

Abstract geometric lines in a dark gray color, forming a series of connected segments that create a jagged, angular shape on the left side of the page.

IMPAIRED CHAIR PROPIOCEPTION

Paola Otero

ABSTRACT

The purpose of this project is to raise awareness about the sense of proprioception (perception of one's own limbs position). The concept of proprioception is explained through its components, evaluation tests, medical cases, fields of research and technological applications. In order to prevent injuries derived from proprioception loss, a new artistic method to communicate its significance has been created. Art provides the liberty to use creative expression approaches therefore a recognizable object is used as the base to communicate the concept of proprioception. The art piece is a chair with flexible joints. This property is hidden by a mechanism with the intention of deceiving the audience into believing the chair is only an ordinary chair. This illusion creates a parallelism between humans and objects proprioception. This thesis attempts to fill the gap between relevant medical topics and the general public knowledge, using art as the medium to communicate.

IMPAIRED CHAIR PROPRIOCEPTION

Master Thesis

Submitted in partial fulfillment of the requirements for the degree of the Master of Arts (MA) at the University of Applied Arts Vienna, Institute of Fine Arts and Media

Paola del Rocío Otero Talavera

Registration number: 1027886

Vienna, 18th of June, 2013

Program number: s 066 776

Study Program: arts & science

Supervisor: Virgil Widrich

Universität für Angewandte Kunst Wien

di: **angewandte**

Universität für angewandte Kunst Wien
University of Applied Arts Vienna

AKNOWLEDGEMENTS

The conception and realization of *Impaired Chair Proprioception* would not have been possible without the contribution of a number of people whom I am greatly in debt.

I would like to express my sincere gratitude to my tutor Virgil Widrich who support my concept and guide me through the organizational aspects of the process. As well as Juliana Herrero and Valerie Deifel who answer countless questions regarding the thesis requirements.

My appreciation for all the texts and research that Bernd Kraeftner suggested and his constant challenge to improve my knowledge.

I would like to thank Stefan Niedermair for his patience, emotional support and most importantly his knowledge in formal formatting which is present through the whole thesis.

My acknowledgement to the excellent English skills of Neda Ghiassi, who help me with the final proof reading.

I would like to thank my father, Luis Otero who help me keep the good sense of humor and positive thinking. My deepest gratitude to my mother, Olga Talavera, who never stop looking for doctors to help me with my undiagnosed proprioception problem, and who has support me in every aspect since I can remember.

Finally and most important, I would like to thank my twin sister, Katherine Otero, who was a psychologist, professor, friend, design consultant, science consultant, writing consultant, and many more through this thesis, the entire Master program and my everyday life.

TABLE OF CONTENT

I	INTRODUCTION
3	PROPRIOCEPTION - Medical Terminology - Proprioceptors - Learning proprioception - Impairment - Research and applications - Medical cases - Space medicine - Sports medicine - Robotics and artificial intelligence
12	EXPRESSION OF CONCEPTS THROUGH ART Found Object
14	IMPAIRED CHAIR PROPRIOCEPTION - Object/chair - Alteration of a chair proprioception - Cable-tensing system - Spring system - Extension springs - Design considerations - Mechanism Design - Assembly - Impaired Chair Proprioception Display
28	CHAIR ARTIST - Bicycle Wheel_Marcel Duchamp - One and Three Chair_Joseph Kosuth - Fat Chair_Joseph Beuys - Chair Events_George Brecht - Office Chair,Chairs and Aktion Kurhaus Weissbad_Roman Signer - Cory's Yellow chair_Arthur Ganson

INTRODUCTION

Some of us have experienced spilling a glass of water, running into a wall, dropping our cellphones from our hands or at the very least, some sort of poor limb coordination when we are tired. Granted that these experiences may not be considered a big problem, understanding its root is of great importance. The same sense impaired in those experiences is the one that allows us to walk without looking at our feet or having to think how to make a step. We move our limbs in a subconscious manner, and precisely that is the reasons why we are unaware of the existence of this sense.

Proprioception, also known as the sense of “self-awareness” is how we perceive information regarding the position of our limbs and its relation to our environment. It is hard to imagine ourselves in a situation where we do not know that information and where the people surrounding us are incapable of understand what it means. In the book ***The Man Who Mistook His Wife for a Hat***, Oliver Sacks describes the case of a woman he called the Disembodied Lady.

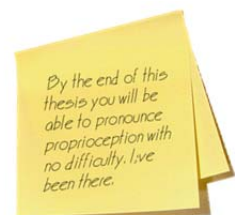
... society lacks words, and sympathy, for such states. The blind, at least, are treated with solicitude we can imagine their state, and we treat them accordingly. But when Christina, painfully, clumsily, mounts a bus, she receives nothing but uncomprehending and angry snarls: ‘What’s wrong with you, lady? Are you blind—or blind-drunk?’ What can she answer—‘I have no proprioception’? The lack of social support and sympathy is an additional trial: disabled, but with the nature of her disability not clear—she is not, after all, manifestly blind or paralyzed, manifestly anything—she tends to be treated as a phony or a fool. This is what happens to those with disorders of the hidden senses...¹

We can **approach proprioception** from many different angles, though one fact remains unalterable, we often become aware of proprioception when we lose it to some degree. The reason for it resides in the information perceived by the affected sensors. Whether it is because the information is not perceived, it is new, altered, interrupted or simply because it is insufficient.

With this in mind we can argue that if the proprioceptive system does not exist to us, neither do its components nor implications.

In order to bring proprioception to existence I take an ordinary object that is part of our reality and transform it. Through this transformation the perception of the object’s reality changes and in consequence so does the perception of the users’ own reality. The object is an ordinary chair that has consequence so does the perception of the users’ own reality. The object is an ordinary chair that has an impaired proprioception; by using it the user will become aware of his or her proprioception.

¹ Sacks O (1985). *The Man Who Mistook His Wife for a Hat, and Other Clinical Tales*. Summit Books.



PROPRIOCEPTION

Medical Terminology

The etymology of **proprioception** comes from the latin *proprius* meaning "one's own". *It is the ability to sense stimuli arising within the body regarding position, motion, and equilibrium.*² Proprioception is sometimes referred as a "self-perception" but this simplistic description does not reflect the complexity of the term.

It was first defined in 1906, by Charles Sherrington, when he introduced the classification of the senses. By analyzing the total action system he categorizes actions into 3 classes of performances: *exteroceptive*, *interoceptive* and *proprioceptive*. The *exteroceptive system* comprises responses to external stimulation adjusting the body to outside events perceived by our eyes, tongue, nose, ears and skin. The *interoceptive system* is concerned mainly with internal organs regulation and propagation. The proprioceptive system exerts regulatory control over the action of the skeletal muscles.

In other words it is a sense or perception, usually at a subconscious level, of the movements and position of the body and especially its limbs.

Proprioceptors

The proprioceptive system receives the information from the proprioceptors, the **muscle spindle**, the **Golgi tendon organ** and the **pacinian corpuscle**. These are specialized sensory nerve terminals found in muscles, skin and tendons combined with fibrous capsules in the joints.

*The traditional view is that signals from muscle spindles provide us with our sense of limb position. However, the present-day view is that the sense of effort would play a more important role in joint position sense than once thought.*³

Some would argue that the proprioceptive system also receives input from the vestibular apparatus in the inner ear but in order to avoid confusion with the sense of balance we will exclude this notion from this text.

² MEDICINENET, INC. Definition of Proprioception. Accessed May 31, 2013, <http://www.medterms.com/script/main/art.asp?articlekey=6393>

³ FORTIER S, BASSET FA (2012). The effects of exercise on limb proprioceptive signals. Journal of Electromyography and Kinesiology, Volume 22, Issue 6 , Pages 795-802, December 2012

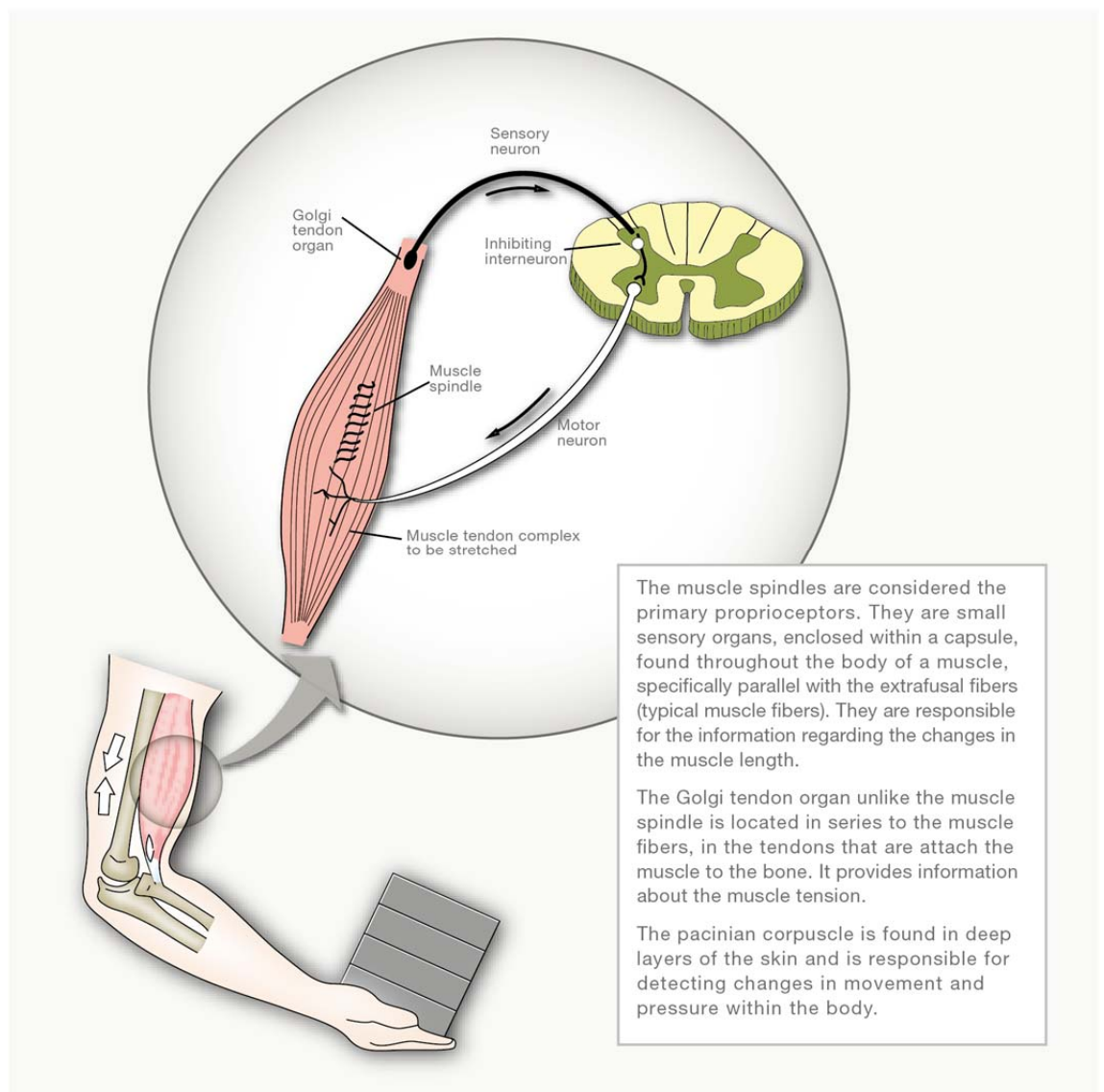


Fig. 1: Proprioceptors (Images: Pearson Education, Inc. and Christopher Gagliardi)

Learning Proprioception

The proprioceptors help us produce sensory information through our lives; this is how we learned to walk with closed eyes without falling for example. Our brain sends the command to move our leg but the proprioceptors in our leg teach the brain how to make a step. We can extend this explanation to a variety of human activities, such as: painting without looking at a canvas, driving a car without looking at the pedals, typing on a keyboard while looking at the screen or eating without looking at our spoon.

What this implies is that allegedly without visual cues our bodies know the position of the different body parts at any time during a movement and have an accurate map of their location in space (Douglass E. 2013). The body relies on the proprioceptive system to achieve such precise placements.

Impairment

An ironic fact about proprioception is that even when it is the sense of “self-awareness”, we are not aware of its existence until there is an impairment of it. We might have all experienced a temporal loss of proprioception during growth, due to drastic differences in body weight, size or muscle mass. Impairment can also occur when we acquire new levels of flexibility and contortion, mostly experienced in sports and dance. *Different factors such as injury, cognitive distraction, muscle exercise, and inactivity have been demonstrated to impair proprioception.*⁴

Proprioception is occasionally impaired spontaneously, especially when a person is tired. Muscle contractions have a considerable effect on joint position sense. The damage and inflammation of the muscles tissues are thought to affect the proprioception feedback.

Most of us would not consider attending therapy for a temporal loss of proprioception. Even if we suspect a chronic impaired proprioception there are few therapies considering any stimulation of this sense; the majority of the joint and posture therapies focus on muscle gain. Eventually most of us will have to deal with proprioception since research shows that over 80% of the population over 70 presents some proprioceptive loss. What aggravates this situation is the fact that most of the research is being done on what proprioception is responsible for rather than how to rehabilitate it. (Douglass E.2013)

There is a considerable amount of research in proprioception; most of it has being done in the medical field combined with sports, space science and artificial intelligence. It is interesting to go through some of the cases to have a wider understanding of how proprioception is studied, evaluated and the results applied.

Research and Applications

There are different protocols to evaluate proprioceptive capabilities, most of the tests limit visual cues and compare bilateral abilities by measuring both limbs. Some are based on position, force-matching tasks or specific measures of speed and motion. The general consensus is that a movement control is highly dependent on the quality of the information perceived by the proprioceptors.

Much of the research has been dedicated to discover what actions proprioception hinders, but little has been done to help those with proprioceptive loss. In most cases patients with impaired proprioception are

⁴ same as ³

taught to use visual and auditory aids thus help themselves to control their movements; the conflict remains on the patients who also experience loss of those senses.

The most common evaluation protocol is the *field sobriety test*. The task consists in touching the nose with eyes closed; under alcohol intoxication the subject will be off the target for at least 20mm. The alcohol disturbs the proprioceptive signals perceived by the sensors altering the information that reach our brain.

Another case that might sound familiar is an experiment known as the **Rubber Hand Illusion**, first demonstrated by Botvinick & Cohen in 1998. A person is sitting in front of a table and one hand is placed out of sight or below the table. A rubber hand is placed on the table and the experimenter starts to simultaneously touch the rubber hand and the subject's hidden hand in synchronization. The participant sees the fake hand being touched and at the same time perceives this touching with the tactile sense of the real hand. After a few minutes the participant starts believing that the fake arm is his or her real arm. He or she feels their own arm placed where the rubber arm is due to the mixed information from the proprioception and visual inputs. Further alterations on this experiment, by Armel & Ramachandran, involve threatening the rubber arm by folding the rubber finger in an unnatural manner, visually perceived as painful. They even suggested that the experiment can work with just a painted hand over the table. *Others like Ijsselstein produced a virtual arm illusion projecting the hand, and Slater with a stereo head-tracked imagery. Most recently it has been shown using a head-mounted display showing stereo real-time video imagery that an illusion similar to the rubber hand illusion can be induced for the whole body*⁵

Medical cases

There are several case studies on proprioception. As already pointed out, one of the most famous was reported by Oliver Sacks in his book: *The Man Who Mistook His Wife for a Hat*. Sacks considers that to be aware of our bodies we rely on three things: vision, vestibular system and proprioception. In this case a woman lost her proprioception due to a viral infection of her spinal cord. This affected her proprioception and as a consequence she could not walk without watching her own legs or talk without listening to her voice.

Another case presented by Blouin in 1995, tried to understand the deficits caused by the lack of neck and body proprioception. The patient was first moved in the presence of light and then moved in the absence of light. Without visual cues her body perception was disrupted; like Sacks' case she needed visual feedback to determine the position and movement of her body.

Some studies specifically on joint proprioception based their experiments on the movement of a limb. For example Sainburg, Ghilardi, Poizner, and Ghez's (1995) demonstrated that a subject with impaired proprioception would describe a circular movement in an attempt to cut bread instead of the expected back and forward movement.

⁵ YUAN Y, STEED A (2010). Is the rubber hand illusion induced by immersive virtual reality? Proceedings of the 2010 IEEE Virtual Reality Conference, Pages 95-102

A particularly interesting subject to study in relation to proprioception is muscular fatigue because it is a familiar phenomenon to all of us. Researchers at the at McGill University, Faculty of Medicine, were interested in estimating to which extent muscular fatigue alters the proprioception of the upper extremity in healthy adult subjects. Any disturbance of this sense can cause instability in the joints and make them susceptible to injuries. The subjects were not able to reproduce the position of the limb but its orientation was not significantly affected.

Among the disciplines involve in the study of proprioception, two particular disciplines stand out, space medicine and sports medicine. Both study the human body under very demanding conditions. In space medicine the state of microgravity generates interesting complications for the proprioceptive system whereas in sports the quality of the proprioception can determine the performance of an athlete or prevent injuries.

Space Medicine

The classic example of proprioception in space medicine is called *space sickness*. In the absence of gravity the stimuli perceived by the proprioceptors are altered causing an impact in spatial orientation. To be more precise, knowledge on the position in the passive limb, accuracy in targeting during voluntary limb movement, modification of tactile sensitivity, and changes in the perception of mass, are affected. It is easily noticed when the astronauts try to touch their limbs without any visual cue and discover they are not where expected. The proprioceptive system can be fooled. Without the stresses in the joints usually caused by the pull of gravity, this sense is sometimes dampened (Science@NASA. 2013).

*Studies conducted during the French-Soviet orbital flight in 1988, have shown that the proprioceptive information contributed, together with the visual, vestibular, and sole cutaneous information to the postural regulation. It is possible that the proprioceptive adaptations are partly attributable to the new whole-body propulsive foot functions imposed by exposure to weightlessness and to the adaptation of motor behavior to the third dimension of space.*⁶

*Following their return to Earth, crewmembers experienced disturbances in their ability to walk and maintain postural stability due to neural adaptation to the microgravity conditions of spaceflight.*⁷ Therefore it is very important to develop training programs to help the astronauts recover the locomotor function by enhancing the sensomotor adaptability and facilitate re-adaptation to the gravity of Earth.

⁶ ROLL JP, POPOV K, GURFINKEL V, LIPSHITS M, ANDRÉ-DESHAYS C, GILHODES JC, QUONIAM C (1993). *Sensorimotor and perceptual function of muscle proprioception in microgravity*. Journal of Vestibular Research: Equilibrium & Orientation [1993, 3(3):259-273]

⁷ BLOOMBERG JJ (2008). Development of a Gait Adaptability Training Program as a Countermeasure for Post-Flight Locomotor Dysfunction. <http://www.nsbri.org/projects/indivProject.asp?id=455&projID=148>



A nice illustration of an alteration of proprioceptive inputs during the early exposure to microgravity is the impossibility for an astronaut to maintain a vertical posture, perpendicular to the foot support, in absence of visual information. Their bodies are tilted forward suggesting a recalibration of the proprioceptive inputs from the ankle joints is needed.

Fig.2: Altered Proprioception in Astronauts

Sport Medicine

As previously stated, proprioception plays a major role in sports disciplines. *Understanding and developing the proprioception sense is crucial for coordinated movement, when there is a deficit in proprioception, controlled movements are impossible without continuous visual guidance, maintenance of force or position are severely impaired, and a tremor develops.*⁸ *This is particularly relevant for ballet dancers where excellent balance and coordination are the key to a successful performance. In ballet, the postural stability requires adequate proprioception from the ankle joint.*⁹

In most ball related sports proprioception, sensing our joints, is what determines the precision of the movement.

In addition to performance, proprioception is very important to prevent injuries, unfortunately though, considering proprioception as part of a regular training is only common in professional and elite athletes.

⁸ same as ³

⁹ LEANDERSON J, ERIKSSON E, NILSSON C, WYKMAN A (1996). Proprioception in classical ballet dancers. A prospective study of the influence of an ankle sprain on proprioception in the ankle joint. The American Journal of Sports Medicine, 1996 May-Jun;24(3):370-4

Almost every professional athlete began a sport while still a child or an adolescent but the difference in proprioception in children compared to adults has not yet been thoroughly studied. (Fayaz S. 2009).

Furthermore, it is important to study the consequences of an injury and how the therapy or surgery affects the proprioception of the patient. Some surgical procedures seem to restore the proprioceptive abilities, meaning that they not only reconstruct the anatomy, but also the neurophysiologic feed-back mechanism. (Jerosch J, Prymka M. 1996).

The typical athlete injuries occurs mostly in the joints, for instance, anterior cruciate ligament, meniscus tears, shoulder dislocation and ankle sprains, being the most common.

Robotics and Artificial Intelligence

Regardless of the vast research that disciplines, such as medicine, sports and space have done on proprioception, technology has yet little invested in it. Few examples of proprioception-technology collaboration are worth to mention: the advances in virtual proprioception and the use of proprioception for artificial intelligence.

Recent and novel applications incorporate wireless accelerometers as an artificial form of proprioception. We can imagine the scope that this can reach considering that most of our mobil devices have accelerometers. An accelerometer system has the capability for quantitative evaluation of locomotion and movement disorder. *It provides the spatial representation imperative for the inertial navigation system of robotic applications, which is analogous to a proprioceptive system in humans (Golgi tendon organs and muscle spindles). Wearable accelerometers are capable of providing artificial proprioception, which can be efficiently stored in a database and post-processed for potential diagnostic interpretation.*¹⁰

The relation between virtual technologies in human environments can be inverted using human proprioception in virtual environments. A virtual environment is usually difficult to navigate due to the lack of haptic feedback with real objects; this can be improved by implementing a human proprioceptive sense.

Furthermore this particular technology could help us develop a virtual proprioception, such as the biofeedback application developed by Researchers at UCLA, suitable for gait rehabilitation.

In contrast to humans that require cues to navigate a virtual environment, robots require cues to navigate our environment, due to their inability to distinguish themselves from the environment without awareness of its own configuration. To solve this problem researchers have developed algorithms that recreates a robot's sense of proprioception based on image data or three dimensional scan data (Lemoyne R., Coroian C., Mastroianni T., Opalinski P., Cozza M., GrundfesT W. 2009). As a result many perception tasks are still far from what humans can perform. For example a robot cannot determine whether a bottle of water is full or

¹⁰ MINE MR, BROOKS FP JR., SEQUIN CH (1997). *Moving objects in space: exploiting proprioception in virtual-environment interaction*. SIGGRAPH '97, Proceedings of the 24th annual conference on Computer graphics and interactive techniques, Pages 19-26

empty only based on graphic data. Some scientists like Jivko Sinapov from the Developmental Robotics Laboratory at Iowa State are experimenting with proprioceptive sensory feedback, in the form of detected joint motor efforts.

Hopefully by this point, we are aware of a few facts that could prevent or improve the conditions of other people that unlike us did not read this text. My guess is that the next time we are confronted with unbalance, injuries or poor coordination we might consider proprioception as a logical cause, by being aware of our “self-awareness”.

EXPRESSION OF CONCEPTS THROUGH ART

The first word associated with art is aesthetic; it should be however, communication. The content in art varies from representations of a scene to more abstract concepts, and the format in which this is expressed has almost no limitations.

modern art steps
away from
narrative

Since the beginning of Modern art the tendency has been to step away from narrative and deepened into experimentation. Contemporary art attempts to relocate reality in human apperception thus setting it at odds with pragmatic science, technical devices and thoughts of the world today.

hidden associations
among objects

This manipulation of reality is influenced by the interpretation the artist has of it. Consequently he or she might try to communicate a specific reality that is unknown to us, using elements that are part of our realities. *Hidden associations may be revealed when one object is related to another, or otherwise taken out of its familiar context, or when even a single detail is removed or altered.*¹¹

object recognition
within
transformation

*The effectiveness of these transformed objects depends to some extent on our recognition of the originals within the transformation - knowing that they are, or were, authentic chairs.*¹² This can be achieved by merely adding a title, producing a "third reality" or other actions such as: scale change, material addition, destruction, portrait of the original or deformation.

object design vs.
object in art, the
difference lies in
functionality

These transformed objects, sculptural objects, are often confused with design objects. The main distinction lies in the fact that design implies functionality whether art does not. Furthermore, art examples have taken prefabricated objects and isolated them from their functional context, elevating them to the status of art by the mere act of the artist's selection. This particular practice is known as *Found Objects*.

Found Object

Found objects derive their identity as art from the designation placed upon them by the artist and the social history that comes with the object. The context into which it is placed is also a highly relevant factor. The term originated from the French *Object Trouvé*, describes art created from undisguised, but often modified objects or products that are normally not considered as art. It was first publicly used by Pablo Picasso when he included a printed image of a chair onto his painting titled *Still Life with Chair Caning* (1912). The use of Found Object was quickly taken by the Dada movement. By the time of the *Surrealist Exhibition of Objects* in 1936, a whole range of sub classifications had been devised, such as,

¹¹ DESIGNBOOM. *still life with chair- installations and manipulations of the undemanding object*. Accessed Max 31, 2013, <http://www.designboom.com/history/stilllife.html>

¹² same as ¹¹

ready-mades, perturbed objects, mathematical objects, natural objects, interpreted natural objects, incorporated natural objects, Oceanic objects, American objects and Surrealist objects

When the *Found Objects* are modified to an extent that cannot be recognized it falls into the category of Ready-Mades.

The term was coined by Marcel Duchamp in 1915 to describe a common object that had been modified but not materially altered. He assembled *Bicycle Wheel* in 1913 by attaching a front wheel and a fork to the seat of an ordinary chair.

*Duchamp envisaged the ready-made as the product of an aesthetically provocative act, one that denied the importance of taste and which questioned the meaning of art itself.*¹³ For this reason this type of art has been the subject of a polarized debate, rejected by the general public and journalists but supported by museums and art critics.

¹³ GALE M (2009). *Ready-made*. © 2009 Oxford University Press.
http://www.moma.org/collection/theme.php?theme_id=10468

IMPAIRED CHAIR PROPRICEPTION

As others in the venue of art, I found the use of objects a more effective medium to express a concept. Confiding in the collective knowledge I could assume that the interpretation of a regular chair would be fairly similar among the audience, giving me a clear path to communicate the concept without distracting associations. This was not possible to accomplish with humans, because every person recognizes their body and their experiences in entirely different ways thus the interpretation of the message would have been impossible to direct towards proprioception

Object: Chair

chair as a
recognizable shape

An object commonly presented as a plank with four legs and a back is what we commonly recognize as a chair. A chair has many variations of its shape nevertheless the configuration usually remains the same. Chairs have become a standard furniture item, thus a recognizable shape.

A chair meant to be standard should not present any special feature, for example the IVAR chair. It is a standard model from IKEA, a master in standardized furniture itself, made with hardwearing pine wood.

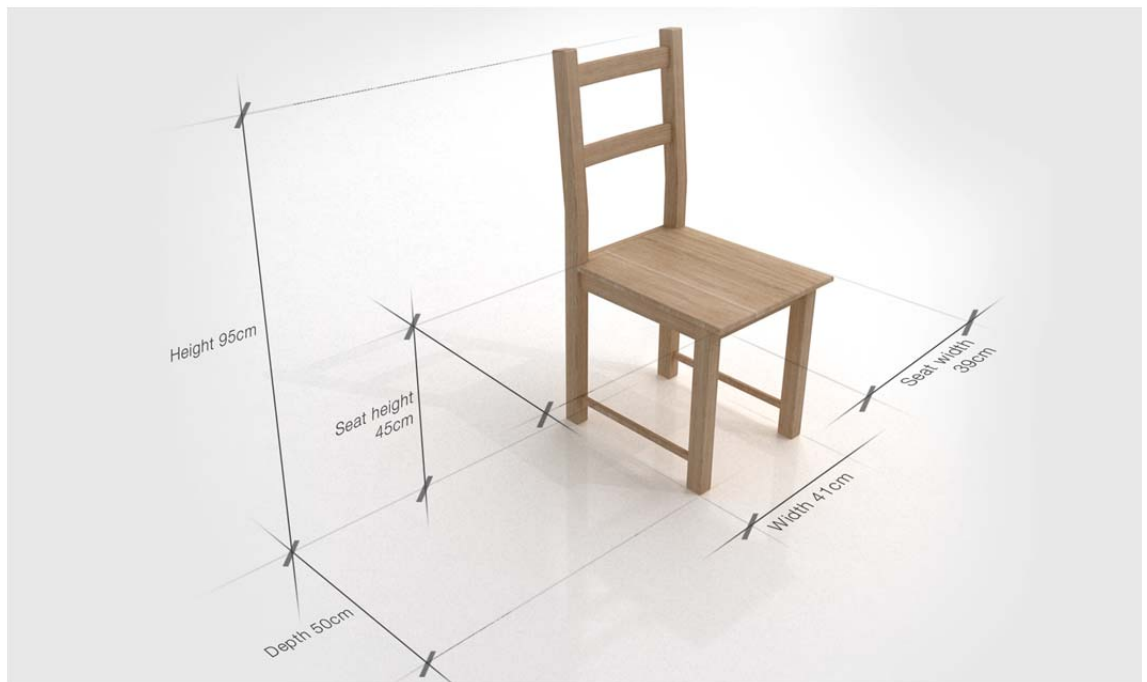


Fig. 2: IVAR Chair dimensions. Designer: IKEA, Sweden.

Regardless of the chair aesthetics, its function has never changed, it is meant to sit on. Design considerations such as: size, stackability, foldability, weight, durability and resistance, are of no value if we cannot sit on it.

chair as a clear
functionality

With this in mind one might wonder if a chair that cannot be used to sit on, can be called a chair at all. On the other hand if we are unable to recognize the lack of functionality we might be able to refer to the object as a chair. It is a matter of perception.

unknown
functionality
equivalent to
unknown
proprioception

Chair: Altered Proprioception

When we sit on a regular chair the deformations are imperceptible, they occur at a molecular level, thus the overall appearance of the chair is not altered. The state of the chair before and after we sit on it, is the same. Moreover, I could argue that the state is just one state.

In the presence of a chair that suffered alterations, we are confronted with two concepts of the same object, a *Chair* and a *Transformed Chair*, even though the volume of it in space remains the same.

Based on the previous reasoning, we can consider the object only a chair as long as the transformations do not become a state but just actions on the object we recognize. If the chair can always return to the initial and only state, then the object is always perceived as a chair.

In the case of the *Impaired Chair Proprioception*, the metaphor allows me to create a parallelism between what happens to a chair under deformations and what happens when people move. The human proprioceptors would detect when a part of our body is out of its natural state and prompt the muscles to return it to the resting state. In a similar manner the mechanism of the *Chair* should reverse the parts of the chair to its original positions.

Two approaches were taken to accomplish the desire reversible quality on the chair. The first one was the *cable-tensing system* which was later replaced by the *spring system*.

Cable-tensing system

A chair is built with an inner channel allowing two cables go through each piece (limb) of the chair connecting every joint. The channel has a circular section and includes a tube in order to protect the cables from possible lacerations. At the end of each cable a weight - equivalent to the chair weight - is attached in order to keep the normal resting appearance of the chair. When a person use the chair, the weights cannot contra rest the load imposed on the chair, therefore the deformation is inevitable.

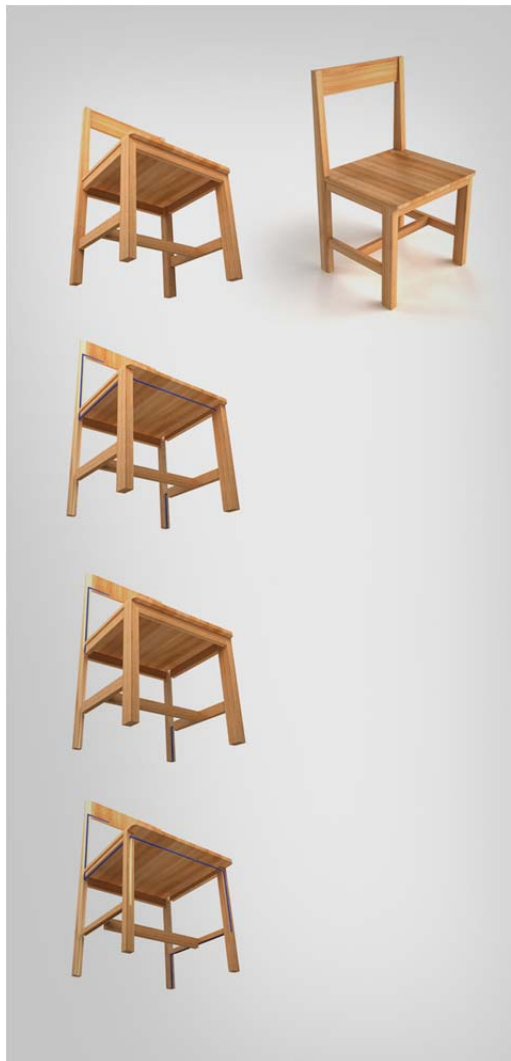


Fig. 3: Exploded Model. Cable-Tensing System Path.
Video online: <http://youtu.be/UWZTlcaKG1I>

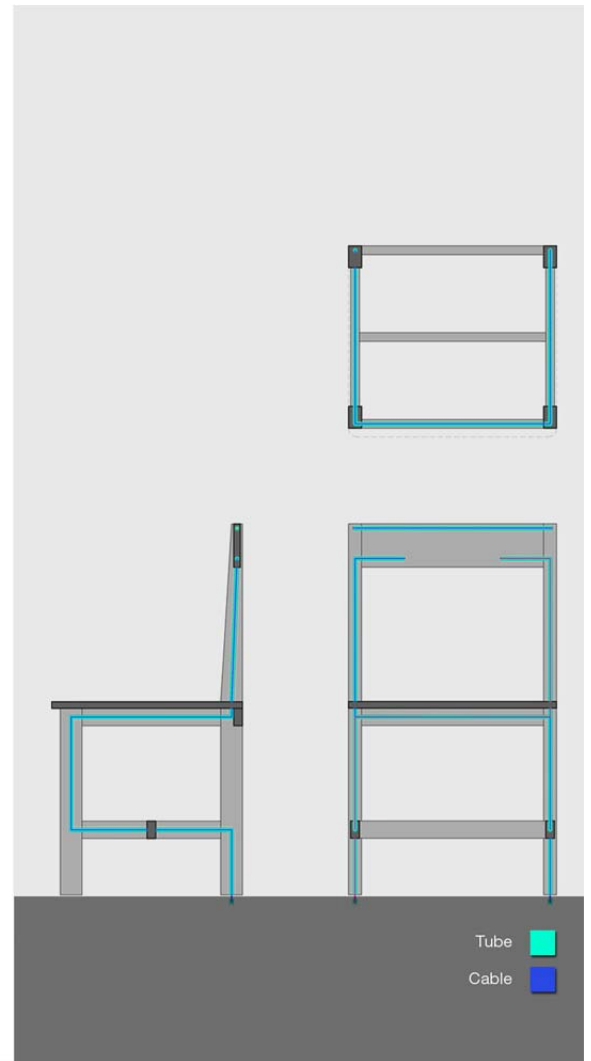


Fig. 4: Cable-Tensing System Path



Fig. 5: Cable-Tensing System Prototypes

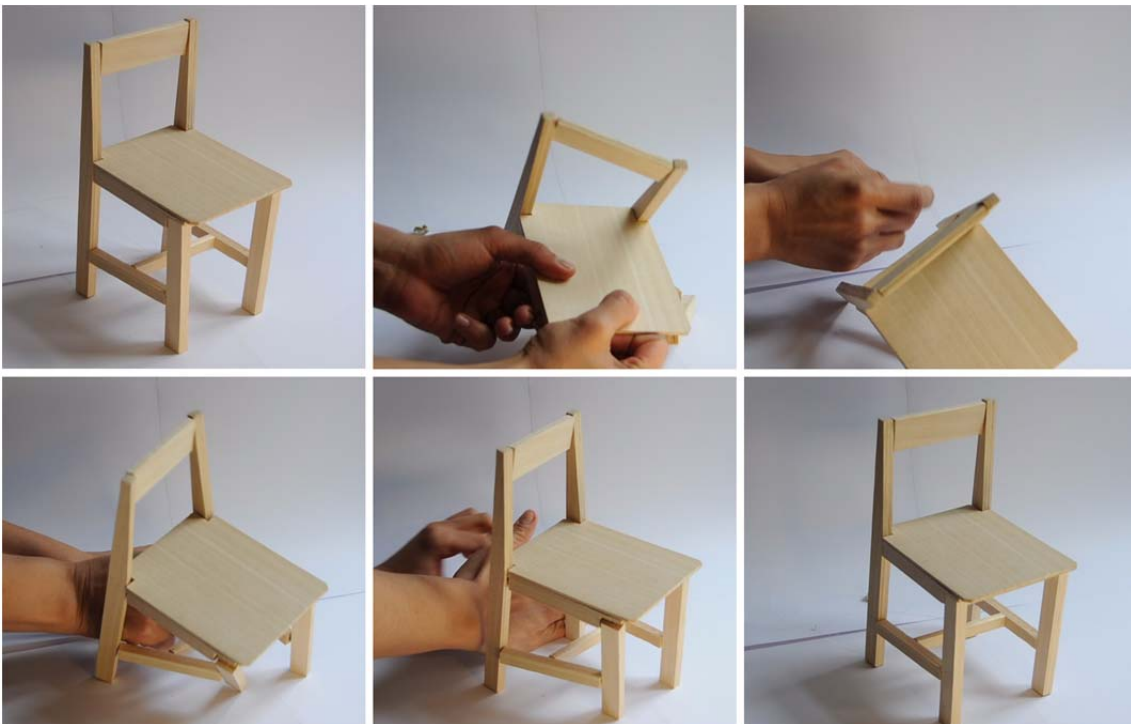


Fig. 6: Chair under deformation. Cable-Tensing System. Video online: <http://youtu.be/rzSliBxBaXo>

This approach presented two complications. The first one was the need for a fake floor under the chair. Without it the cables would have been visible, thus destroying the illusion of a regular chair. Since the exhibition areas were not all the same, creating a specific floor for each area was certainly inefficient.

The second complication was the complete loss of the chair configuration given that the cable system does not prevent the joints from completely separating from each other. This de-configuration of the chair was an aspect that distracted the attention of the main topic. An idea to solve this was to connect each joint with a cable, which lead me to the second approach.

Springs System

After dismissing the *cable system* approach I needed to consider a mechanism that would allow a degree of movement freedom in every joint of the chair and above all, return the chair to its original shape configuration. The ***spring system*** solves this problem.

We all have a notion of what a spring is; we can see them in everyday objects that use a mechanical system because springs are part of its fundamental components. They are elastic members which exerts a resisting force when their shape is changed. Springs come in several types, the three major categories fall into, ***compression, tension/extension and torsion.***



Fig. 7: Spring Types

Extension Springs

The clear choice for the *Impaired Chair Proprioception* were the extension springs due to its resting state qualities. They are helically wound, made from tightly wrapped coils (guarantee of initial tension) and have a hook or loop at each end. The hooks allowed me to attach them into the pieces (limbs) of the chair. When the pieces move apart the extension spring absorbs and stores energy and provides a tension or pulling force to pull them back to the original position.



Fig. 8: Extension springs used in this piece

Design Considerations

The selection of the hook type depended on two factors. I needed a hook that would allow me to keep a circular section in the carved holes, thus only a drill would be needed. In addition to that, the hook should provide an efficient constrain mobility of the end of the spring in combination with the screws on the wood. Hence the ***crossovers hook***.

An extra consideration in relation to the spring's end is that most extension spring failures occur where the hook meets the body of the spring; therefore, my main concern was limiting the stress of the hook area and procuring a smooth wire path.

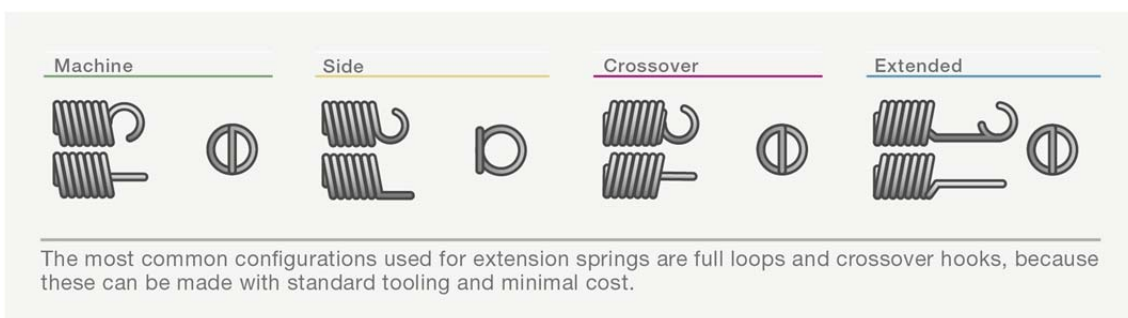


Fig. 9: Hook Types

The behavioral design of the spring implied controlling the initial state of it and the risk factors. Extension springs are manufacture with an ***initial tension*** which presses the coils together in a free state. This initial tension was not enough to guarantee that the pieces held together would be perpendicular among them. For this reason I added a small initial force to the spring by extending it approximately 10% of its length in every joint. In consequence the springs are never in a resting position but the chair is.

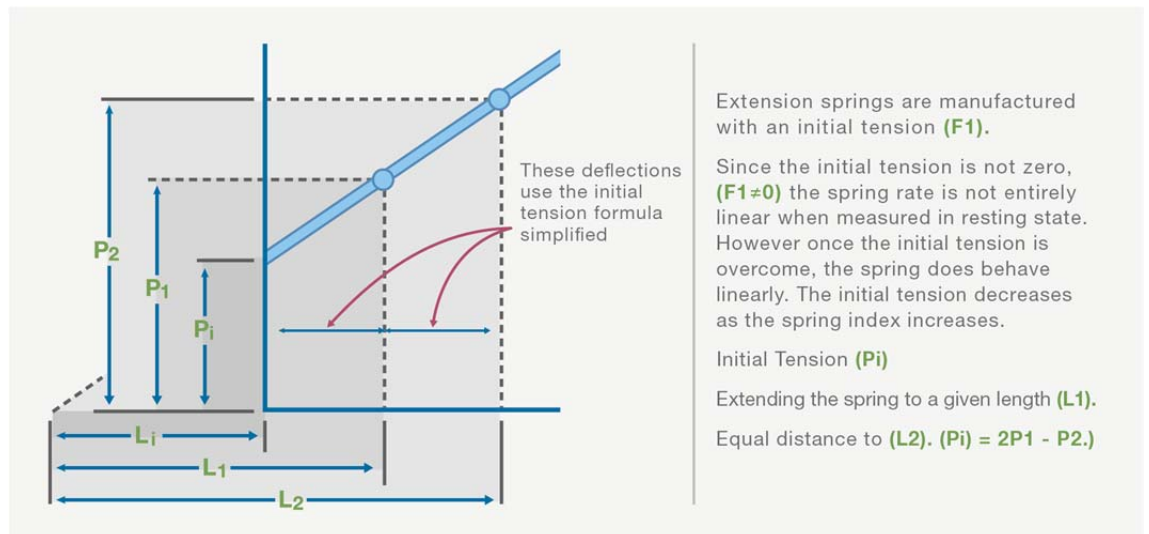


Fig. 10: Initial Tension

Despite the great advantages of using extension springs, there present two risks that were taken into account, such as, stress concentrations and deformations. To avoid stress concentrations I attempted to keep the maximum working stress at three fourths of what a compression spring of similar geometry and material would have. The shear stress, in particular, occurs in the inner face of the coils, it can be analyzed as a compression spring with a negative force. Nevertheless I had to embrace the risk of deformation in order to preserve the resting appearance of the *Impaired Proprioception Chair*.

Mechanism Design



Fig. 11: Expected deformation. Simulation online: <http://youtu.be/Lcaa00aK8yA>

Spring Load

With the collaboration of Raúl Cabrita (Civil Eng.), it was possible to understand the behavior of the chair, based on simulations he run on SAP (System Analysis and Program Development). The simulation took into account the material of the Chair (pine wood) and the degree of freedom expected on the joints. The diagrams consisted in axial and shear force, torsion, joint reaction and deformation. Together with Cabrita explanations, they provided me the basic criteria to design each joint based on the load estimations and the consequent spring distribution.

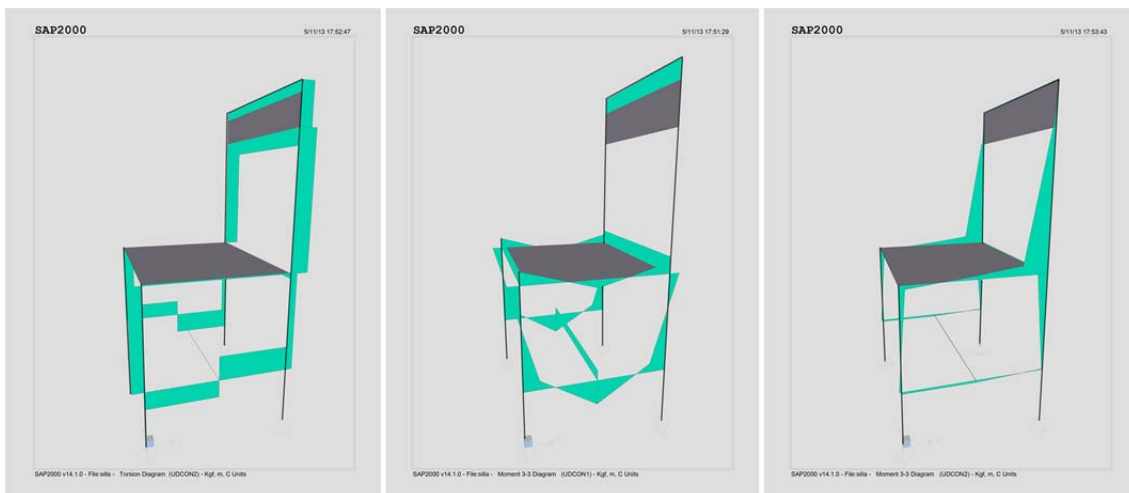


Fig.13: SAP Diagrams

Knowing the distribution of the load was not enough to distribute the springs; first I needed to be able to estimate how much each spring can resist and afterwards decide the number of springs required for each joint. Most springs are assumed linear and obey the Hooke's Law, which states that the force needed to extend or compress a spring by some distance is proportional to that distance.

$$F = k\Delta$$

F resisting force
 Δ displacement
k spring constant

Due to market limitations, these calculations were only a contribution to estimate the type of springs needed for the final piece.

Spring distribution

Based on the loads and the springs available I could already distribute the springs. In the first tests only one spring was use per limb. This configuration was incorrect given that the limb had no constrained to rotate around the spring's axe. Taking into account this result the final design included two springs per limb and as we can see in the images, every pair of spring have different properties. For each pair, one would have the function to resist the extension force and the other to resist the torsion and rotation of the limb. The utilization of equal springs would have being counterproductive, given that restricting the rotation would have limited the degree of freedom of the leading spring.

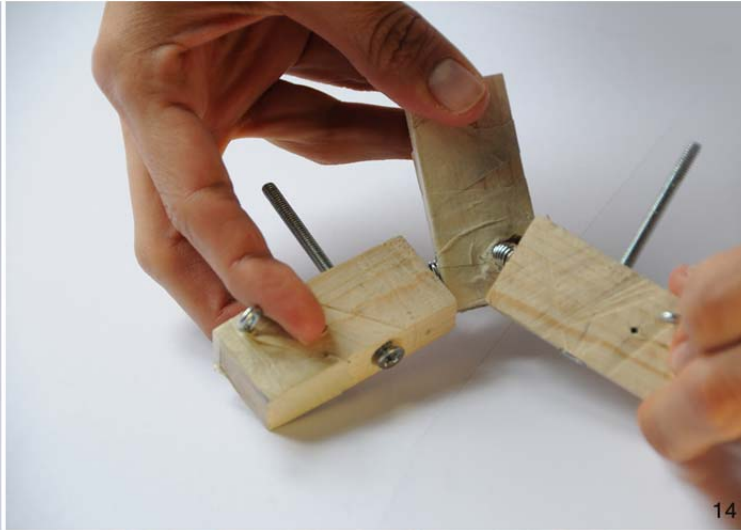
Two types of joints

Not only is relevant to know how many springs were used per limb but also how many springs were needed per joint. In the design there are ***two types of joints***, those with three connecting limbs which required four springs, and those connecting two limbs requiring two springs. In the case of the three connections, the four springs were first installed in the shared limb and then the other limbs were attached. In the case of the two connections the order was not relevant.

As mentioned before the springs were not installed in a resting state, therefore I needed a method to extend the spring while installing the screw to lock the hook. To accomplish this the spring was locked into the first limb, then extended and lock with an auxiliary tool until the second hook was properly locked in the second limb.



14



14

One spring per piece resulted in undesirable torsion around its axe.



15

The strong spring hold the loads and the medium spring prevent torsion

Fig. 14: One spring per pieces (limb)

Fig. 15: Two springs per piece (limb)

CLASIFICACION AND DISTRIBUTION

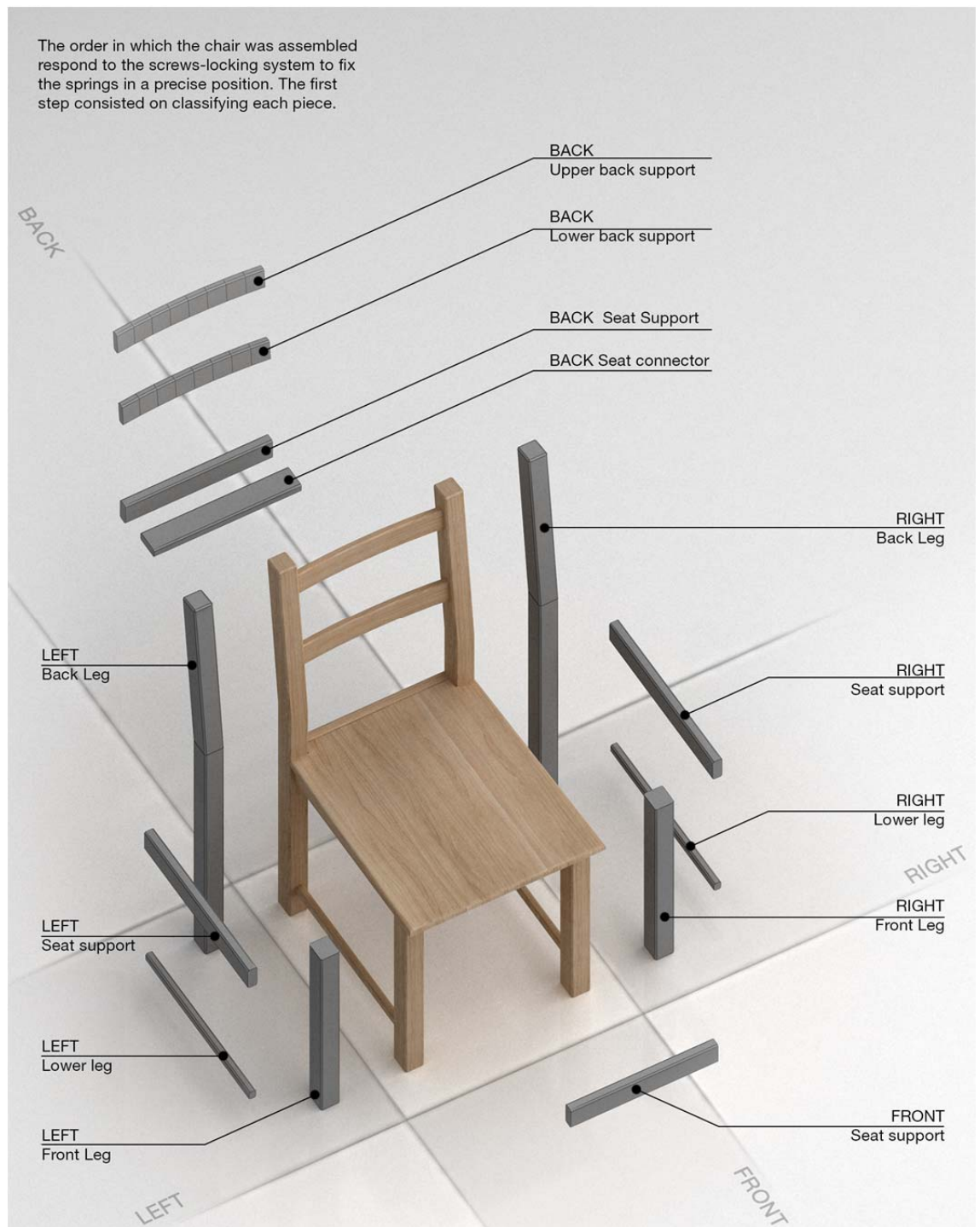


Fig. 12: Parts Clasification

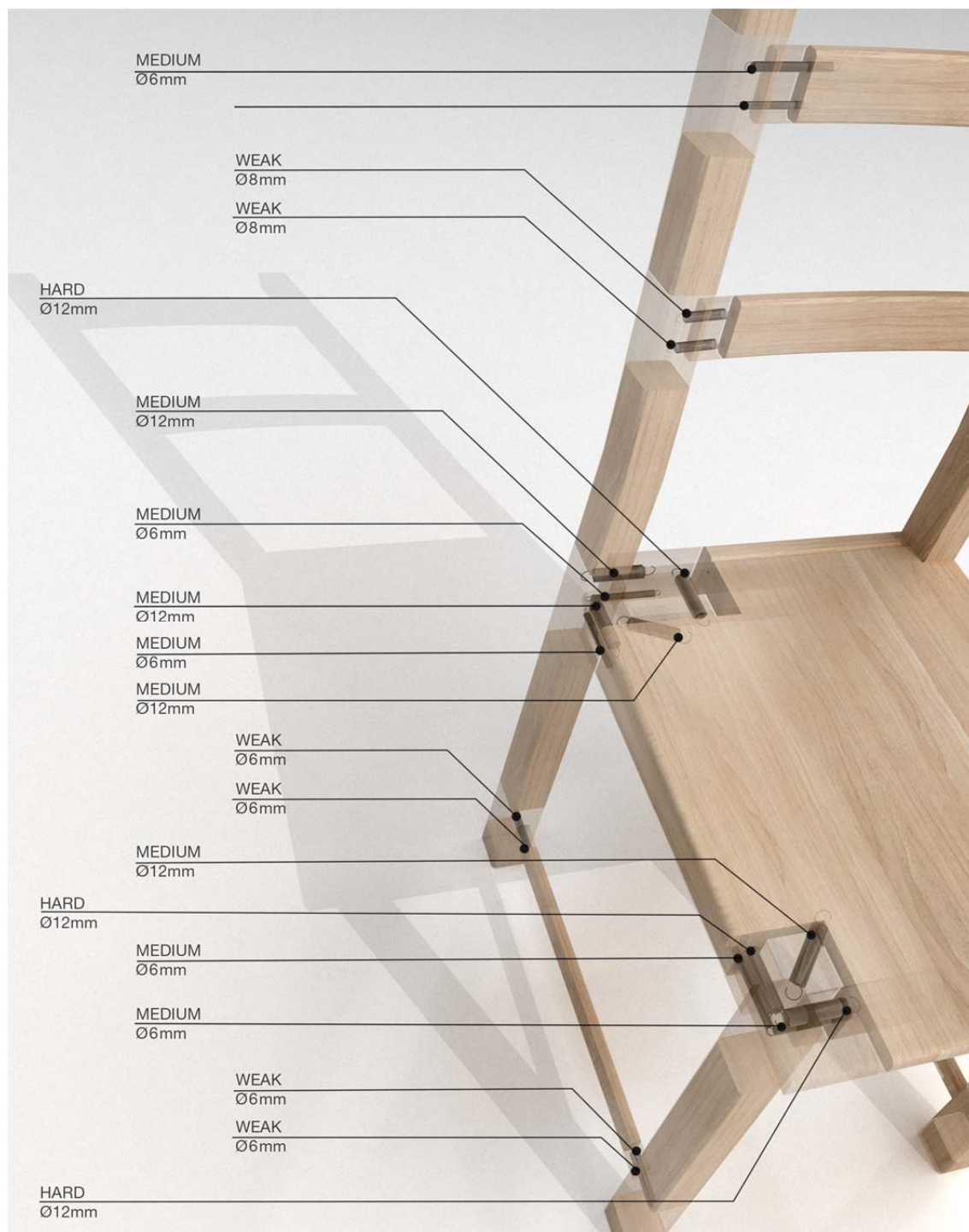


Fig. 17: Spring Distribution

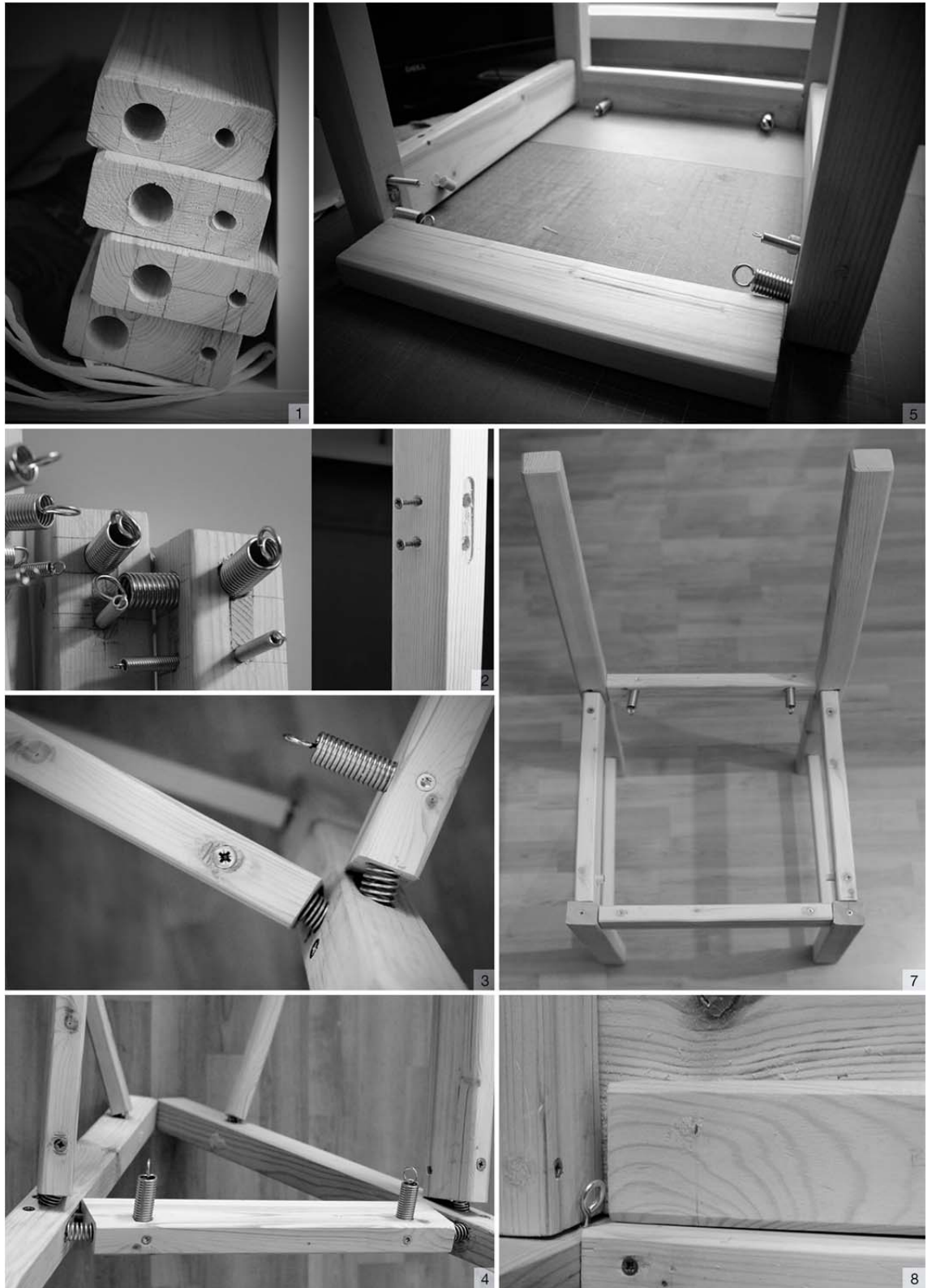


Fig.18. Assemble

ASSEMBLE:

1. Drill every hole, starting with a 2mm tip, increasing the diameter until the required spring diameter is reached. This technique prevent possible damage into the wood
2. Insert and lock the springs in the legs holes of the four legs
3. Assemble each side separately; left and right. Taking into account that the weak springs must come before the stronger ones
4. Insert and lock the springs from the sides into the front and back seat support, in this order.
5. Connect the Back_SeatConector into the Back SeatSupport
6. Insert and lock the springs into the Back_SeatConnector
7. Assemble the seat
8. Insert the hooks into the corners of the seat and each leg
9. Connect the hooks with the springs.

DISPLAY



Fig. 19: Video Display Setting

For those in the audience that have no understanding of what proprioception is, observing one chair bending could have different interpretations. Therefore at the display of the piece there will be more chairs with the same model with the differences that these ones are not impaired.

On the other hand, the Chair by itself is not able to lead the interpretation and connect it to a sense present in humans. To somehow control this aspect of the exhibition two screens would be display parallel to each other. One has a looping recording of a person sitting on the *Chair* and falling. The other one has a looping recording of what is called stork standing. The stork standing is a body position which consist in a person standing in one leg and its efficiency to test proprioception is enhanced by closing the eyes of the patient

This *Chair* prototype has not being design to last under strenuous circumstances hence is recommended to prevent people for over 70 kg to sit on it. Unfortunately an irreversible deformation is expected due to the low flexibility of some of the springs used. Aspects like the deformation path and the variations on the spring's section were too random to calculate for this prototype.

In addition to these the white color of the chair responds to a technical issue rather than a design criteria. The Chair required several screws to lock the springs in position, detail easily noticeable in comparison to the normal functioning chair. By painting the chairs white, the screw can be camouflage.

CHAIR ARTISTS

One of the most recurrent object used by artist is the Chair, in this regards some artists' pieces and their approach to art are relevant to this thesis. For instance, Joseph Kosuth, Joseph Beuys, George Brecht, Roman Signer, and Arthur Ganson, among others

Bicycle Wheel – Marcel Duchamp

One of the first ones was Duchamp in the *Bicycle Wheel* (1913), creating an impossible conjunction of sitting and moving inducing us to see what was not there, the imprint of the human body. This piece by Duchamp could be reproduced several times without altering the concept of it. In a similar manner the piece *One and Three Chairs*, by Joseph Kosuth, could also be recreated as long as the configuration was the same. (Fig. 20)

One and Three Chairs – Joseph Kosuth

In *One and Three Chairs* (1965), the artist displayed a photograph of a chair, an actual chair, and an enlarged dictionary definition of the word 'chair' in English. The piece distinguishes between the three aspects involved in the perception of a work of art: the visual representation of an object (the photograph of the chair), its real referent (the actual chair), and its intellectual concept (the dictionary definition). The work of art in fact consists of the specification or design of all these stages. There is no 'original'; there can be any number of different chairs, photographs and definitions; each is 'the' work of art. The election of the chair only resides in the fact that is common and functional. Kosuth states that art exists in the artist's ideas rather than in the object itself. (Fig. 22)

Fat Chair – Joseph Beuys

Another example is *Fat Chair* by Joseph Beuys in 1964. It is composed of an old, rather ordinary chair with fat placed in the right angle between seat and back. Beuys reduced the body to a symbolic presence by replacing our digestive and excretive organs areas with fat. Using natural materials and cult-like ceremonies, he underlines the importance of the irrational and mystical in human beings. (Fig. 21)



Fig. 20: Bicycle Wheel Chair- Marcel Duchamp

Fig. 21: Fat Chair. Joseph Beuys

Fig. 22: One and Three Chair- Joseph Kosuth

Chair Events – George Brecht

Chairs played a central part in George Brecht's iconography, his belief was that every object is an event and every event has an object-like quality. The work known as Chair Events are a poetic association of ideas and actions which a priori, have no direct relationship or connection, they are sometimes accompanied by information and musical scores, left over the seats.

In 1961 at the Martha Jackson Gallery in New York, Brecht exhibited a realization of his Three Chair Events. Three chairs were shown in different places in the exhibition: a white wicker chair under a spotlight in the gallery, a black one in the toilet and a yellow one just outside the entrance of the gallery. *In the score for Three Chair Events, Brecht uses the term 'occurrence' again, suggesting this time that 'sitting on a black chair' and finding a 'yellow chair' are two such occurrences: the events are thus framed above all by perception. In the exhibition, the chairs indeed existed as artworks only when they were noticed as such by a visitor.*¹⁴ (Fig. 23)

Roman Signer

For Roman Signer and ordinary object reveals its aesthetic potential when is altered by physical activity. He carries out experiments that show the relationship between art and the physical manifestations that occur in everyday life. Often these experiments include immediate utilitarian objects and Swiss landscapes that are part of his lived experience.

One of Signer examples using chairs is the **Aktion Kurhaus Weissbad** (1992), where he catapulted chairs out of a hotel window. Also relevant is the piece **Chairs** (2007), where he let loose a small automatic lawnmower to prowl the main gallery parquet floor, only to be blocked by a dozen chairs. *The mower senses them, skirts around, knocks into and conscientiously attempts to get at the narrow spaces between their legs.*¹⁵

And at last, the film **Office Chair** (2010), in which he places a chair in a rushing stream with the water current making the chair spin around its base. (Fig. 24, 25 and 26)

¹⁴ OLD.LIKEYOU.COM. *George Brecht - Works from 1959 – 1973*. Accessed May 31, 2013, http://old.likeyou.com/archives/george_brecht_gaglondon_04.htm

¹⁵ HAUSER & WIRTH. *Roman Signer*. Accessed May 31, 2013, <http://www.hauserwirth.com/exhibitions/18/roman-signer/view/>

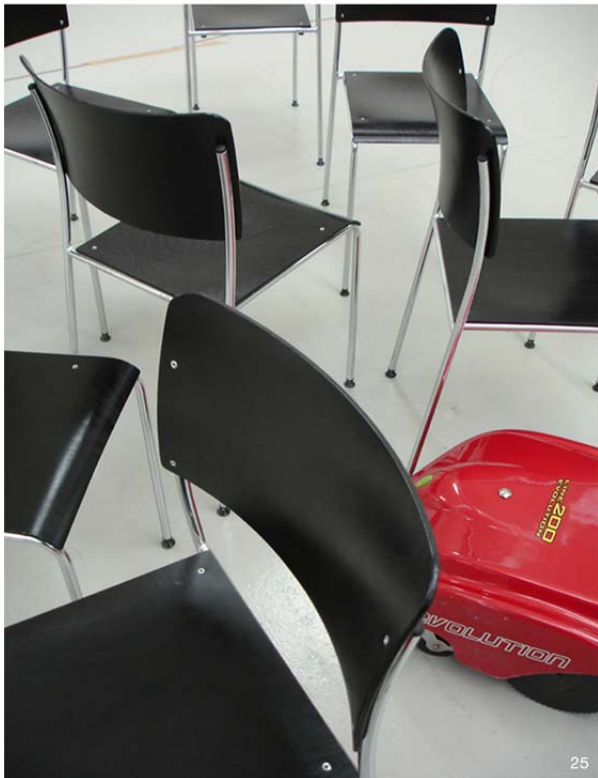


Fig.23. Chair Events. George Brecht.

Fig.24. Aktion Kurhaus Weissbad. Roman Signer

Fig.25. Chairs. Roman Signer

Fig.26. Office Chair - Roman Signer (© Roman Signer. Courtesy Galerie Barbara Weiss, Berlin)

Cory's Yellow Chair – Arthur Ganson

Arthur Ganson, a kinetic sculptor also uses a chair as an everyday object that is easily recognizable. In his piece *Cory's Yellow Chair*, a chair is showed exploding into six pieces, which hover at a distance, then gently reassemble, to instantly explode again. Ganson said he wanted the chair pieces to explode at infinite speed, rest in stillness at the extreme, and then reassemble gradually. *The piece is stab at the question of "when is now?" Now is when the chair coalesces, but it doesn't last.*¹⁶ (Fig. 27)

¹⁶ Brand S. <http://longnow.org/seminars/02009/sep/14/machines-and-breath-time/>



Fig. 27: Corys's Yellow Chiar-Arthur Ganson (found on syraweb.org)

BIBLIOGRAPHY

SACKS O (1985). *The Man Who Mistook His Wife for a Hat, and Other Clinical Tales*. Summit Books. ISBN 0-671-55471-9

FORTIER S, BASSET FA (2012). *The effects of exercise on limb proprioceptive signals*. Journal of Electromyography and Kinesiology, Volume 22, Issue 6 , Pages 795-802, December 2012

YUAN Y, STEED A (2010). *Is the rubber hand illusion induced by immersive virtual reality?*. Proceedings of the 2010 IEEE Virtual Reality Conference, Pages 95-102

ROLL JP, POPOV K, GURFINKEL V, LIPSHITS M, ANDRÉ-DESHAYS C, GILHODES JC, QUONIAM C (1993). *Sensorimotor and perceptual function of muscle proprioception in microgravity*. Journal of Vestibular Research: Equilibrium & Orientation [1993, 3(3):259-273]

BLOOMBERG JJ (2008). *Development of a Gait Adaptability Training Program as a Countermeasure for Post-Flight Locomotor Dysfunction*. <http://www.nsbri.org/projects/indivProject.asp?id=455&projID=148>

LEANDERSON J, ERIKSSON E, NILSSON C, WYKMAN A (1996). *Proprioception in classical ballet dancers. A prospective study of the influence of an ankle sprain on proprioception in the ankle joint*. The American Journal of Sports Medicine, 1996 May-Jun;24(3):370-4

MINE MR, BROOKS FP JR., SEQUIN CH (1997). *Moving objects in space: exploiting proprioception in virtual-environment interaction*. SIGGRAPH '97, Proceedings of the 24th annual conference on Computer graphics and interactive techniques, Pages 19-26

JUDSON HC (1947). *The proprioceptive nervous system*. The Journal of Nervous and Mental Disease, New York 1947, 106/3 (355-358)

QUINN E (2013). *Proprioceptors - What Are the Proprioceptors and Proprioception*, About.com Guide, Updated May 08, 2013

JEROSCH J, PRYMKA M (1996). *Proprioception and joint stability*. Knee Surgery, Sports Traumatology, Arthroscopy, 1996, Volume 4, Issue 3, pp 171-179.

LEMOYNE R, COROIAN C, MASTROIANNI T, OPALINSKI P, COZZA M, GRUNDFEST W (2009). *The Merits of Artificial Proprioception, with Applications in Biofeedback Gait Rehabilitation Concepts and Movement Disorder Characterization*. Published in Biomedical Engineering, ISBN 978-953-307-013-1

JOSEPH J, LUDERS B (2006). *Modeling and Simulation of Robot Proprioception from Sensor Data*. 16.413 Principles of Autonomy and Decision Making. Massachusetts Institute of Technology, December 8, 2006

FAYAZ S (2009). *Studies of lower limb isokinetic strength and proprioception in young football players*. PhD thesis, University of Glasgow. <http://theses.gla.ac.uk/id/eprint/2364>

VAFADAR AK, CÔTÉ JN, ARCHAMBAULT PS (2012). *The effect of muscle fatigue on proprioception in an upper limb multipoint task*. PT School of Physical and Occupational Therapy Faculty of Medicine, McGill University, Montreal, Quebec, Canada

MEDICINENET, INC. *Definition of Proprioception*. Accessed May 31, 2013, <http://www.medterms.com/script/main/art.asp?articlekey=6393>

WIKIPEDIA. *Proprioception*. Last edited May 30, 2013, <http://en.wikipedia.org/wiki/Proprioception>

UNIVERSITY OF WASHINGTON. *Proprioceptors*. Accessed May 31, 2013, <http://courses.washington.edu/conj/bess/spindle/proprioceptors.html>

TERRA PLANA INTERNATIONAL. *Proprioception*. Accessed May 31, 2013, <http://trainingclinic.vivobarefoot.com/proprioception/stepbystep.php>

STEDMAN'S MEDICAL DICTIONARY. *Definition: 'Proprioception'*. Accessed May 31, 2013, <http://www.medilexicon.com/medicaldictionary.php?t=72809>

DOUGLASS E. *Proprioception Loss: Blinding the Mind From the Body*. Accessed May 31, 2013, <http://www.laurenscharff.com/courseinfo/SL2000/propriocept.html>

TSAKIRIS M, HAGGARD P. *The Rubber Hand Illusion Revisited: Visuotactile Integration and Self-Attribution*. Journal of Experimental Psychology: Human Perception and Performance 2005, Vol. 31, No. 1, 80 –91

SCIENCE@NASA HEADLINE NEWS. *Mixed Up in Space*. Accessed May 31, 2013, http://science.nasa.gov/science-news/science-at-nasa/2001/ast07aug_1/

WILLOW GARAGE. *Learning Proprioceptive Properties*. Accessed May 31, 2013, <http://www.willowgarage.com/blog/2010/11/16/learning-proprioceptive-properties>

GALE M (2009). *Ready-made*. © 2009 Oxford University Press. http://www.moma.org/collection/theme.php?theme_id=10468

WIKIPEDIA. *Modern art*. Last edited May 20, 2013, http://en.wikipedia.org/wiki/Modern_art

PROPAGANDUM. *Bicycles, beds, chairs, doors – the use of modern art*. Accessed May 31, 2013, <http://propagandum.wordpress.com/2012/06/21/bicycles-beds-chairs-doors-the-use-of-modern-art/>

DESIGNBOOM. *still life with chair- installations and manipulations of the undemanding object*. Accessed May 31, 2013, <http://www.designboom.com/history/stilllife.html>

WIKIPEDIA. *Chair*. Last edited May 29, 2013, <http://en.wikipedia.org/wiki/Chair>

EFUNDA, INC. *Spring Introduction*. Accessed May 31, 2013, http://www.efunda.com/designstandards/springs/spring_introduction.cfm

WERMKE SPRING MANUFACTURING CO. *Extension Spring: Custom Spring Manufacturing*. Accessed May 31, 2013, <http://www.wermkespring.com/extension-spring.php>

NEWCOMB SPRING CORP. *Extension Springs*. Accessed May 31, 2013, <http://www.newcombspring.com/extensionsprings.html>

WIKIPEDIA. *Hooke's law*. Last edited May 31, 2013, http://en.wikipedia.org/wiki/Hooke_law

OLD.LIKEYOU.COM. *George Brecht - Works from 1959 – 1973*. Accessed May 31, 2013, http://old.likeyou.com/archives/george_brecht_gaglondon_04.htm

HAUSER & WIRTH. *Roman Signer*. Accessed May 31, 2013, <http://www.hauserwirth.com/exhibitions/18/roman-signer/view/>

PENTAK S, ROTH RL, LAUER DA (2012). *Design Basics: 2D and 3D*. Cengage Learning, Jan 1, 2012.

DAVOR D. *Fat Chair - The Artist as "Shaman"*. Accessed May 31, 2013, <http://smarthistory.khanacademy.org/joseph-beuys-fat-chair.html>

LOWNDES S. *George Brecht*. Frieze Magazine, Issue 98, April 2006.

CASHDAN M. *Roman Signer*. Frieze Magazine, Issue 135, November–December 2010.

SALA DE ARTE PÚBLICO SIQUEIROS, *Roman Signer: Acht Stühle (Eight Chairs)*. Accessed May 31, 2013, <http://www.saps-latallera.org/saps/roman-signer-acht-stule-ocho-sillas/?lang=en>

PROPAGANDUM. *Bicycles, beds, chairs, doors – the use of modern art*. Accessed May 31, 2013, <http://propagandum.wordpress.com/2012/06/21/bicycles-beds-chairs-doors-the-use-of-modern-art/>

DESIGNBOOM. *still life with chair- installations and manipulations of the undemanding object*. Accessed May 31, 2013, <http://www.designboom.com/history/stilllife.html>

DARWENT C. *George Brecht: Composer and artist with the Fluxus movement who pioneered conceptual art*. Accessed May 31, 2013. <http://www.independent.co.uk/news/obituaries/george-brecht-composer-and-artist-with-the-fluxus-movement-who-pioneered-conceptual-art-1646481.html>

COLLECTION OF THE LYON MUSEUM OF CONTEMPORARY ART. Press Release: *George Brecht - Partitions, Glasses and Chair events... 1959–2012*. Accessed May 31, 2013, http://www.mac-lyon.com/static/mac/contenu/fichiers/dossiers_presse/2012/pr_george_brecht_partitions_glass_chair_event_s.pdf

DEZEUZE A. *Brecht for beginners*. Papers of Surrealism, Issue 4, winter 2005. Accessed May 31, 2013, <http://www.surrealismcentre.ac.uk/papersofsurrealism/journal4/acrobat%20files/dezeuze.pdf>

TIME OUT BOSTON. *Interview: Arthur Ganson*. Accessed May 31, <http://timeoutboston.com/arts-culture/art/105899/interview-arthur-ganson>

WHITNEY MUSEUM OF AMERICAN ART. *Lucas Samaras – Chair transformation number 16, 1969–70*. Accessed May 31, 2013, <http://whitney.org/Education/ForTeachers/Collection/LucasSamaras/701574/Activities>

VISIT-SALZBURG.NET. *Hellbrunn Palace - Schloss Hellbrunn Castle*. Accessed May 31, 2013, <http://www.visit-salzburg.net/sights/hellbrunn.htm>

WIKIPEDIA. *One and Three Chairs*. Last edited March 2, 2013, http://en.wikipedia.org/wiki/One_and_Three_Chairs

MOMA – THE COLLECTION. *Joseph Kosuth - One and Three Chair*. Accessed May 31, 2013, http://www.moma.org/collection/browse_results.php?criteria=O%3AAD%3AE%3A3228&page_number=1&template_id=1&sort_order=1

ARMAN - THE OFFICIAL ARMAN WEBSITE. Accessed May 31, 2013, <http://www.armanstudio.com>

YOUTUBE. *Arthur Ganson - Little yellow chair*. Accessed May 31, 2013, <http://www.youtube.com/watch?v=tIfnxYItoVE>

YOUTUBE. *Arthur Ganson: Exploding Chair Machine*. Accessed May 31, 2013, <http://www.youtube.com/watch?v=ZAMN4CW-2wc&feature=youtu.be>

YOUTUBE. *Machine with Chair - Arthur Ganson*. Accessed May 31, 2013, <http://www.youtube.com/watch?v=6VBXQxoP814>

YOUTUBE. *HolyChic.com: Joseph Kosuth*. Accessed May 31, 2013, http://www.youtube.com/watch?feature=player_embedded&v=xoD5au1UCdI

YOUTUBE. *Charlie Chaplin - sit you down*. Accessed May 31, 2013, <http://www.youtube.com/watch?v=4eYUQUymrIQ>

IMAGE LIST

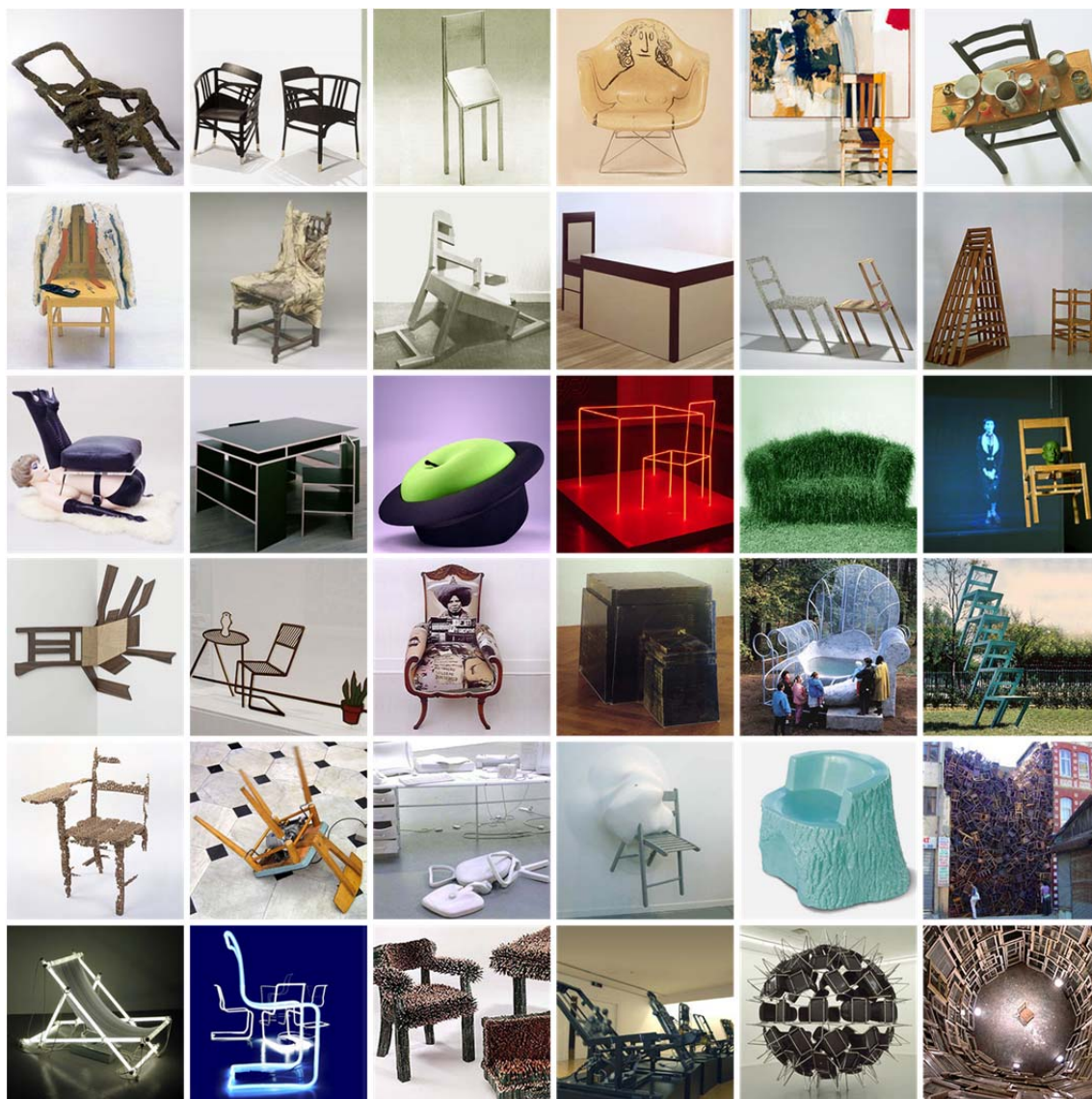
Fig. 1: Proprioceptors (Images: Pearson Education, Inc. and Christopher Gagliardi) http://www.acefitness.org/blog/2868/what-39-s-the-difference-between-autogenic-and/ http://medic4u.webs.com/cnspnssensemovment.htm	4
Fig. 2: Altered Proprioception in Astronauts Clément Gilles, Fundamentals of Space Medicine. Springer, The Netherlands	8
Fig. 3: IVAR Chair dimensions. Designer: IKEA, Sweden	14
Fig. 4: Exploded Model. Cable-Tensing System Path	16
Fig. 5: Cable-Tensing System Path	16
Fig. 6: Cable-Tensing System Prototypes	17
Fig. 7: Chair under deformation. Cable-Tensing System. Video online: http://youtu.be/rzSiBxBaXo	17
Fig. 8: Spring Types	18
Fig. 9: Extension springs used in this piece	19
Fig. 10: Hook Types	19
Fig. 11: Initial Tension	20
Fig. 12: Expected deformation Simulation online: http://youtu.be/Lcaa00aK8yA	20
Fig. 13: SAP Diagrams	21
Fig. 14: One spring per pieces(limb)	23
Fig. 15: Two springs per piece(limb)	23
Fig. 16: Parts Classification	24
Fig. 17: Spring Distribution	25
Fig. 18: Assemble	26
Fig. 19: Video Display Setting	28

Fig. 20: Bicycle Wheel Chair- Marcel Duchamp	31
imageobjecttext.com: http://imageobjecttext.com/tag/marcel-duchamp/	
Fig. 21: Fat Chair. Joseph Beuys	31
slightstruggle.tumblr.com: http://slightstruggle.tumblr.com/page/4 http://www.flickr.com/photos/gscheiterl/2918463900/	
Fig. 22: One and Three Chair- Joseph Kosuth.	31
studyblue.com: http://www.studyblue.com/notes/note/n/contemporary-art-midterm/deck/5477064	
Fig. 23: Chair Events - George Brecht.	33
Fig. 24. Aktion Kurhaus Weissbad – Roman Signer	33
oribanana.blogspot.co.at: http://oribanana.blogspot.co.at/2013/03/chosen-art-work-and-its-reference.html	
Fig. 25. Chairs - Roman Signer	33
hauserwirth.com: http://www.hauserwirth.com/exhibitions/18/roman-signer/list-of-works/2	
Fig. 26. Office Chair - Roman Signer© Roman Signer. Courtesy Galerie Barbara Weiss, Berlin;	33
http://www.moma.org/collection/object.php?object_id=114556	

OTHER CHAIRS IN ART

Diminution du Comfort. Arman, 1999.
The Hidden chairs. IBRIDE.
Singer chair (for short visits). Bruno Munari, 1946.
Chair with drawing. Saul Steinberg, circa 1952.
Pilgrim, Robert Rauschenberg, 1960.
Kichka's breakfast. Daniel Spoerri, 1960.
Shirt with objects on a chair. Claes Oldenburg, 1962.
Wrapped chair. Christo, 1961.
Untitled. Pieter Engels, 1964.
Table and chair. Richard Artschwager, 1964.
Untitled. Lucas Samaras, 1965.
Ladder and chair. Alighiero Boetti, 1966.
Chair. Allen Jones, 1969.
Chairs and table. Donald Judd. A series started in 1973.
'MAGriTTA chair. Sebastian Matta, 1970.
Neon table and Chair. Joe Rees, 1975.
Untitled by daniel spoerri, 1988.
Shit in your hat-head on a chair. Bruce Nauman, 1990.
Splatter chair. Richard Artschwager, 1992.
Chair table and flower pot. Roy Lichtenstein, 1992.
Seat for the rich on the lap of the poor. Stephen Cohen, 1993.
Table and chair. Rachel Whiteread, 1994.
Chair pool. Dennis Oppenheim, 1996.
Chair Transformation number 20B. Lucas Samaras, 1996.
Untitled. Tom Friedman, 1999.

Chair. Allen Jones, 1969.
Chairs and table. Donald Judd. A series started in 1973.
MAGriTTA chair. Sebastian Matta, 1970.
Neon table and Chair. Joe Rees, 1975.
Untitled by daniel spoerri, 1988.
Shit in your hat-head on a chair. Bruce Nauman, 1990.
Splatter chair. Richard Artschwager, 1992.
Chair table and flower pot. Roy Lichtenstein, 1992.
(Title unknown). Louise Bourgeois.
Seat for the rich on the lap of the poor. Stephen Cohen, 1993.
Table and chair. Rachel Whiteread, 1994.
Chair pool. Dennis Oppenheim, 1996.
Chair Transformation number 20B. Lucas Samaras, 1996.
Untitled. Tom Friedman, 1999.
Kinetic furniture. Theo Kaccoufa, 2000.
Soft office with office chair. Loris Cecchini, 2001.
Gap. Loris Cecchini, 2001.
Haini. Franz West, 2003.
Chair like a tree-stump. Doris Salcedo, 2003.
Folding chair. Iván Navarro, 2005.
Neon tube chair. Paul Tames Van den Berg, 2005.
Pencil installation. Kerstin Schulz, 2005.
Massage chair installation. Yang Zhenzhong, 2005.
The black hole. Michel de Broin, 2006.
His chair. Chiharu Shiota, 2006.



<http://www.armanstudio.com>
<http://www.ibrade.fr/#/collection/>
<http://www.designboom.com/history/stilllife.html>

