target:





Target:





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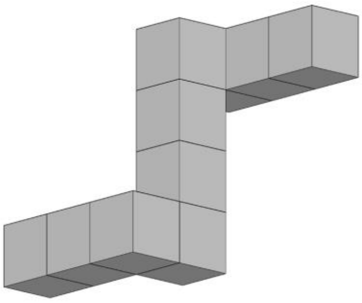
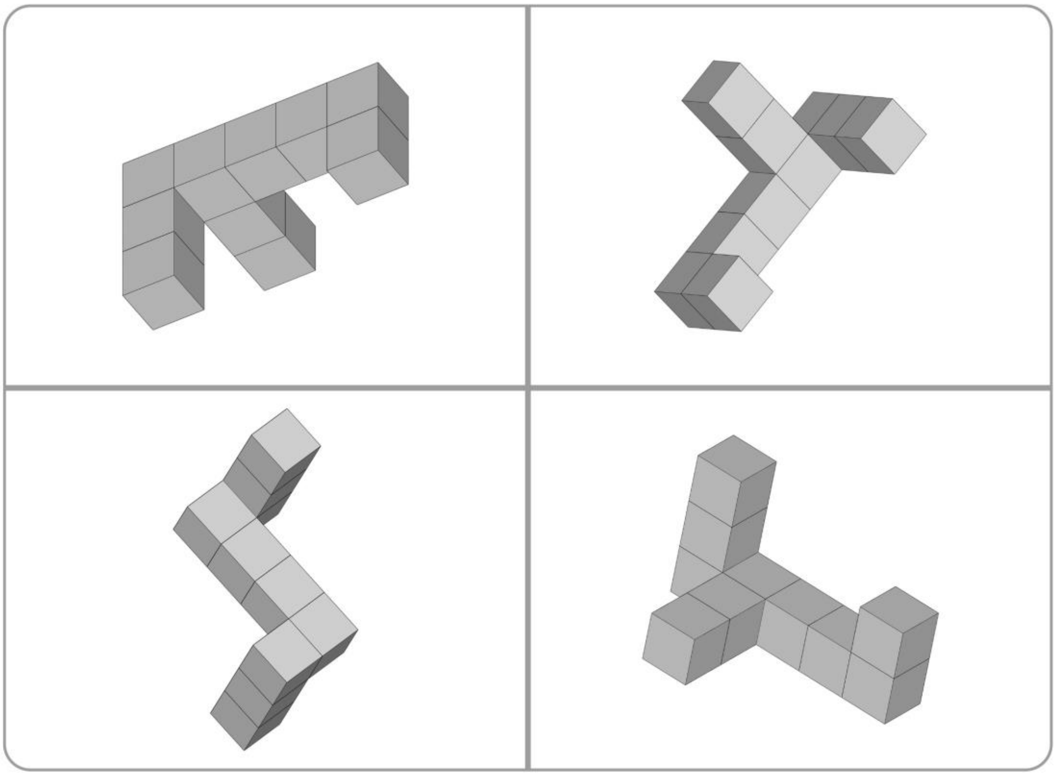




5. Body Schema Interpretation

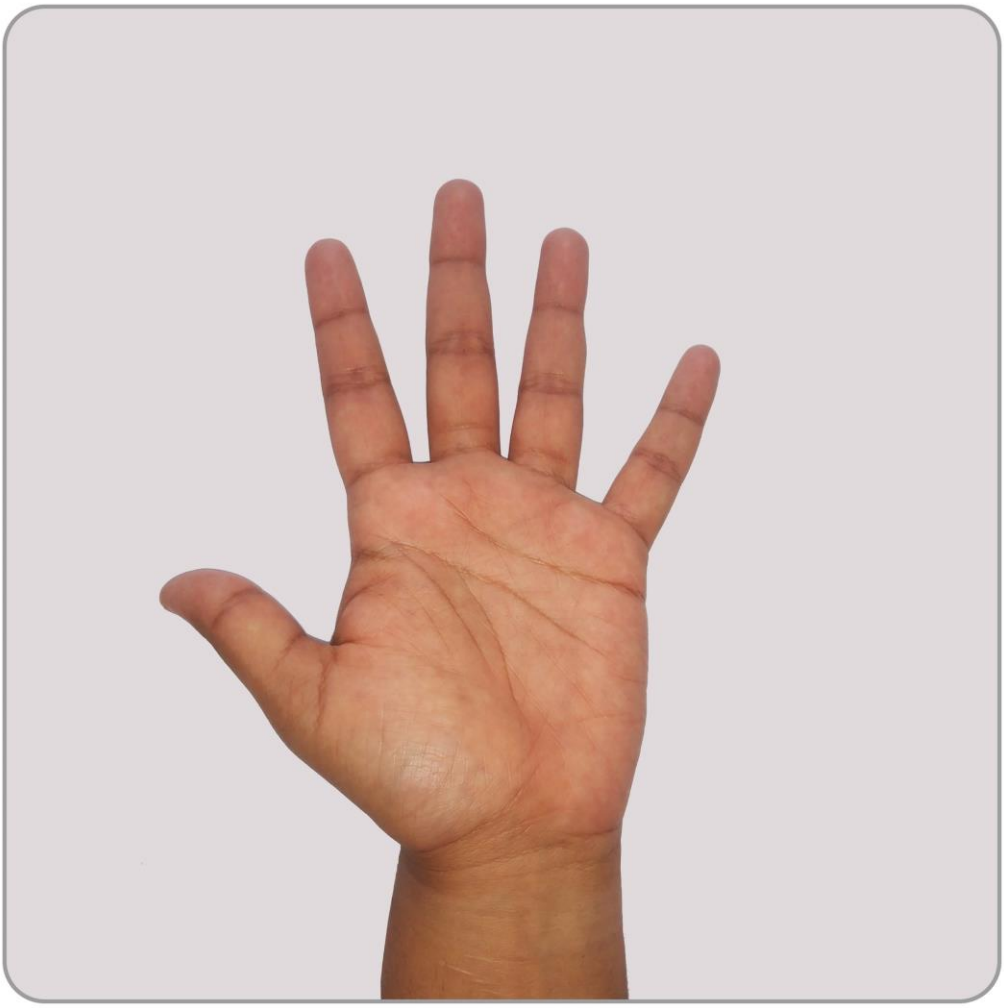
Instruction: *"I will be giving you pictures of a hand, and you will have to tell me whether it is the left hand or the right hand."*

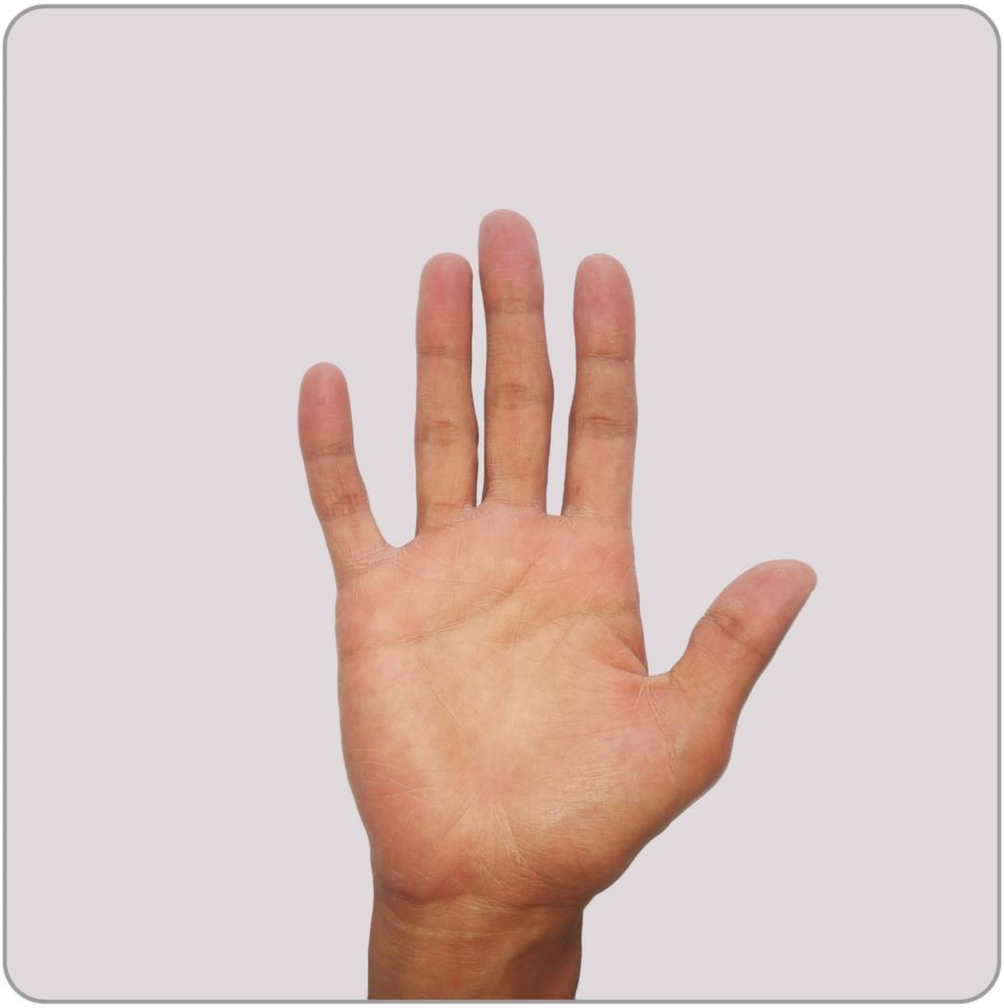
ಸೂಚನೆ: ನಾನು ನಿಮಗೆ ಒಂದು ಕೈ ಚಿತ್ರಗಳನ್ನು ನೀಡುತ್ತೇನೆ. ಅದು ಎಡಗೈ ಅಥವಾ ಬಲಗೈ ಎಂದು ನೀವು ನನಗೆ ಹೇಳಬೇಕು.

TRIAL

RESPONSE - RIGHT

Stimuli 1





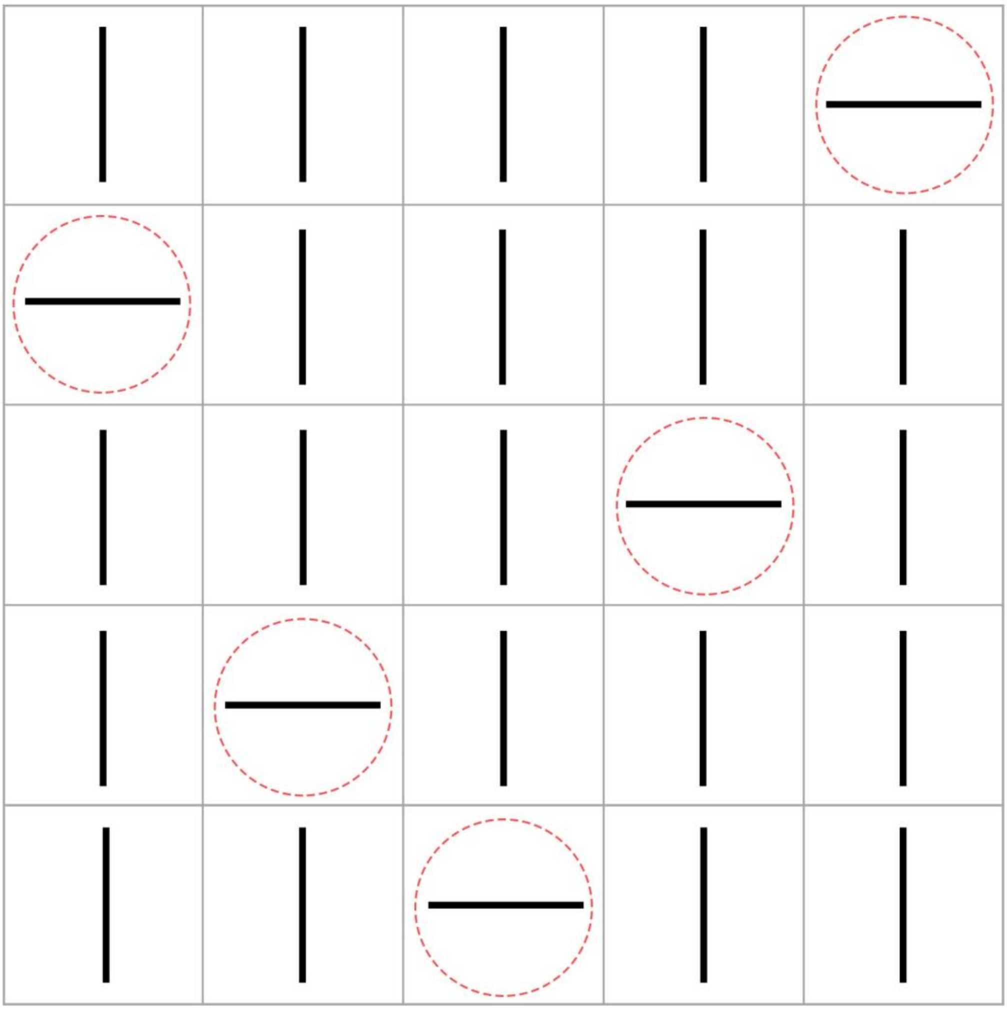
Stimuli 2

Stimulus Card -48

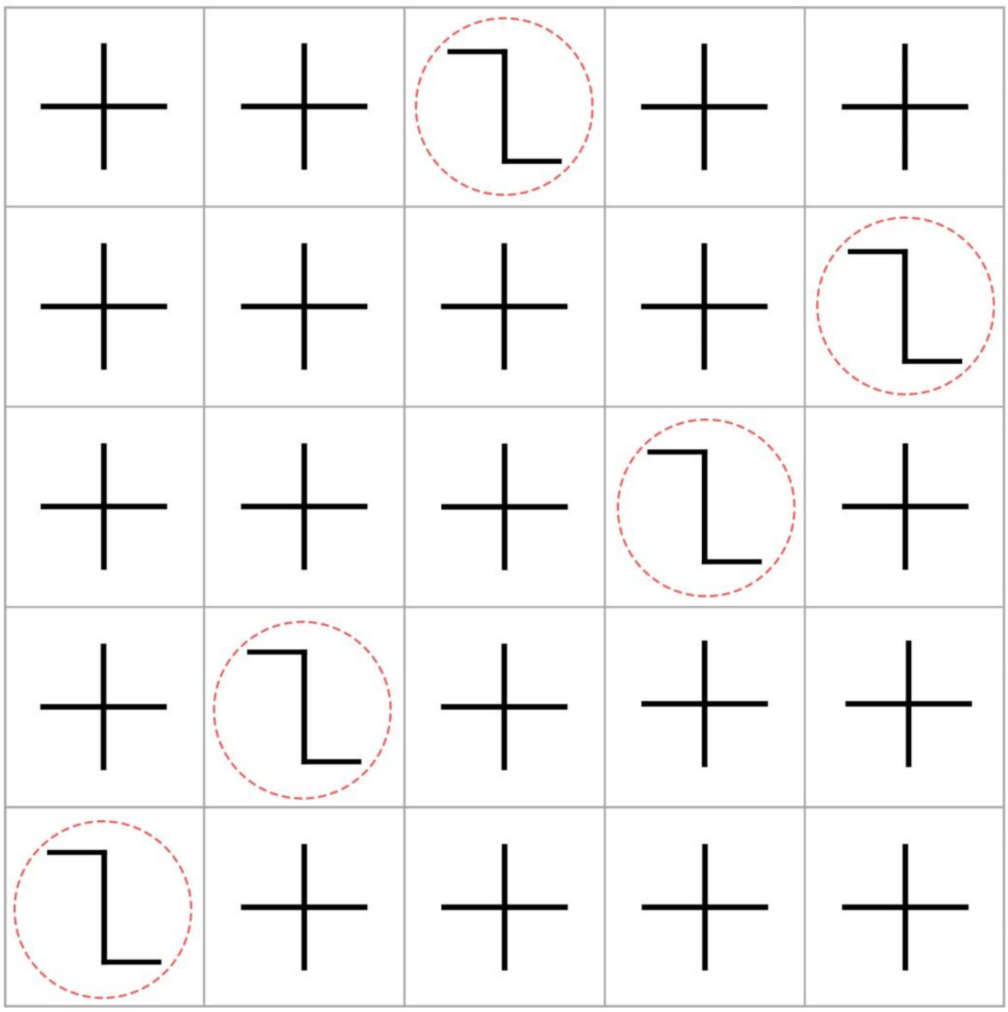
Expected Responses

Symbol Cancellation Task

Target Symbol:

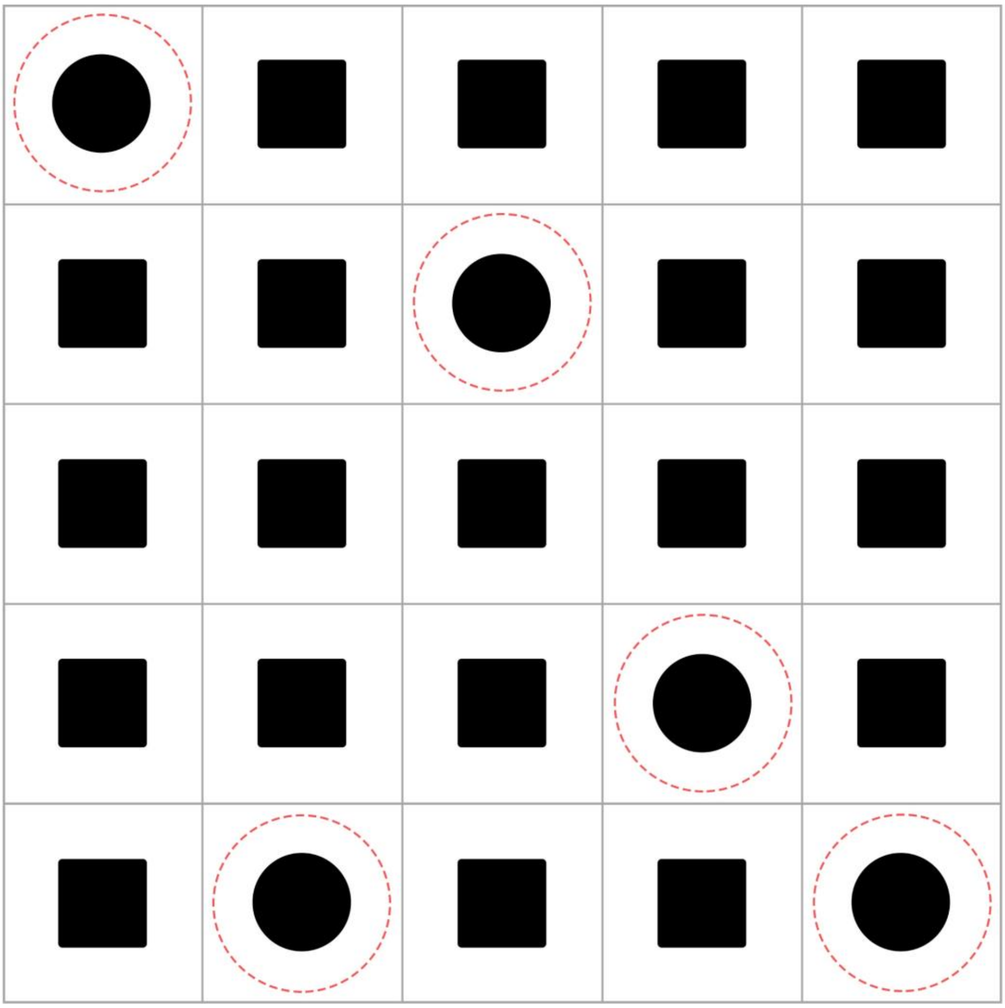


Target Symbol: 



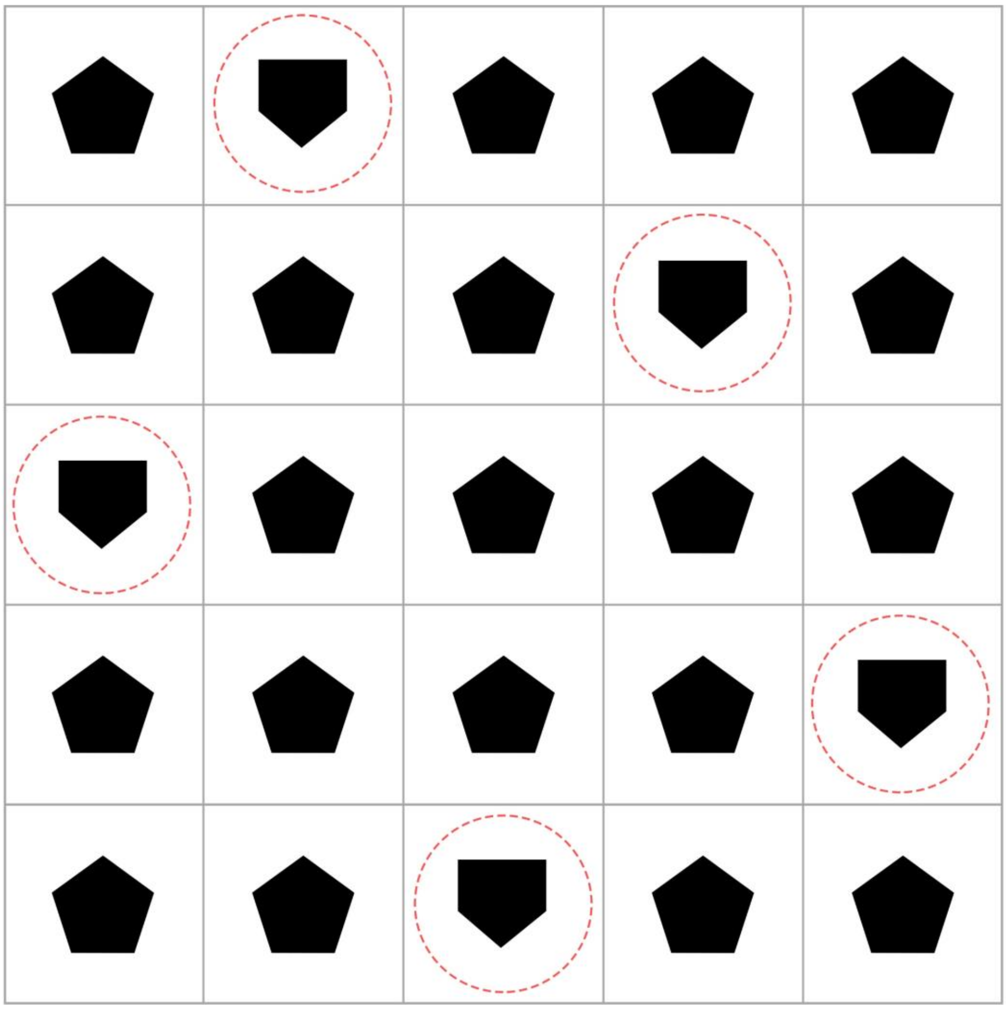
Response for stimulus card -3

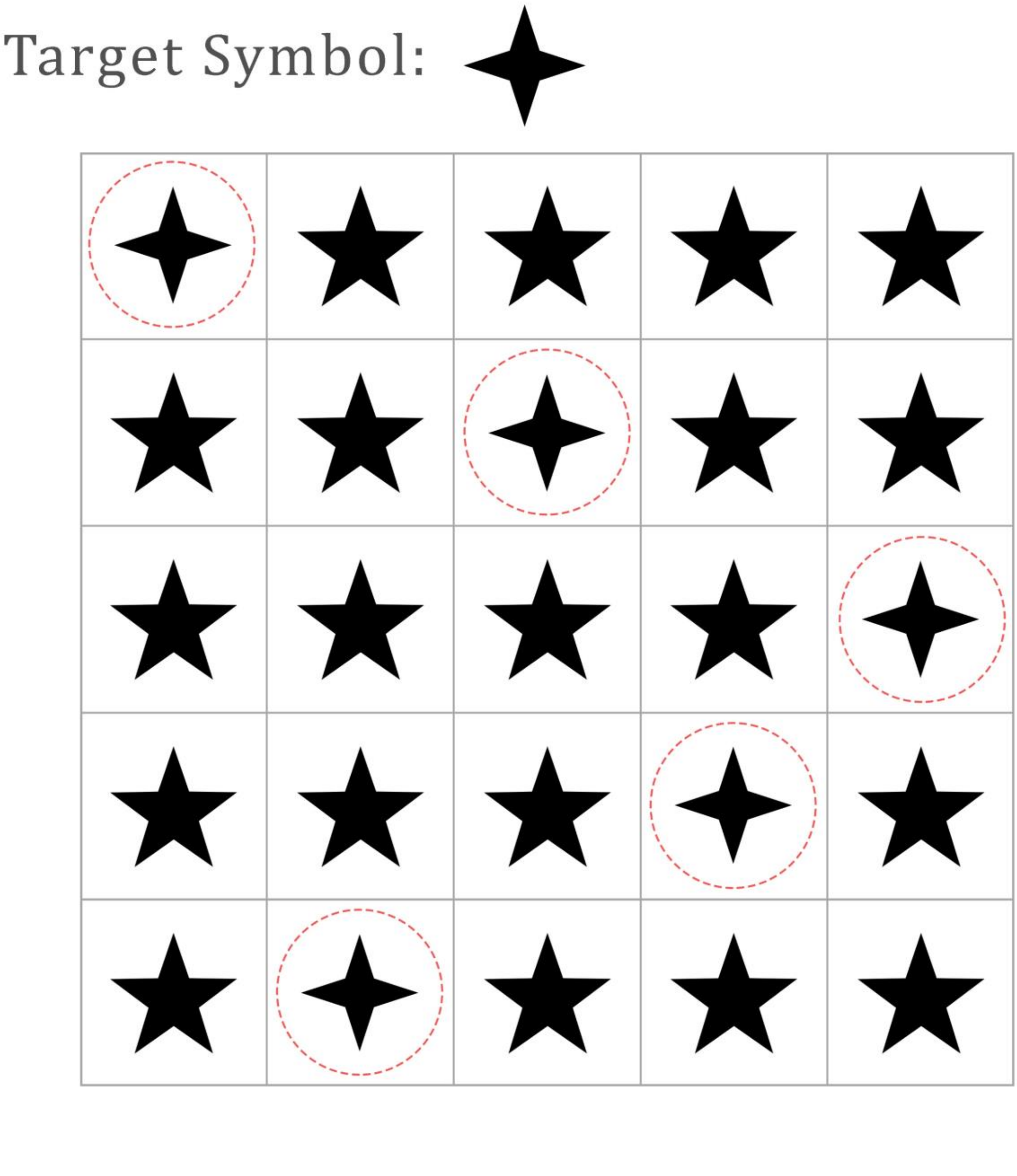
Target Symbol: 



Response for stimulus card -4

Target Symbol: 

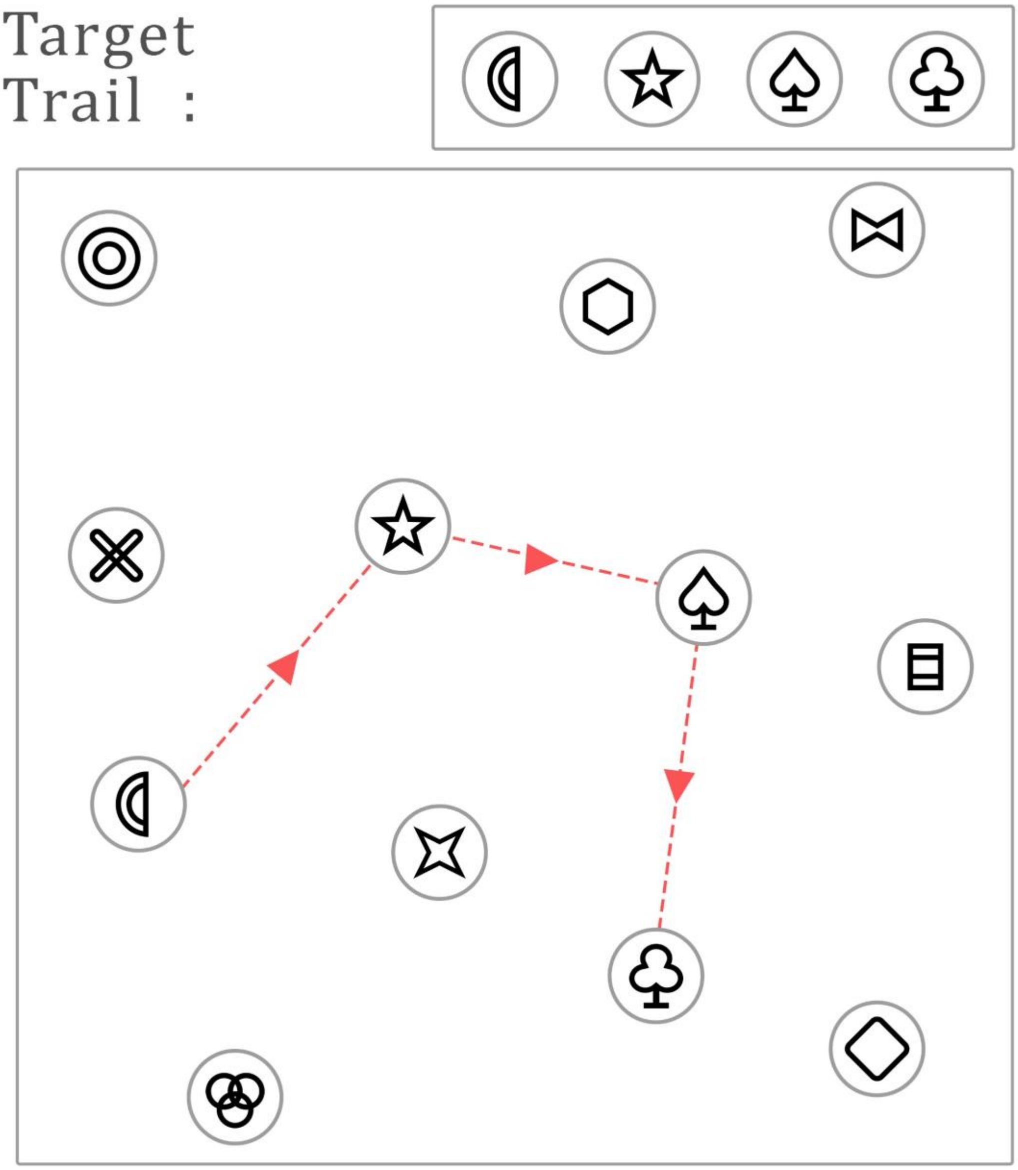



Target Symbol:

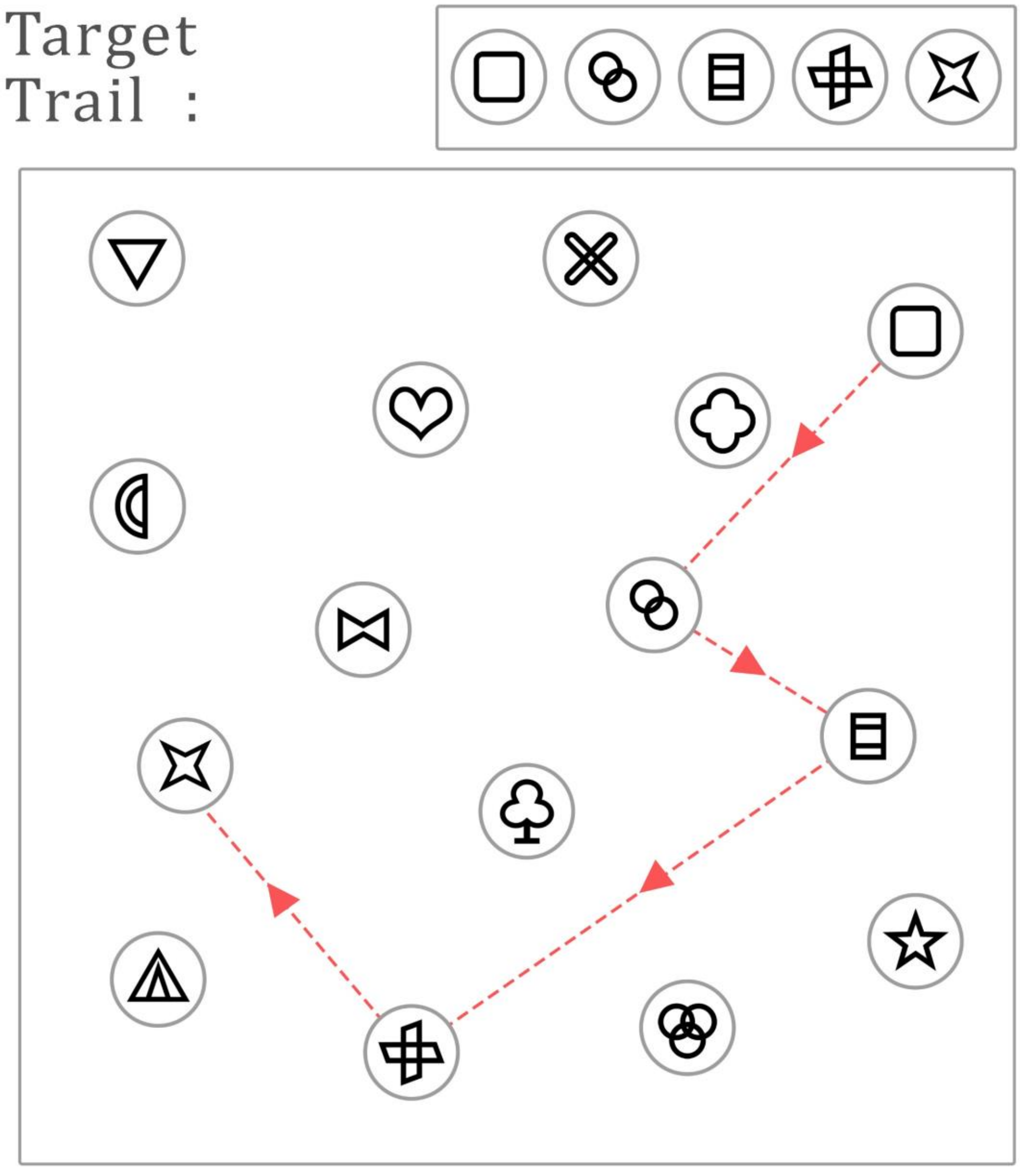
Symbol Trial Task

Response for stimulus card -6

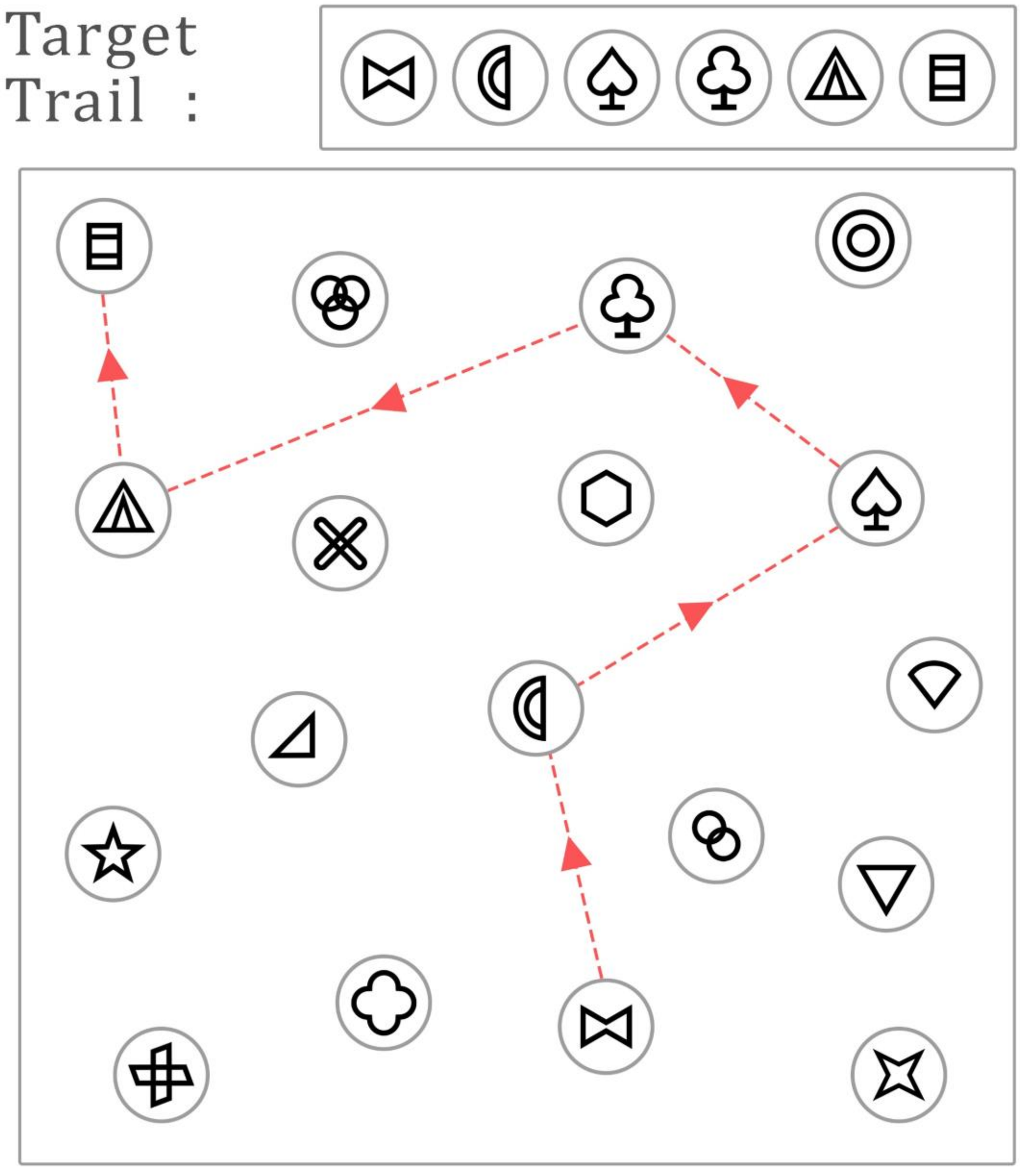
Target Trail :

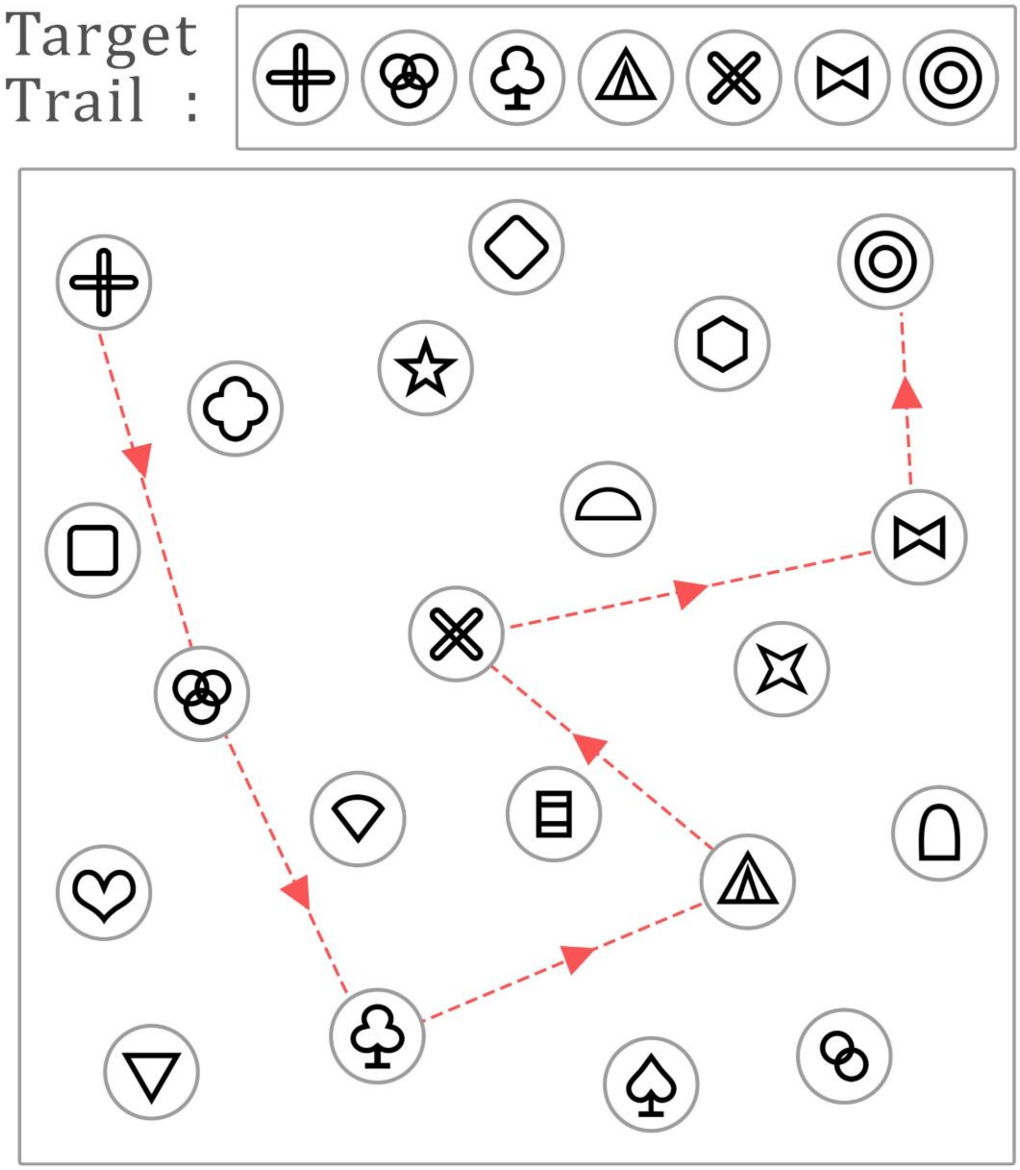


Response for stimulus card -7

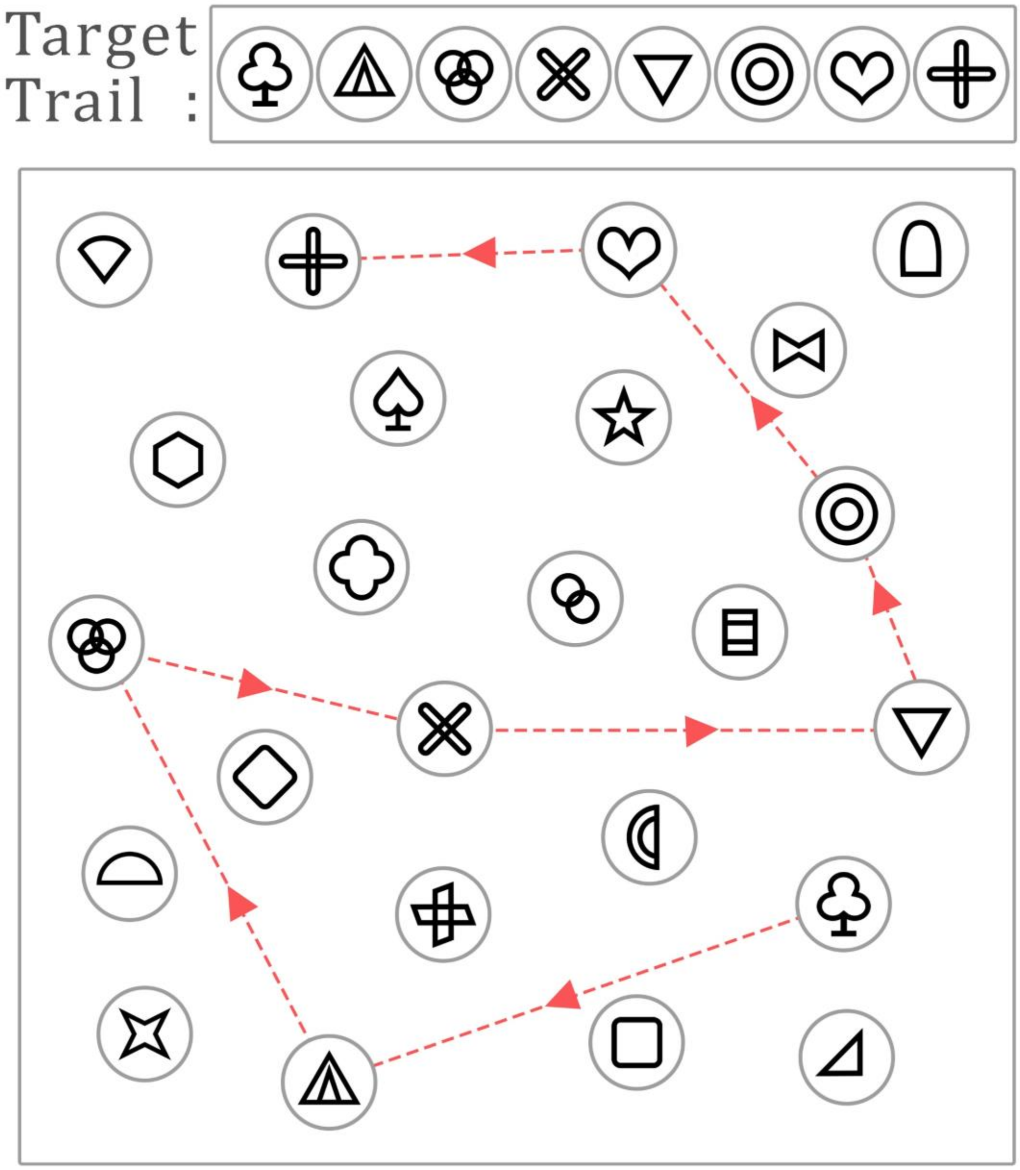


Response for stimulus card -8




Target Trail :

Response for stimulus card -10

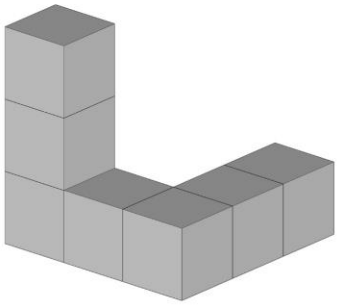


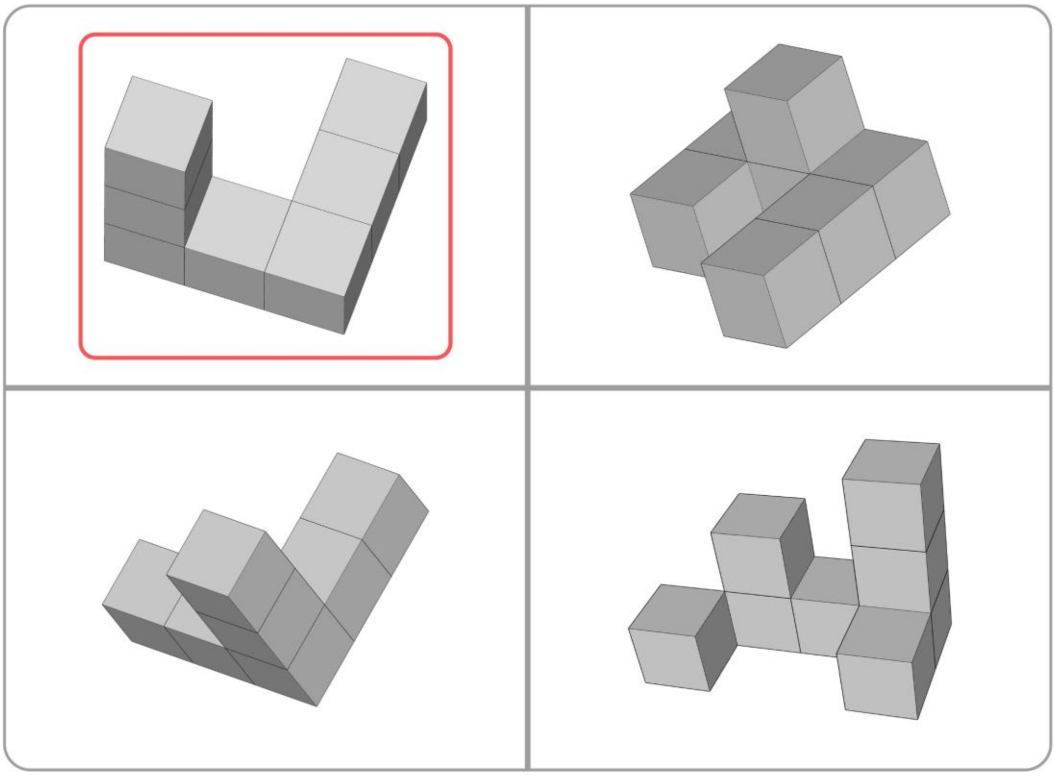
Pattern Matching Task

Stimulus .	Response
Stimulus Card -11	Match
	Non-match
	Non-match
	Match
	Match
Stimulus Card -12	Non-match
	Match
	Non-Match
	Match
	Match
Stimulus Card -13	Match
	Non-match
	Match
	Non-match
	Non-match
Stimulus Card -14	Non-match
	Match
	Match
	Non-match
	Match
Stimulus Card -15	Non-match
	Match
	Non-match
	Non-match
	Match

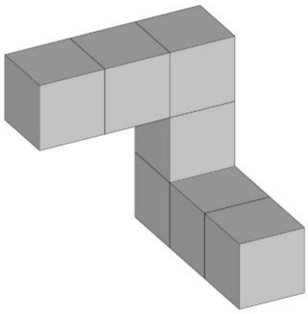
Mental Rotation Task

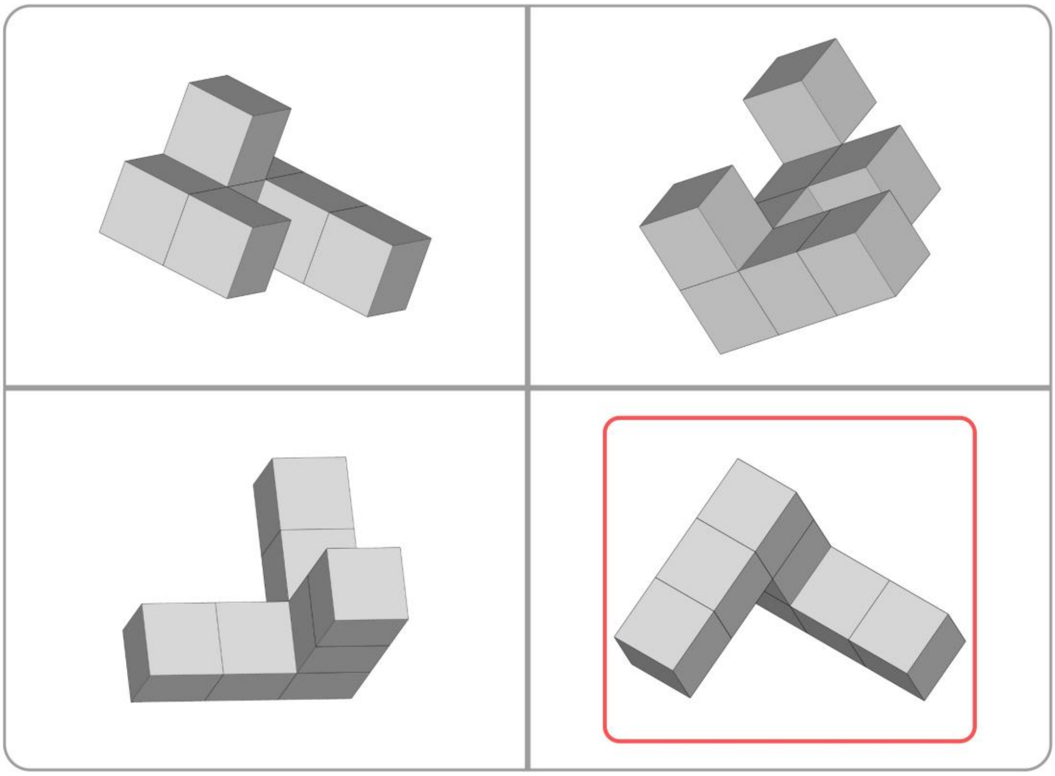
Target:





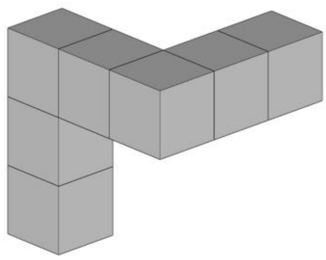
Target:

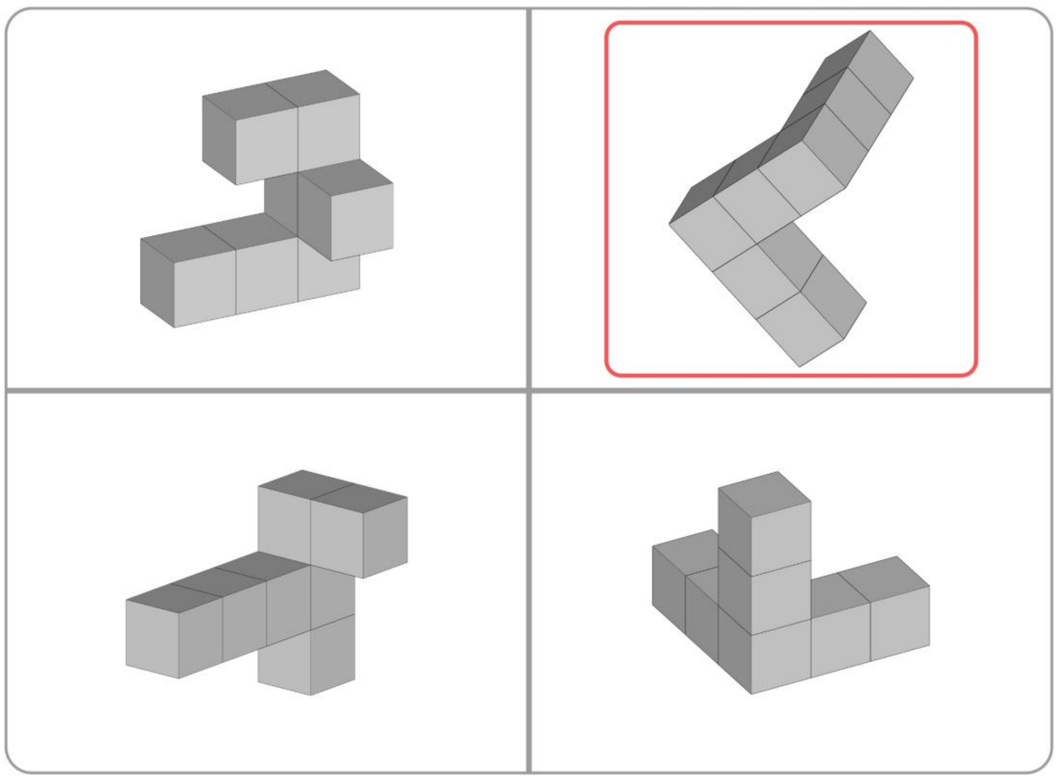




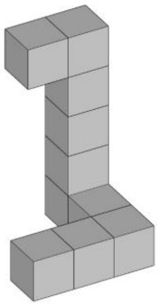
Response for stimulus card -18

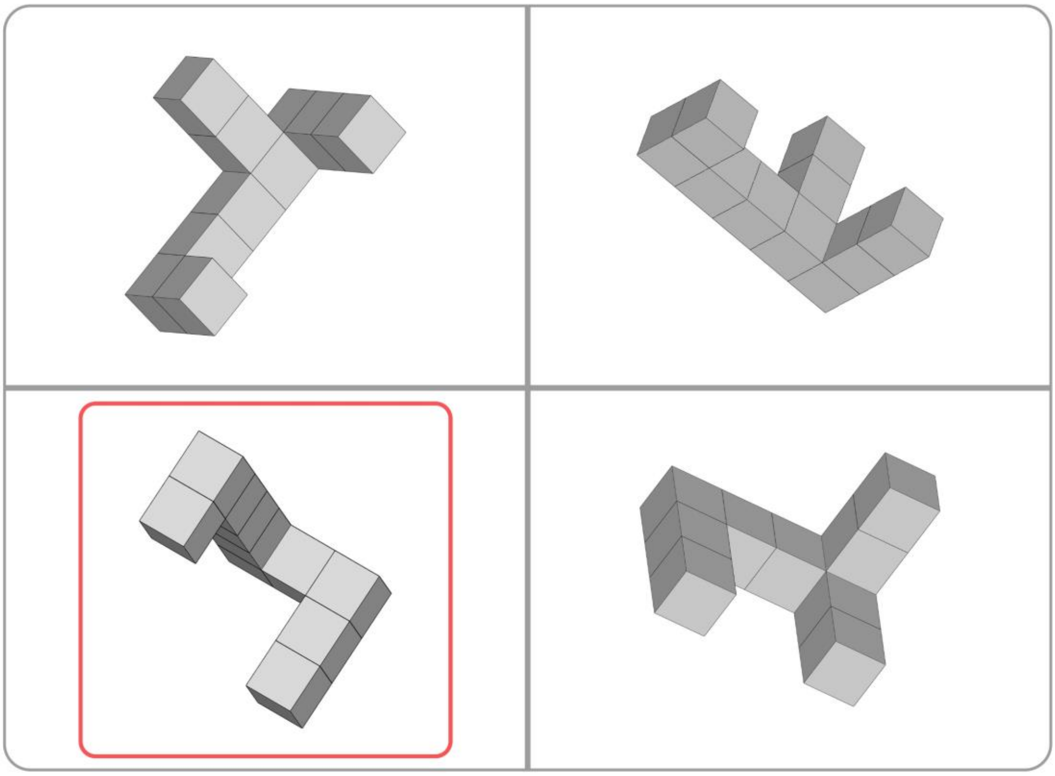
Target:



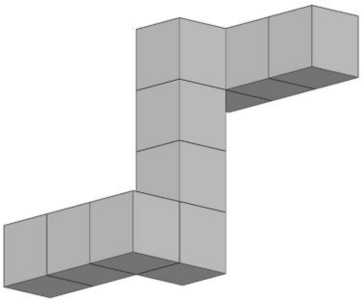


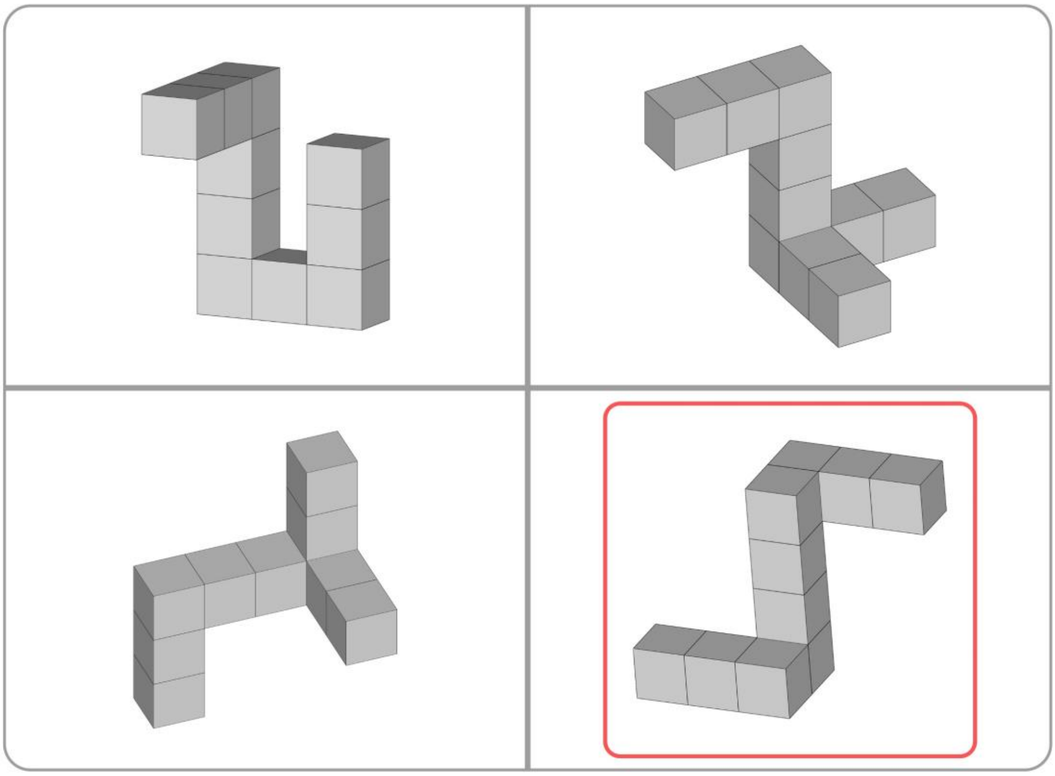
Target:





Target:





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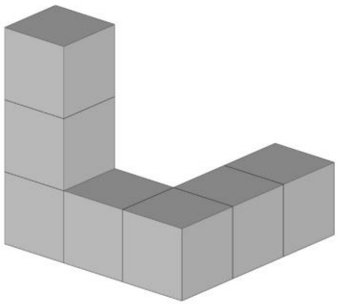
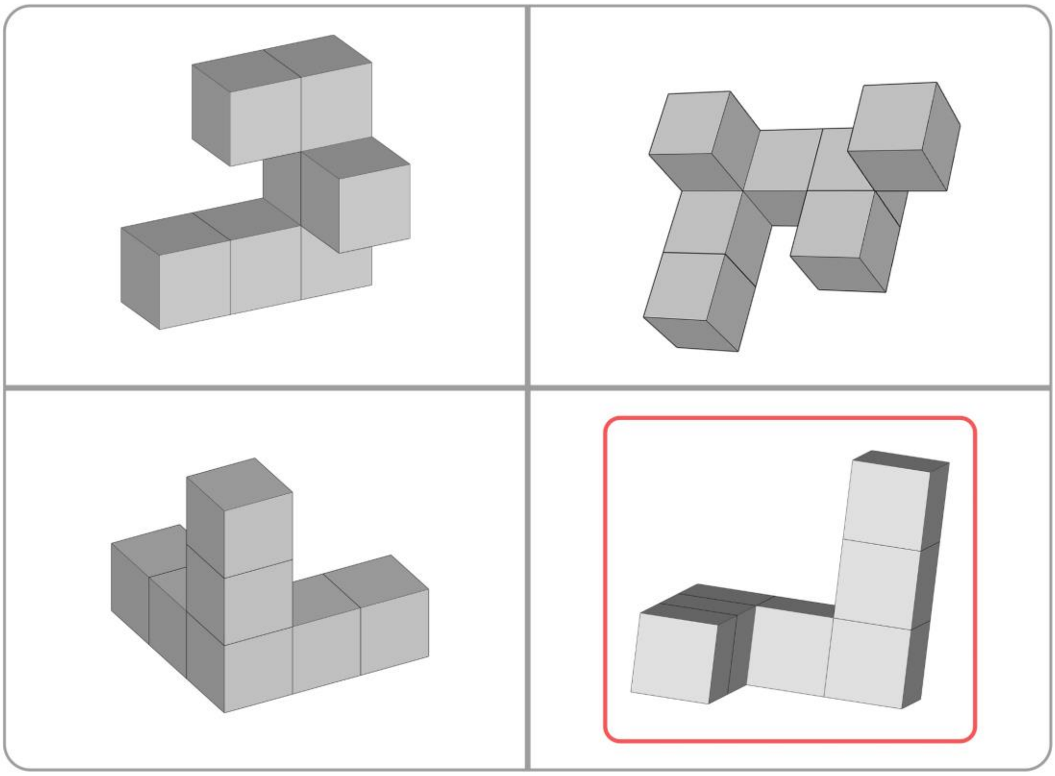
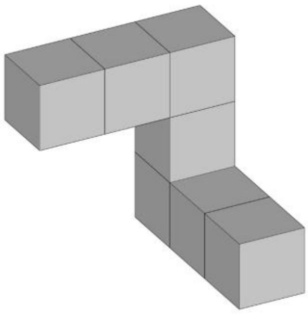
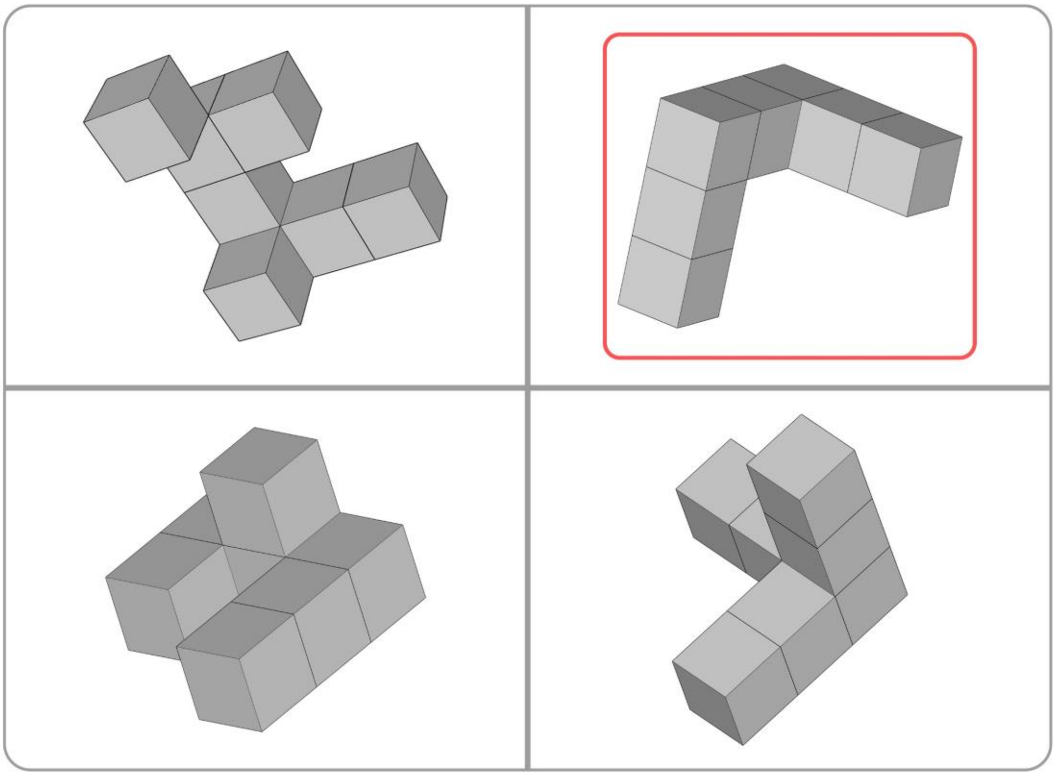




Response for stimulus card -22

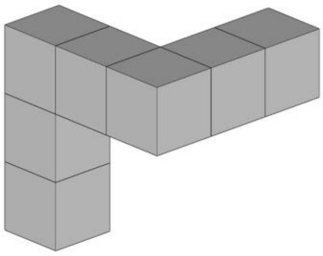
Target:

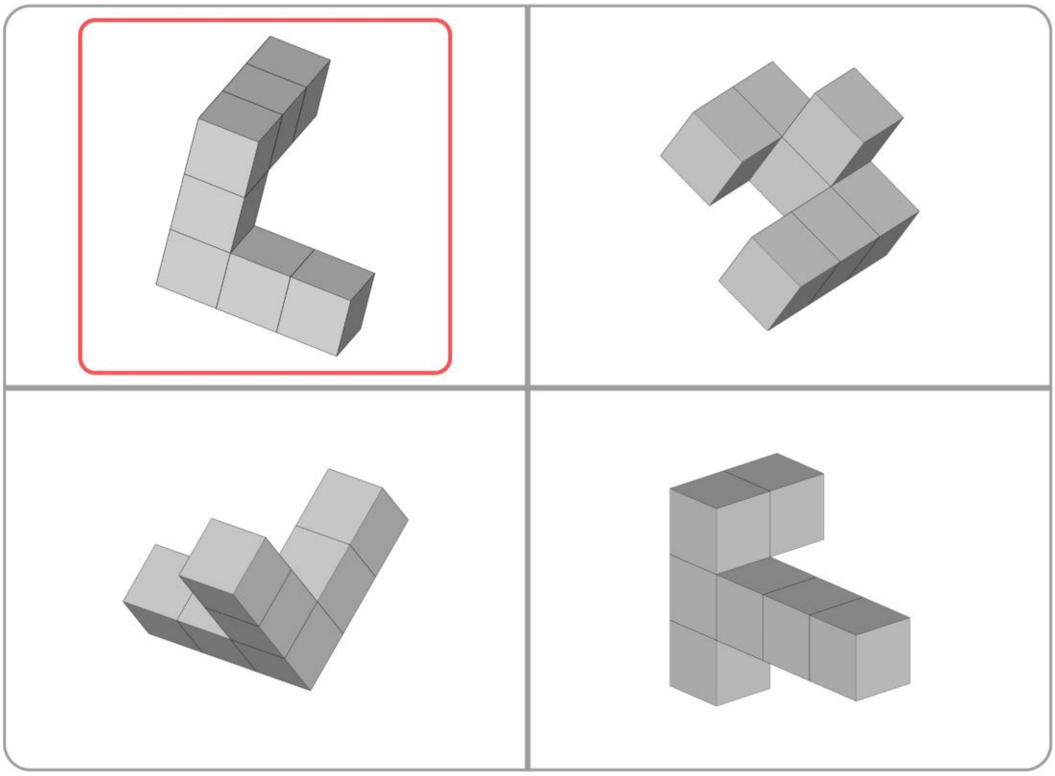




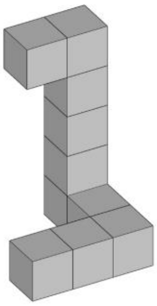
Response for stimulus card -23

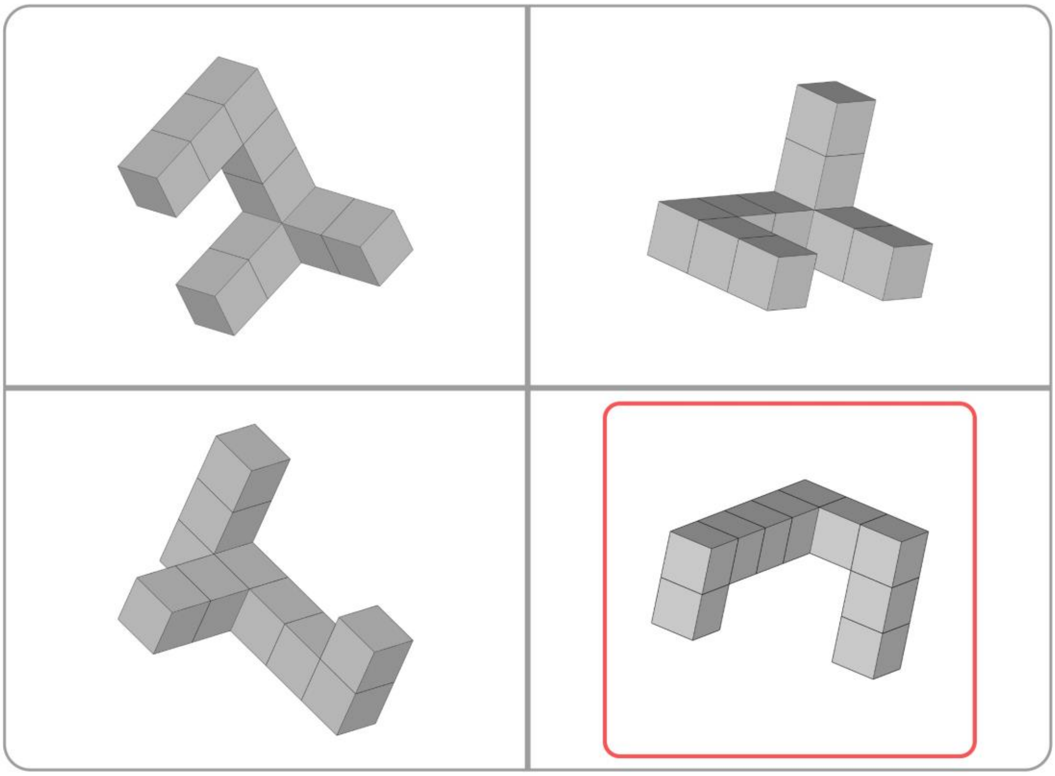
Target:





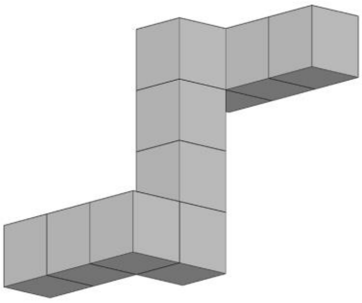
Target:

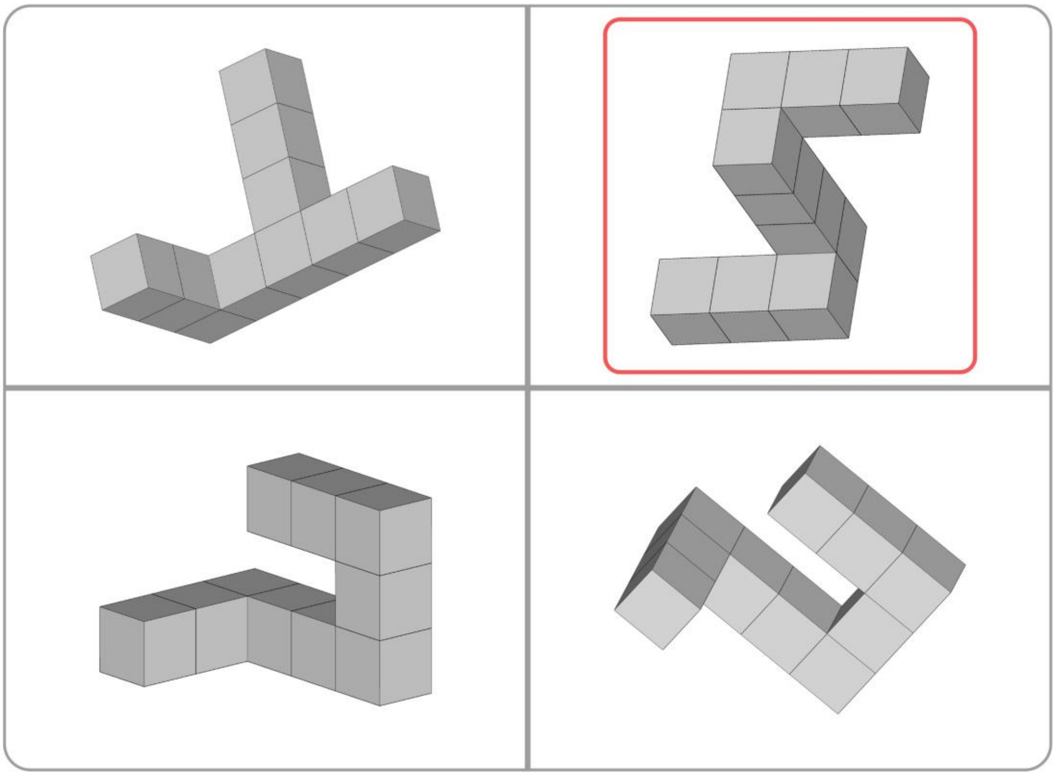




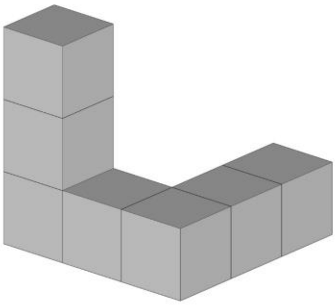
Response for stimulus card -25

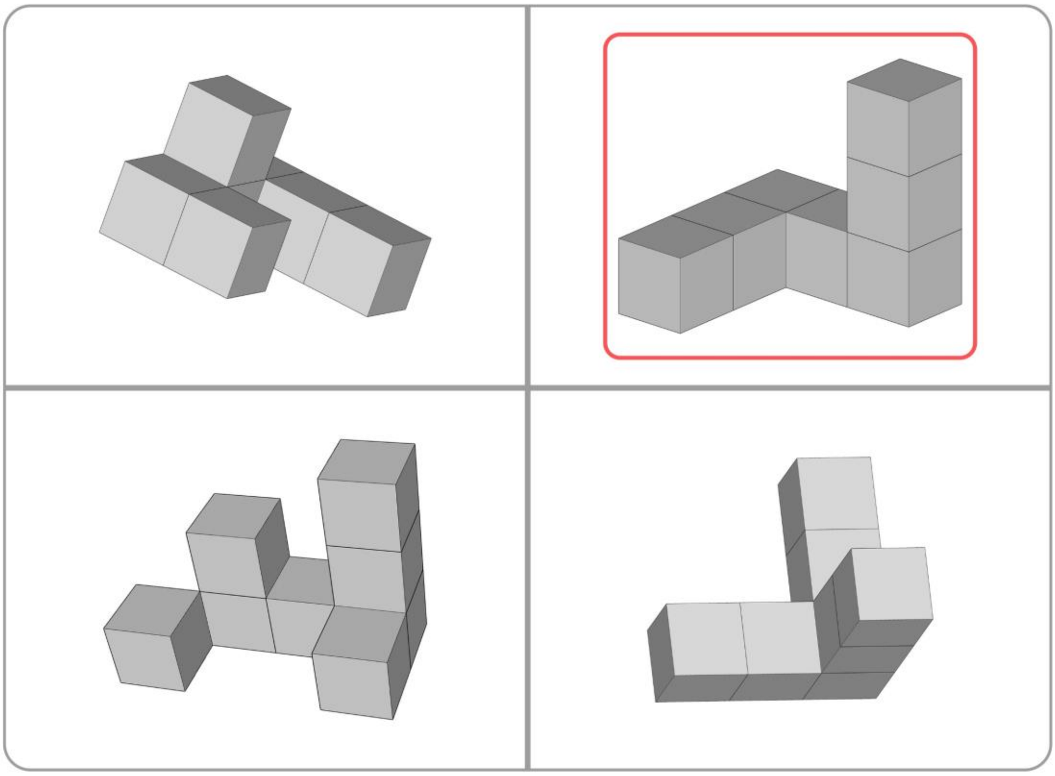
Target:



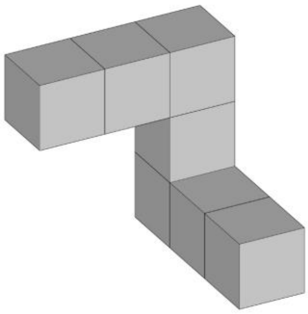


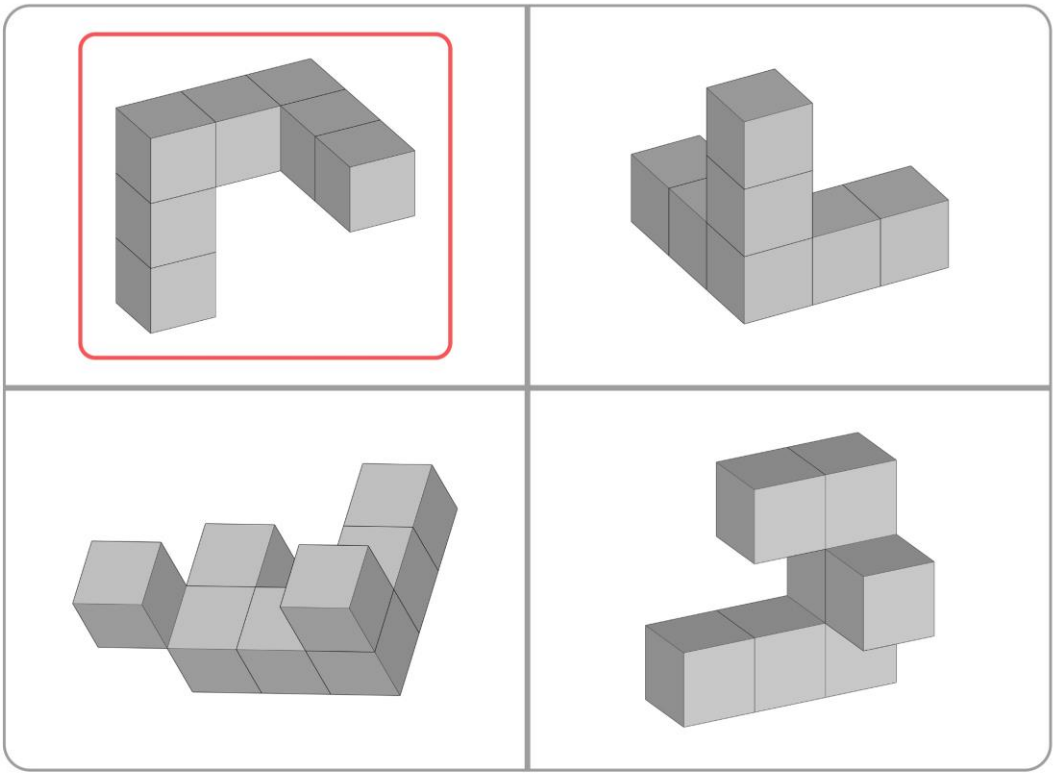
Target:

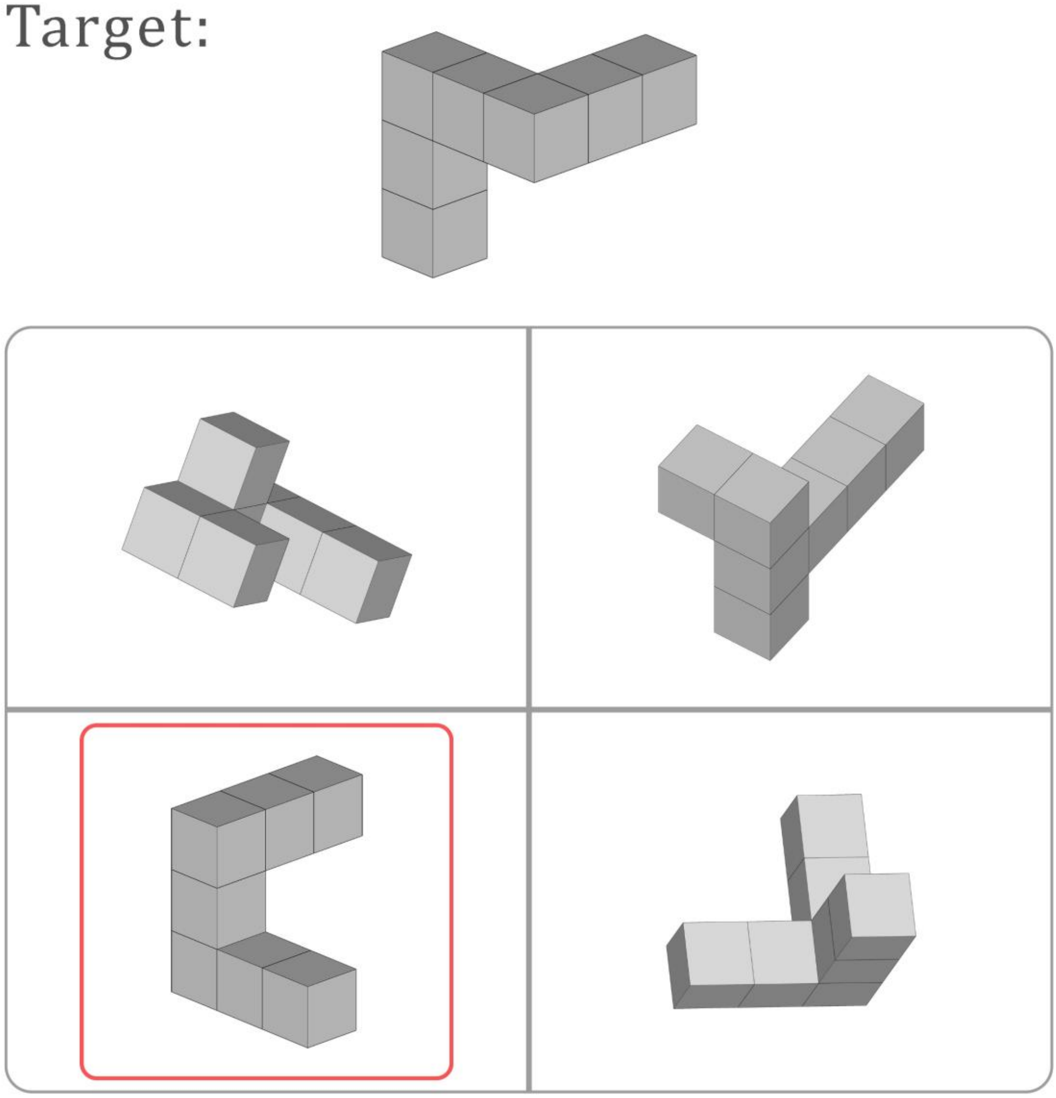




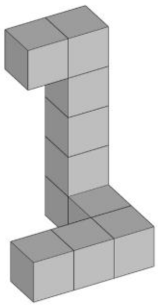
Target:

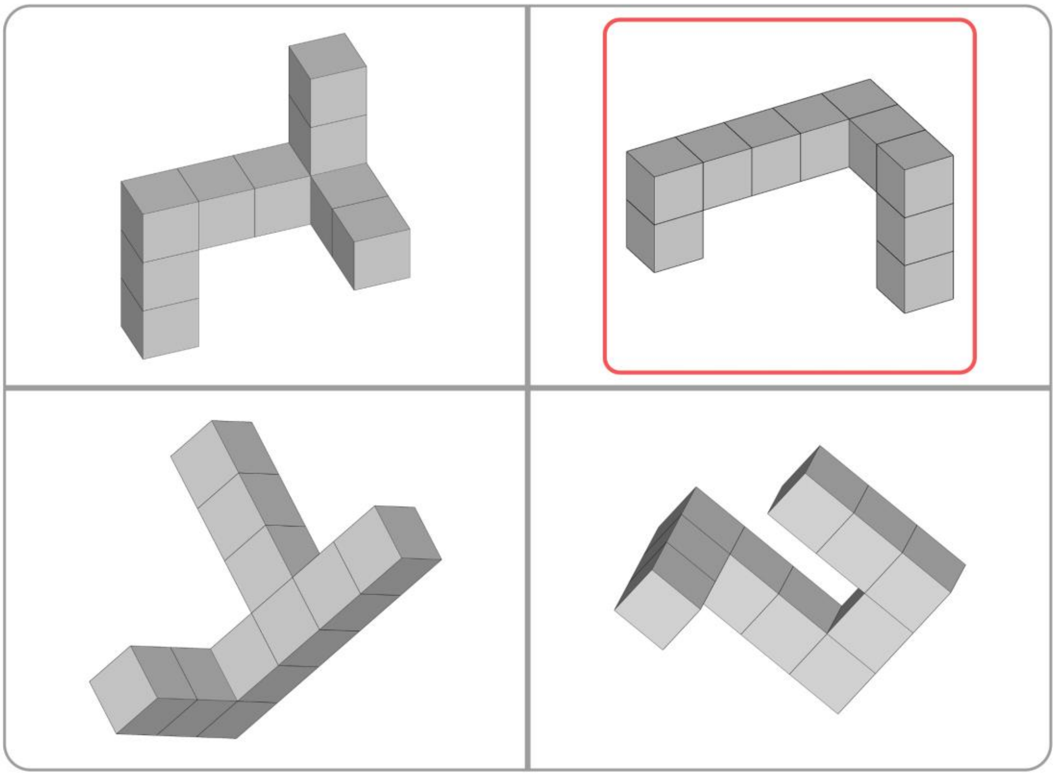





Target:

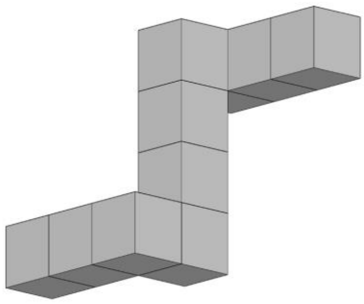
Target:

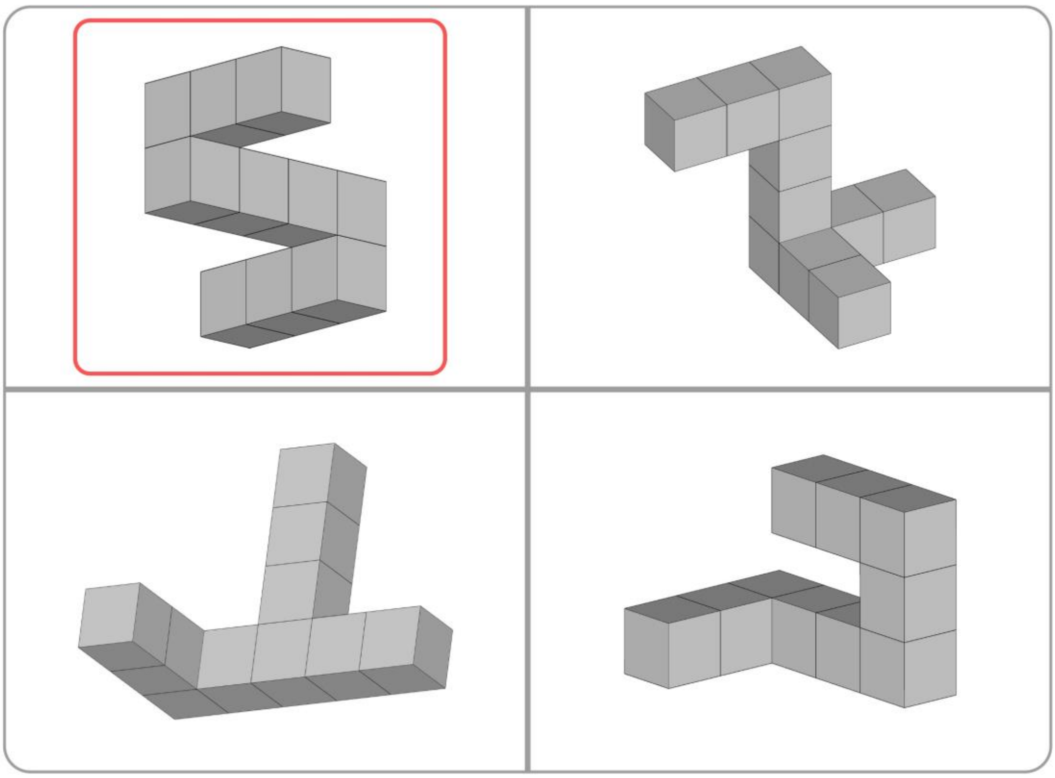




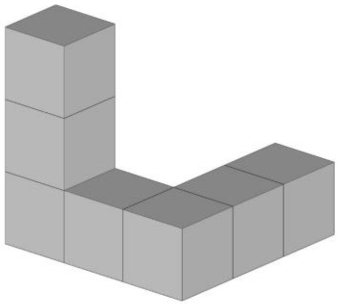
Response for stimulus card -30

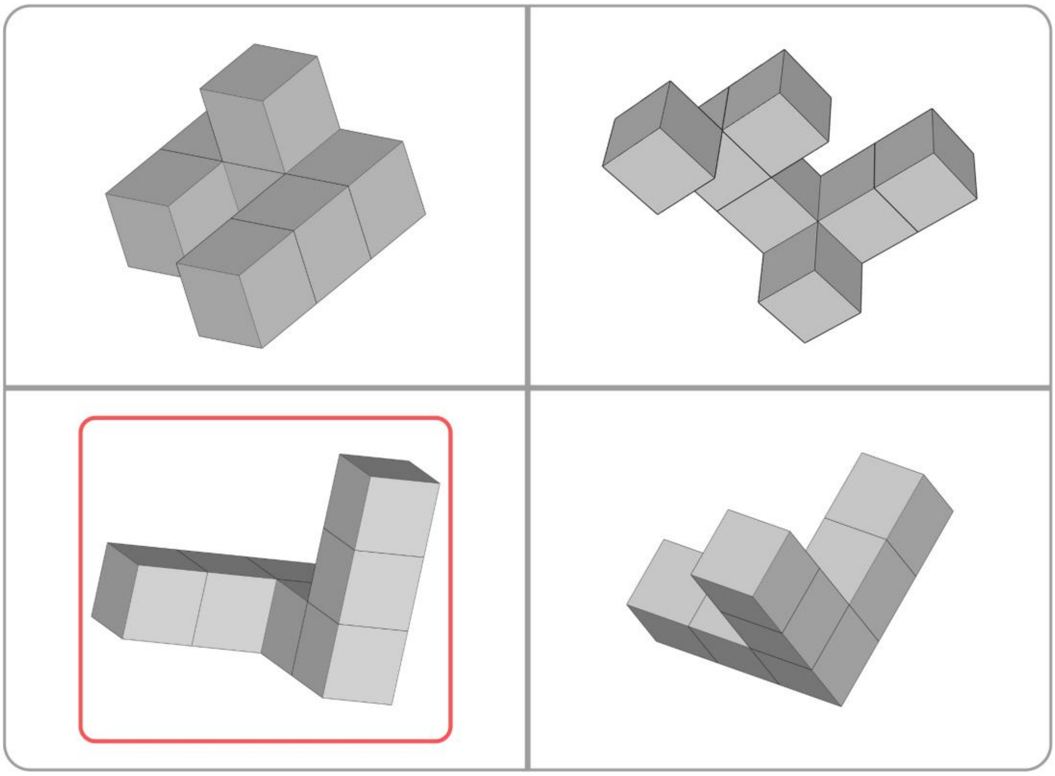
Target:



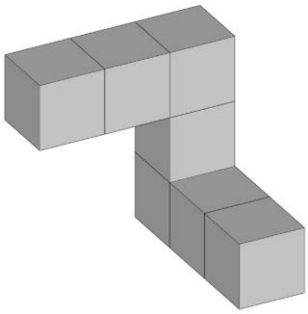


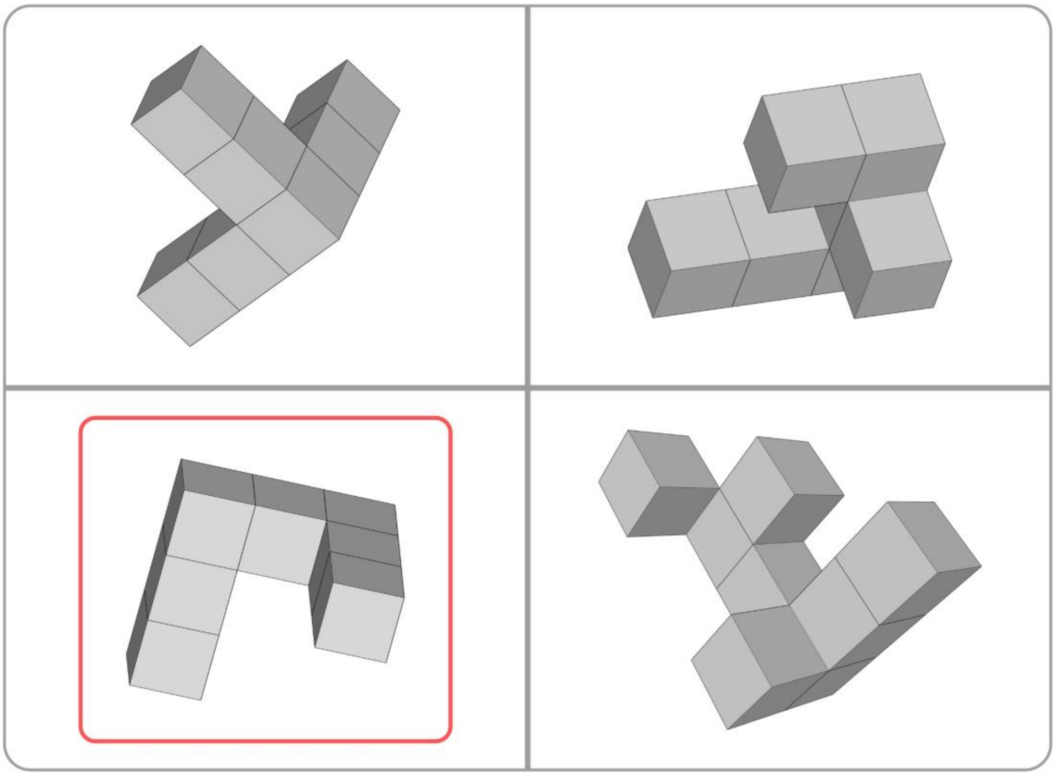
Target:



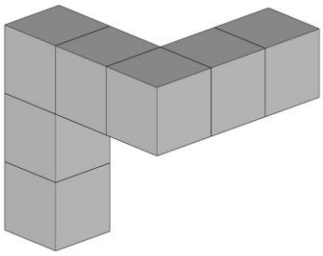


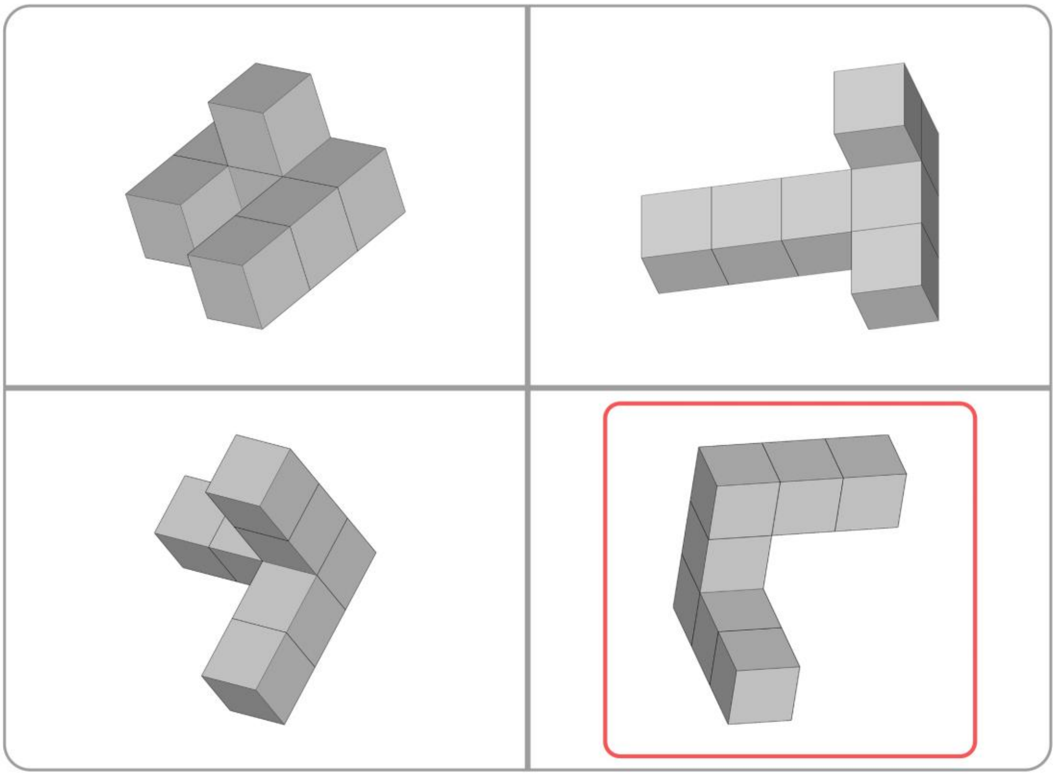
Target:



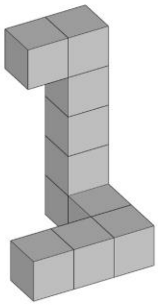


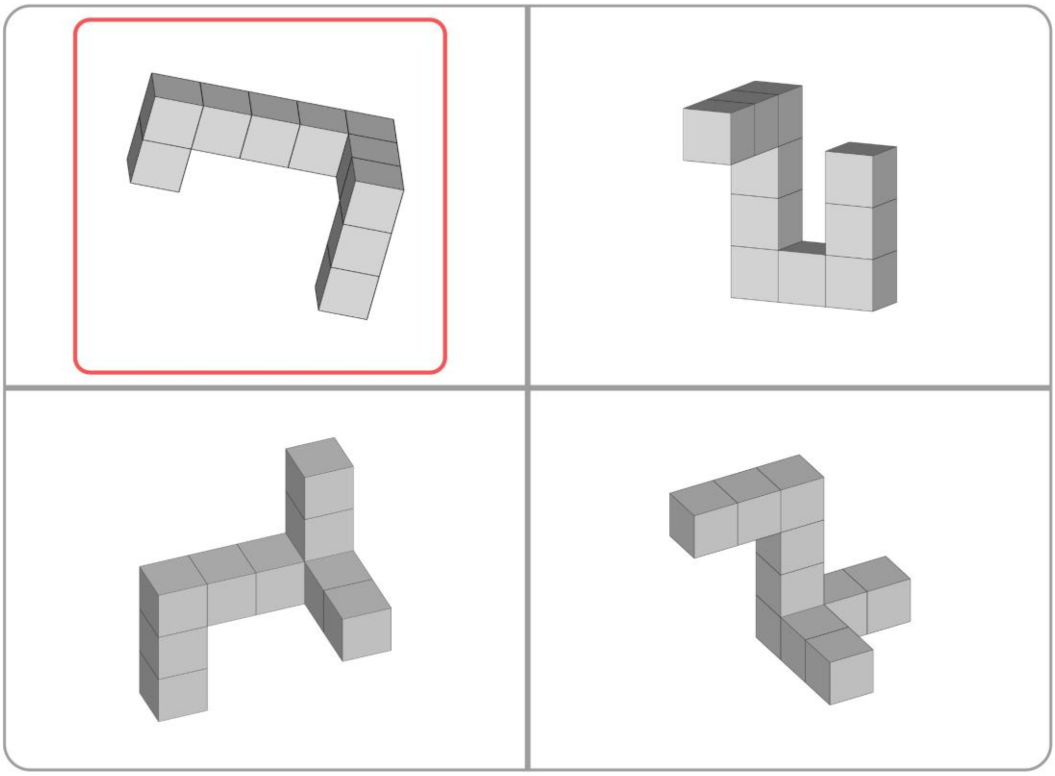
Target:





Target:





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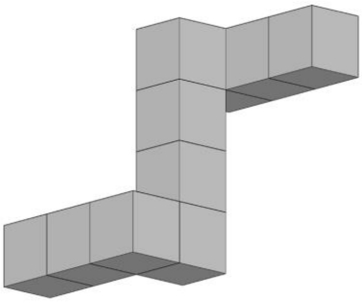
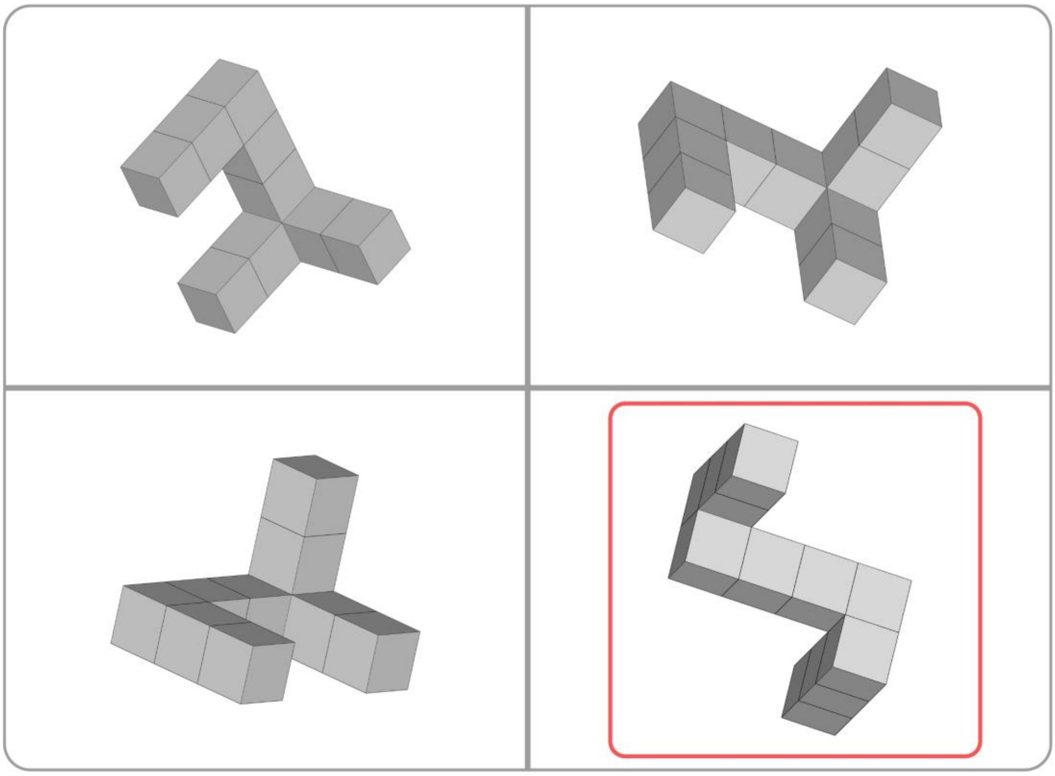
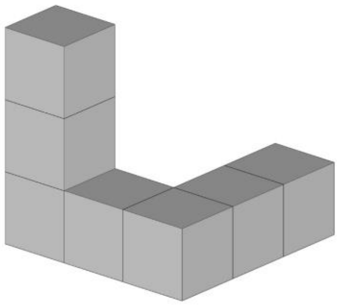
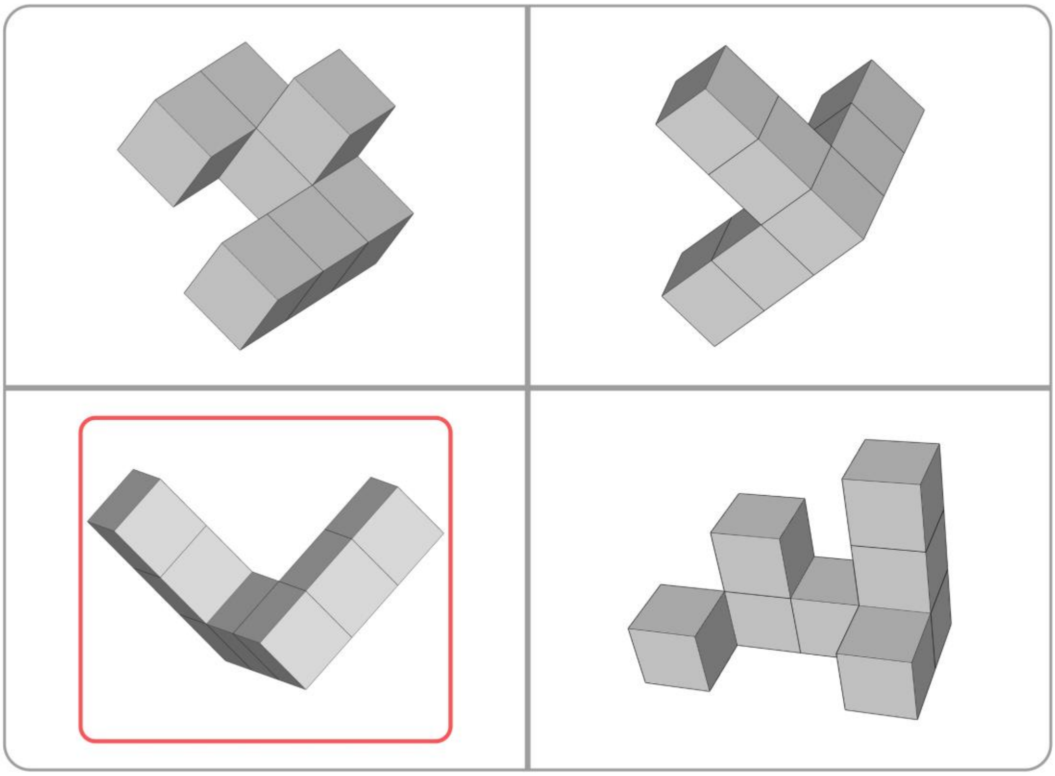


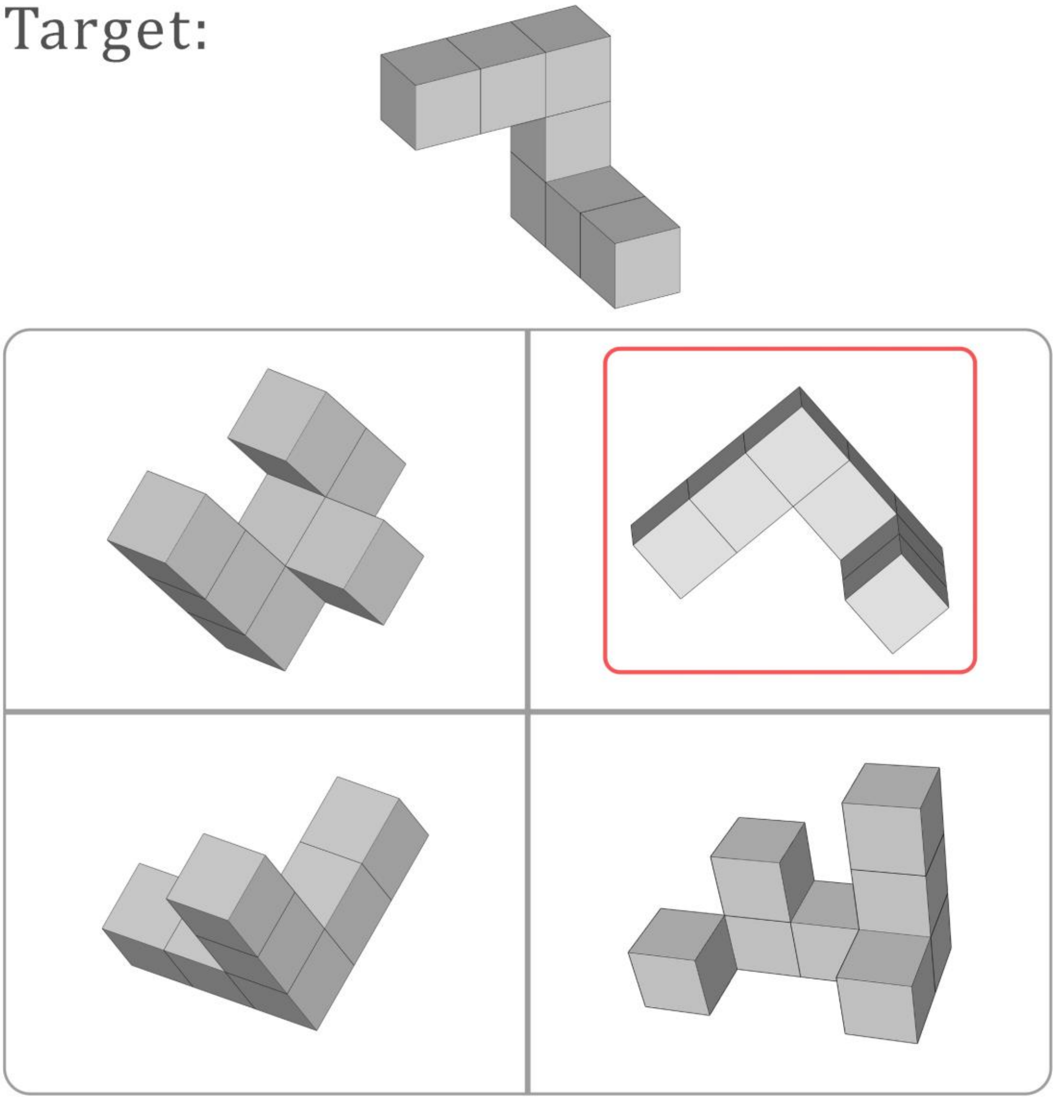


Target:

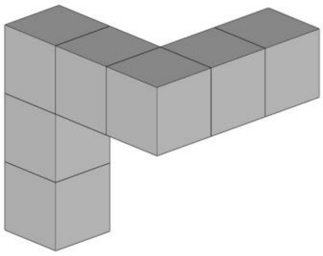


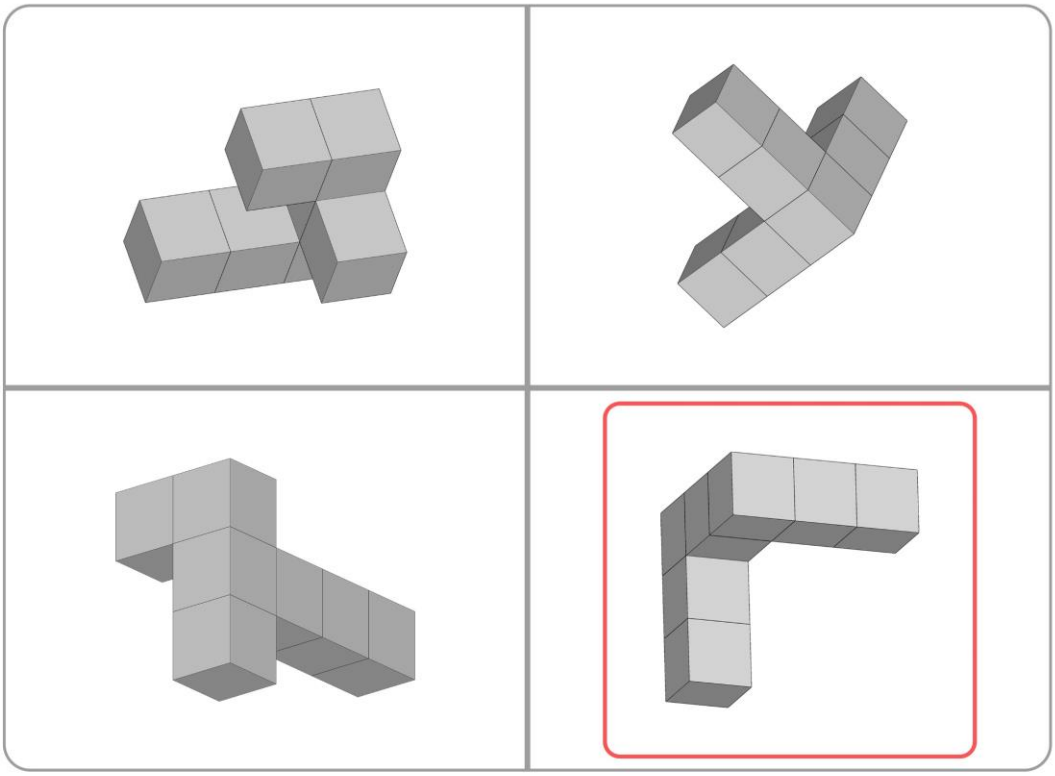


Target:

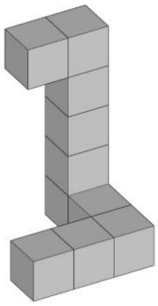


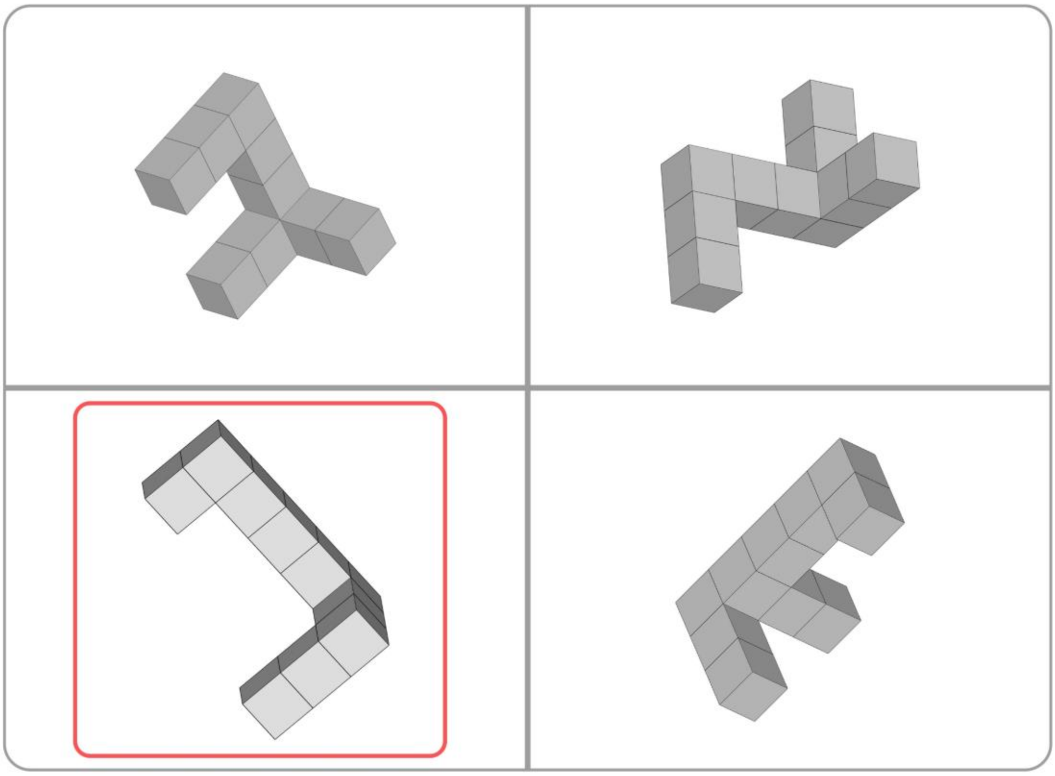
Target:





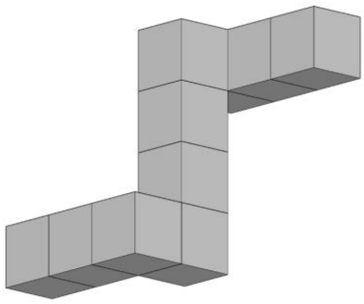
Target:

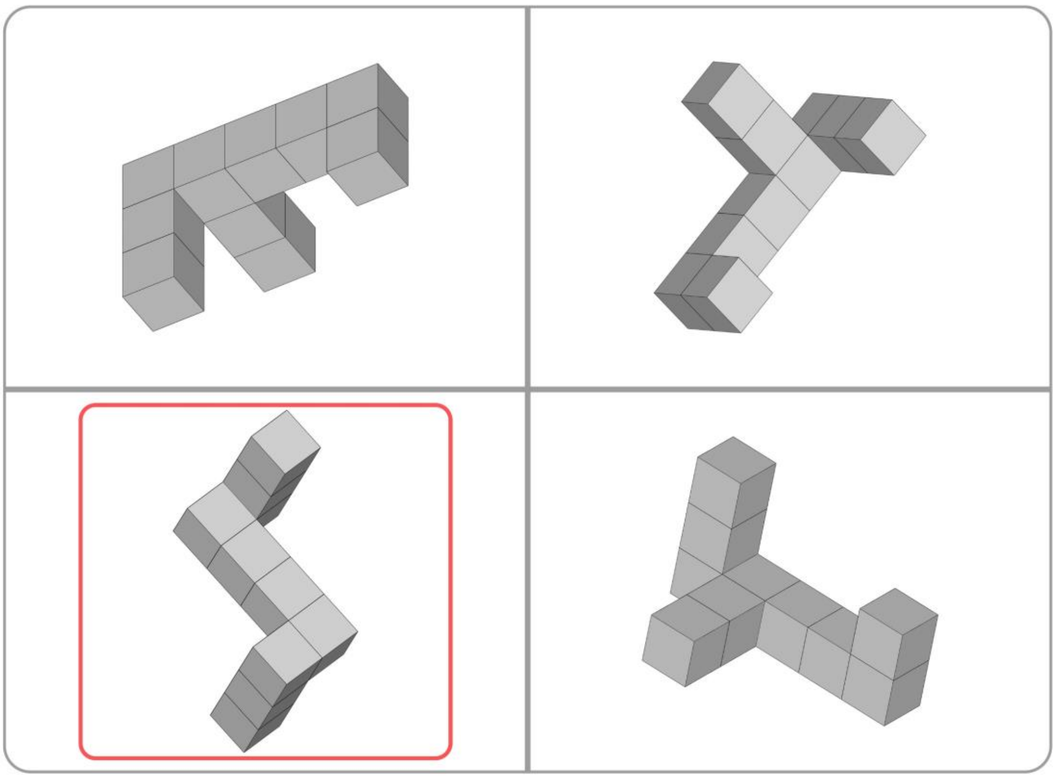




Response for stimulus card -40

Target:





Interpretation of Body Schema

Stimuli		Response
Stimuli 1	**Stimulus card -41**	Right
	Stimulus card -42	Left
	Stimulus card -43	Left
	Stimulus card -44	Right
	Stimulus card -45	Right
Stimuli 2	**Stimulus card -46**	Right
	Stimulus card -47	Left
	Stimulus card -48	Right
	Stimulus card -49	Right
	Stimulus card -50	Left

Appendix - D

MANUAL FOR VISUOSPATIAL ORGANIZATION ACTIVITIES FOR PERSONS WITH BRAIN DAMAGE

SCORE SHEET

Name: **Age/Gender:** **Case number:** **Date:**

Provisional Diagnosis:

Task	Stimuli	Score	Total score
Symbol cancellation task	Stimulus 1	---/5	---/25
	Stimulus 2	---/5	
	Stimulus 3	---/5	
	Stimulus 4	---/5	
	Stimulus 5	---/5	
Symbol trail task	Stimulus 1	---/3	---/25
	Stimulus 2	---/4	
	Stimulus 3	---/5	
	Stimulus 4	---/6	
	Stimulus 5	---/7	
Pattern matching task	Stimulus 1	---/5	---/25
	Stimulus 2	---/5	
	Stimulus 3	---/5	
	Stimulus 4	---/5	
	Stimulus 5	---/5	
Mental rotation task	Stimulus 1	---/5	---/25
	Stimulus 2	---/5	
	Stimulus 3	---/5	
	Stimulus 4	---/5	
	Stimulus 5	---/5	
Interpretation of body schema	Stimulus 1	---/5	---/10
	Stimulus 2	---/5	

Remarks:

Appendix – E

Validation form used for the constructed manual

Adapted from the Manual for Non-Fluent Aphasia Therapy in Kannada (Goswami et al., 2012)

Sl. No	Parameters	Very Poor	Poor	Fair	Good	Excellent
1.	Simplicity					
2.	Familiarity					
3.	Size of the picture					
4.	Color and appearance					
5.	Arrangement					
6.	Presentation					
7.	Volume					
8.	Relevance					
9.	Complexity					
10.	Iconicity					
11.	Accessibility					
12.	Flexibility					
13.	Trainability					
14.	Stimulability					
15.	Feasibility					
16.	Generalization					
17.	Scope of Practice					
18.	Scoring Pattern					
19.	Publications, outcomes and developers (Professional Background):					
20.	Coverage of parameters (Reception & Expression):					

Definition of parameters

1. Simplicity: Are the test stimuli comprehendible?
2. Size of the picture: Whether the picture stimuli are of appropriate size?
3. Color and appearance: Are the picture stimuli appropriate in terms of colour and dimension?
4. Arrangement: Whether the picture stimuli is within the visual field of an individual?

5. Presentation: Are the number of stimuli in each section placed appropriately?
6. Volume: Is the overall manual appropriate in size?
7. Relevance: Whether the test material is culturally and ethically acceptable?
8. Complexity: Is the material arranged in the increasing order of difficulty?
9. Iconicity: Does the picture stimuli appear to be recognizable and representational?
10. Accessibility: Is the test material user-friendly?
11. Flexibility: Can the stimuli be easily modified?
12. Trainability: Can the stimuli be used for intervention purposes in different milieu?
13. Stimulability: Does the stimulus material elicit responses from the individuals?
14. Feasibility: Whether the test material is viable?
15. Generalization: Can the test material be generalized to any other adult language disorders and various settings?
16. Scope of Practice: Is the test material within the profession's scope of practice or within the personal scope of practice?
17. Scoring Pattern: Whether the scoring pattern followed in the resource material applicable?
18. Publications, outcomes and developers (Professional Background): Is there any other resource material similar to this test material which you are aware of?
19. Coverage of parameters (Reception & Expression): Does the resource material contain the essential language components to be treated?