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# The Grasp Reflex in Adults

## The forensic significance of other neurosurgical and neurological subjects



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In some gunshot wound cases, grasp reflexes are given as triggers for “accidentally fired shots”, i.e. accidental gunshot wounds inflicted by the shooting party. The specification of a reflex should underline the accidental nature of a shooting event. This article deals with the question of what exactly a grasp reflex is and what its significance is in the forensic context of gunshot wounds. In addition, the medical knowledge of individual specialist disciplines is growing and is leading to a considerable increase in the amount of data and further sub-specialisations in the various medical specialist disciplines. Thus, it is necessary to highlight clinical focuses of the neurological and neurosurgical disciplines with the lack of knowledge that may arise due to missing clinical relevance in the forensic consideration.



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### 1. WHAT ARE REFLEXES? WHAT ARE PRIMITIVE REFLEXES?

Reflexes are involuntary movements to stimuli which are often controlled by the nervous system at the level of the spinal cord and which represent systematic responses to certain stimuli. Reflex movements are therefore not consciously controlled by a human being. Many people are familiar with the triggering of the patellar tendon reflex at the doctor’s. During a neurological examination, the doctor strikes the patellar tendon of the knee of a relaxed leg with a reflex hammer, triggering an unintended stretching movement of the leg at the knee. The important thing here is that the knee is not tense, as a reflex release is not possible with the wilful use of the muscles. The extension of the knee is automatic and not controlled consciously by the patient. In a healthy person, the so-called reflex response is equally strong on both

sides. The absence of the patellar tendon reflex and the weakening or strengthening of the reaction are considered pathological. As neurological symptoms, these point towards disorders of the nervous system.

There are reflexes in all parts of the body. Medicine differentiates between polysynaptic and monosynaptic reflexes. In the case of a monosynaptic reflex (e.g. the patellar tendon reflex), the reflex stimulus and the reflex response occur in the same organ; the switching takes place via the spinal cord.

A polysynaptic reflex refers to a reflex that has a longer switching mechanism. Here, the reflex response occurs via switching in several segments; reflex stimulus and reflex response do not take place in the same organ. For example, in the case of the cremasteric reflex, the inside of the thigh is brushed, which results in the elevation of the man’s testicle on the same side.



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The stimulus is thus placed on the skin of the inner thigh, while the reflex response (the testicular lift) occurs in the cremaster muscle. The lack of this reflex indicates a spinal cord disorder at L1–L2.

However, other classifications are also used in medicine. Thus, the reflexes that occur in healthy people, such as the patellar tendon reflex, are called physiological reflexes. These differ from the pathological reflexes, the abnormal reflexes that are present in the patient (e.g. Babinski's, Chaddock's, Gordon's or Oppenheim's reflexes), which are generally absent in healthy people.

Another set of reflexes, the so-called primitive or early childhood reflexes, arise during the period of human development from newborn to adult. These are reflexes that are normal in the first year of life of a human being, i.e. occur physiologically, then disappear in the course of development and are considered pathological in adults. This group includes the grasp reflex, which is also called the gripping reflex.

## 2. THE GRASP REFLEX IN A CHILD

Grasp reflexes can be triggered in two different locations in a healthy infant: the hand's grasp reflex is called the palmar (palm) grasp reflex, whereas the sole of the foot's is the plantar (sole) grasp reflex. Only the palmar grasp reflex is significant in the forensic context.

The literature often refers to Louis Robinson (Robinson 1891) as the first person to describe the palmar grasp reflex, especially as he described the "grasping power" of 60 infants in his article "Darwinism in the nursery". In this article, Robinson considered the grasping power of 60 infants immediately after birth, who could not grasp deliberately at that time. Kotter (Kotter 2012), on the other hand,

describes two lead authors regarding the hand's grasp reflex and also attributes the first description to Wilhelm T. Preyer (Preyer 1882), whose article "The soul of the child" described the development of his son, whom he observed three times per day and whose development he documented precisely.

The examination of the grasp reflex in an infant consists of touching the palm with an object or, for example, a finger. The hand of the infant grasps the object tightly. Experiments have demonstrated that the infants' grip is so strong that they can even be lifted with the grasped object using the grasp reflex.

The same applies to the plantar grasp reflex of the foot. Here, for examination purposes, the sole of the foot is brushed, resulting in the toes bending.

Both reflexes regress in the course of the child's development. A grasp reflex would prevent a deliberate grasping. As children begin to hold objects between thumb and forefinger, the palmar reflex disappears by the 6<sup>th</sup> month of life so that the infant can support itself on its hands and learn to grasp. After the 6<sup>th</sup> month of life, the manifestation of the controlled motor function of the infant and the disappearance of the grasp reflex are part of normal develop-

Source: <https://commons.wikimedia.org/wiki/File:Greifreflex.JPG>



Grasp reflex in a five-month-old child

ment. A missing or increased grasp reflex in the first half year of an infant's life is an indication of a neurological disease, e.g. infantile cerebral palsy or spasticity in the neuromuscular system.

It is simple to understand why the infantile reflexes have to regress: to enable people to control their motor skills at will. On the one hand, constant, uncontrollable movements of the hands would make it impossible to hold objects. If people had uncontrolled grasp reflexes, they could not even hold a banana in their hands, as it would be crushed. It would also not be possible to hold a glass, and in reality, even under serious alcohol influence, people have no problem holding their glasses.

The same applies to the sole of the foot, which would prevent learning to walk. Given that walking is learned later during motor development using the hand to grip, the grasp reflex of the sole of the foot remains physiological until the age of one.

Voluntarily controlled motor skills develop as the brain matures. The myelination of the nerve cells begins before birth as various nerve cells begin to develop myelin sheaths. This leads to the faster conduction velocity of the nerves via the medullary sheaths that are formed (also called myelin sheaths). The conduction velocity of the learned voluntary motor skills is faster than the control of the reflex arcs, which results in the early childhood reflexes disappearing.

It should also be noted that the myelination of the nervous system continues after birth and reaches its peak during the first six months of life. It continues until puberty and beyond. This is one of the reasons why an adolescent's brain is more sensitive to the use of drugs, e.g. cannabis, and why, from a medical point of view, the use of cannabis is more harmful to adolescents than adults. Brain maturation is still ongoing in adolescents and is influenced

by the use of cannabinoids as the endocannabinoid endogen uses the same receptors as hashish, but with different effects on the development of cognitive function.

### 3. THE GRASP REFLEX IN ADULTS

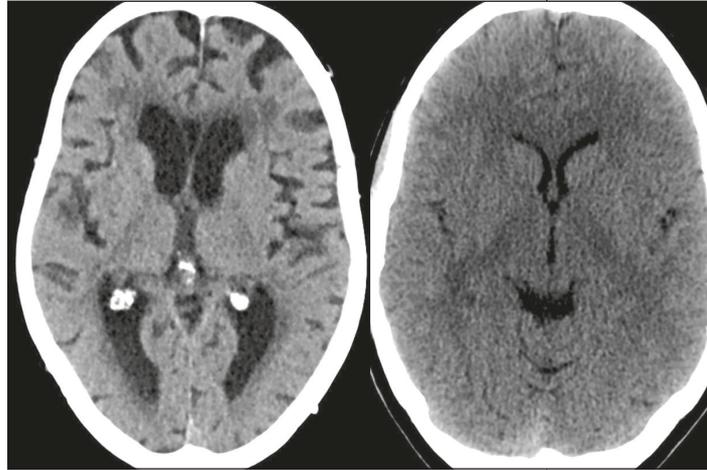
A grasp reflex cannot be detected in a normal, healthy adult. It is obligately pathologically associated with people with severe brain disorders.

Some authors further summarise the term grasp reflex. E.g. under the term hand grasp reflex, Pöck summarises (Pöck 1994): in the case of illness, claspings movements in the patient after the sudden stretching of the fingers or resistance at the elbow joint in the event of jerky stretching of the arm. Pöck includes other phenomena, such as clinging or reaching, under the grasp reflex and refers to these symptoms as an expression of general brain damage or as a symptom of intracranial pressure. Other authors, such as Mummenthaler and Mattle as well as Masuhr (Mummenthaler/Mattle 2012; Masuhr 1998) describe the grasp reflex in the original sense with a simple reference to the grasping movement of a hand. This description does not include the elbow joint or other hand movements. A classic clinical picture of a hand grasp reflex is described here as symptomatic of severe brain disorders, such as e.g. apallic syndrome. Apallic syndrome denotes the vegetative state of a patient. Such patients lie in bed with their eyes open and it is impossible to get through to them. They do not respond to stimuli in their environment, are unable to communicate and show no signs of conscious perceptions. Patients in a vegetative coma usually have a preserved respiratory function. The condition is also referred to as "persistent vegetative state" (abbreviated to PVS), i.e. a state of permanent vegetative function. The causes of this serious brain disorder vary and may

be e.g. traumatic or infectious. The list of possible causes is long, but one thing they have in common is that they lead to severe disorders and tissue loss in the cerebral cortex (cortex cerebri) and usually only vegetative functions, such as respiration, digestion and perspiration, are present. Primarily the higher functions of human beings, such as the processing of sensory stimuli, sight, planning of voluntary movements and others, are located in the cerebral cortex. There are many debates in the medical world about the prognosis of severe cortex disorders, which also differs with regard to the cause of the underlying disease.

As diagnostic apparatus have become more prominent in modern medicine (MRI and functional MRI, CT, EEG and evoked potentials), the grasp reflexes are shown to be clinical symptoms in the clinical studies of these patients. The difference is that images of organs are produced in sectional views in the diagnostic apparatus of magnetic resonance imaging (MRI) and computer tomography (CT); however, the clinical situation of the patient is not determined by these images without a physical examination. The same applies to those medical examinations which, for example, measure currents as an expression of function, such as electroencephalography or the measurement of brain waves for stimuli, the so-called evoked potentials. The return of the grasp reflex is a clinical diagnosis and occurs when the mature brain structures fail and the vegetative structures are still present. The presence of vegetative functions distinguishes vegetative coma patients from the brain dead, who no longer have any function in the brain. The PVS condition is a clinical symptom of seriously ill and severely brain-damaged patients, which is diagnosed by physical examination in conjunction with the diagnostic apparatus.

Source: Öhman



**On the left: brain of a seriously ill patient with an impaired reflex status. On the right: brain without pathological findings (both images made with axial CT)<sup>1</sup>**

#### **4. THE GRASP REFLEX IN FORENSICS**

This results in two factors for the consideration of “grasp reflexes” as the cause for firing. Firstly, it concerns a group of patients who are generally no longer able to hold a weapon in their hand. Thus, in most cases, the question of a grasp reflex in a normal, neurological examination is unnecessary. The presence of a grasp reflex in a healthy person is medically excluded.

One difficulty here is that examining the grasp reflex is not part of a normal neurological examination. It is one of the differential diagnostic examinations, which usually only occur in the case of the most neurologically ill patients and are therefore only performed by neurologists or neurosurgeons who also work with such patients on a daily basis. Neurologists who only examine walking and talking patients in their daily work will not clinically see grasp reflexes. It is therefore necessary to consult a qualified, differential diagnostics expert regarding the regular measures of trained assessors who are involved in the treatment of severely neurologically ill patients on a daily basis.

Even if the connections to brain development appear difficult, the quality assessment of examinations is thus simpler from a legal perspective: healthy, clinical findings of a person and the existence of a grasp reflex are mutually exclusive. There is a misjudgement in the case of such a report.

Furthermore, there are no indications that drug use (e.g. heroin or cocaine) has a direct influence on the development of a grasp reflex. At the same time, it should be mentioned that there is no such thing as a short-term grasp reflex, rather that if such exists for a long period of time, usually even persistent, it is thus there permanently until the end of the patient's life.

### **5. THE GRASP REFLEX IN FIRE-ARM OFFENCES**

In firearm offences, the question of accidental or unintentional firing often arises. Therefore, statements from gunmen occasionally indicate that there was a grasp reflex. This is usually done to emphasise the unintentional nature of the shooting. Lawyers often demonstrate a degree of uncertainty in dealing with this issue. As a purely medical question, this falls within the realm of a suitably qualified medical doctor.

Firearm events are assessed by experts from various specialist areas (e.g. firearm experts, dactyloscopy, blood pattern analysis, DNA, crime reconstruction and other disciplines) based on the fundamentals of their specific forensic field. All experts are subject to the general, forensic standards for trace and evidence conservation, prevention of contamination, training and further education as well as the use of suitable, modern forensic investigation methods. Questions, on the other hand, and the possible answers from the individual disciplines differ depending on their field of expertise. A forensic firearms expert

primarily assesses the technical aspect of the weapon and ammunition in the context of the act. Forensic firearms examiners and experts cannot and may not make statements about the reflex status of a person, especially as they lack medical expertise.

Grasp reflexes are not the cause of triggering shooting as they are associated with severe brain disorders. Therefore, the indication of a grasp reflex as the cause of a homicide must be considered as subterfuge.

Should it become necessary in a proceeding to have the question of whether a grasp reflex exists assessed by an expert, it is recommended at the same time that the cause of the development of the grasp reflex is diagnosed and that the patient is provided with proper treatment for his underlying disease.

### **6. OTHER NEUROLOGICAL AND NEUROSURGICAL ASPECTS IN FORENSICS**

In addition to the grasp reflex, there are other neurological and neurosurgical subjects that have forensic significance and can often lead to misinterpretations in lawsuits. Thus, some examples are given below.

One example is traumatic brain injury. The correct cause of death from a single shot through the skull and brain which is incompatible with life is e.g. "central failure as a result of a head-shot injury" or "brain paralysis as a result of a head shot", especially since the brain is damaged by the shot as the first organ of the body with an unsustainable injury. These injuries can be found for example in long-range gunshot wounds at the base of the skull with the destruction of the cerebral vessels. Survival without the afferent cerebral vessels as well as the large cerebral veins is impossible and death occurs directly. Thus, the primary cause of death in the case of a

head shot with massive brain destruction is central failure. Other organ diagnoses as cause of death in the case of the quick death of a previously healthy person after a single head shot are medically unfounded.

Another forensic problem area often results from the temporal development of brain injuries, e.g. as a result of dull traumas. Increased swelling of the brain tissue usually follows such a brain injury. Meanwhile, the critical condition of the patient, depending on the circumstances as well as the extent and location of the injury, also deteriorates over a longer period of time. From a forensic point of view, this means that patients with corresponding brain injuries are still able to act and communicate in the early phase following the injury. Therefore, the condition of a patient in a comatose state with a pronounced brain swelling does not necessarily mean that incapacitation occurs immediately after the emergence of a brain injury by a blunt trauma. These periods may not only last minutes, but possibly also hours. Forensically, these contents are important for trace analyses at crime scenes. If there is any swelling of the brain, it may also be the case that some of the traces were caused by the injured persons themselves at the scene of the crime. This has implications for the crime reconstruction and disregarding this circumstance leads to cases in which post-crime traces are mistakenly assigned to the primary traces of the crime scene.

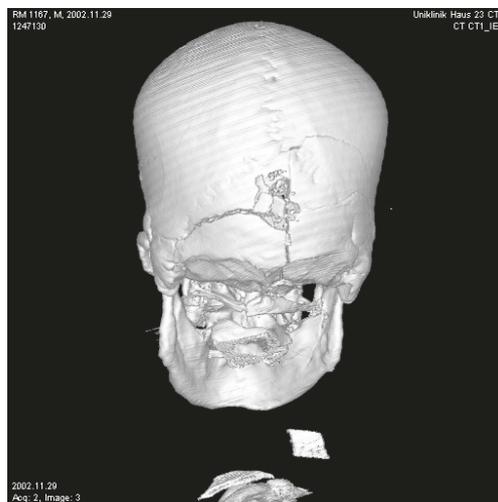
The forensic difficulties in dealing with neurological and neurosurgical contexts have two causes. On the one hand, clinical neurological or neurosurgical content is not part of forensic education and training and, on the other hand, autopsy as a method is destructive.

The central nervous system, consisting of the brain and the spinal cord, is naturally embedded in bone structures for its protec-

tion. Thus, there is only a limited volume within the skull. If the volume inside the cranial cavity increases, e.g. due to tissue swelling or bleeding, the sensitive brain tissue comes under pressure and suffers damage. The longer the increased cerebral pressure lasts and the more the pressure is increased, the greater the tissue damage.

This illustrates the problem with autopsy. In order to view the contents of the cranium, the bony structures must be sawn. The brain is firmly attached to the body by its nerve branches and vessels in the cranial cavity, so removing the brain always involves additional destruction of the basal cerebral structures that must be cut through. Autopsy is therefore a destructive process and highly dependent on the accuracy of the dissection.

Source: Brodbeck



Exit point from a skull in post-mortem computer tomography<sup>2</sup>

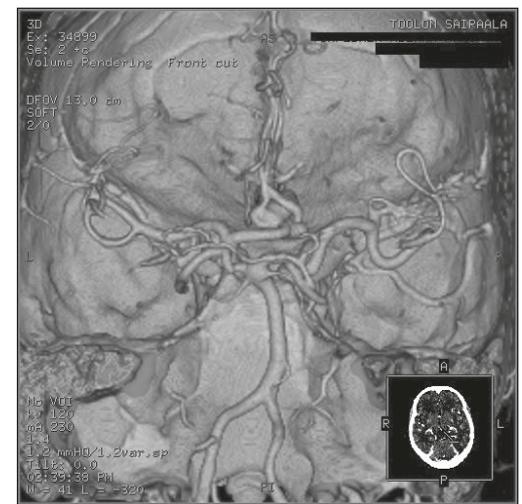
Content-limited findings in the documentation of autopsies may be indicative of such a problem. Thus, for example, the destruction of the skull base is described without presenting the individual structures and without describing the basal damage to the brain in detail. This problem is also often seen in autopsy photography, in the form of inaccurate photo documentation. For example, only the bone or the

brain findings are photographed as partial findings. Both sides of the damage are documented in careful photographic autopsies and the key findings, such as vascular lesions of the cerebral veins, are described in a good autopsy report.

Moreover, the autopsy technique is also important for a correct and proper assessment of a skull injury. If the brain is carelessly sectioned with just a few cuts, damage in undivided sections of the brain or the magnitude of the damage often remains undocumented. It is therefore important to ensure a regular and rather small-scale division of the structured and a detailed description of the destroyed structures. Gunshot wounds to the brain often lead to more extensive damage, as the temporary wound cavity causes pressure damage to the surrounding tissue. Thus, in basal, extensive injuries in the area of the carotid, the alleged injury to a large cerebral vein and the exclusion of the large cerebral artery are implausible and, without documentation of these findings, are often classified as wrong, especially since the key structures are stored close to each other at the brain base.

Difficulties often present themselves when assessing the danger to life posed by cranial cerebral injuries. At the beginning of an event, there is damage to the brain structures and vessels, which can cause symptoms and bleeding and lead to death. In the course of applying force to the head, bleeding in the skull often occurs (so-called intracranial haemorrhages), which are named based on their position to the meninges. Thus, there is an epidural haemorrhage on the hard meninges (dura mater), a subdural haemorrhage below the hard meninges and a subarachnoid haemorrhage below the soft arachnoid mater.

When small haemorrhages are immediately followed by appropriate, intensive medical care, their course is often in-



**Overview image (angio-CT) of the arterial vessels at the brain base of a living person with an aneurysm<sup>3</sup>**

conspicuous and the bleeding is rapidly dissipated by the body, e.g. with a bruise (haematoma). Neurosurgically, minor haemorrhages are usually treated in intensive care, as they can also lead to brain death. Hence, even small and rapidly resorbed haemorrhages are considered as life-threatening even if they proceed without clinical complications in the course of intensive care measures.

This becomes clear upon looking at the injury more closely. In the acute phase, the primary injury to the brain and its vessels as well as the resulting bleeding into the brain tissue cause the symptoms. The severity of the bleeding and the symptoms it causes depends on the location of the haemorrhage and its size. However, a haemorrhage in the skull is due to a vascular injury, which results in the life-threatening condition of the patient, as there is the risk of secondary bleeding. In addition to the secondary bleeding, the patient is further threatened by the development of a cerebral oedema (cerebral swelling). Secondary bleeding can still occur weeks after an initial small haemorrhage and can lead to brain death. Even if the small haemorrhage can no longer be seen in the imaging

procedures, the trauma-related weak spot in the vessel wall persists. The vascular defect is a risk to the patient, even if the patient survived the first haemorrhage.

Radiological diagnosis can only show the cerebral haemorrhage. The underlying vascular injuries of the vessel walls themselves cannot be shown radiologically. They subsequently become a weak spot for the patient and can be reopened, e.g. by blood pressure peaks. The intensive care measures in such cases serve to monitor and ensure early intervention in the case of a secondary bleeding.

Thus, patients with minor cerebral haemorrhages should always be treated in neurosurgical units, especially since time plays a major role in survival in secondary bleeding complications and only transporting the patient after a secondary bleeding represents a significantly reduced prognosis factor for the patient. Due to the risk of secondary bleeding, patients are admitted to hospital overnight even in the case of simple craniocerebral traumas, such as concussion (*commotio cerebri*). This is for the safety of the patient.

Legal cases often deal with the consequences of a craniocerebral trauma for the survivor and again, the focus must be placed on the patient's clinical condition. Such patients are in the early stages of neurosurgery, which, however, subsequently results in the patients being transferred to rehabilitation. Especially in the case of victims of physical violence, mental symptoms are often also added to this, e.g. in the course of an acute stress disorder, which often results in a post-traumatic stress disorder. Therefore, in the follow-up rehabilitation of patients with minor haemorrhages, psychiatric treatment usually takes priority.

However, at this stage in particular, it should not be forgotten that craniocerebral traumas with intracranial haemorrhage

leave behind symptoms that require specific cognitive testing and are too easily attributed to psychiatric illness. Regardless of the size of the haemorrhage, a variety of neurological symptoms, such as fatigue, susceptibility to exhaustion, speech disorders, cognitive disorders and others, persist for even years after the trauma. If these are assigned prematurely to a mental illness, the cognitive deficits remain untreated. Hence, performing cognitive performance diagnostics is recommended for assessing the damage in a survivor of a craniocerebral trauma, regardless of the size of the intracranial haemorrhage. In many cases, these late deficits recede over time; however, they may also persist. Careful differentiation should therefore be made between mental and physical symptoms.

## CONCLUSION

In summary, the following can be stated:

1. The grasp reflex is an expression of severe brain damage and is incompatible with an inconspicuous brain finding. A healthy, neurological finding excludes the presence of a grasp reflex.
2. A grasp reflex cannot be caused by the consumption of cocaine or heroin. Moreover, no occurrence of grasp reflexes caused directly by any other substance use has been described.
3. A recurrent grasp reflex in an adult human being after infancy is a permanent finding. It is not possible for a grasp reflex to be activated for a short time (seconds, minutes) and then disappear again.
4. Common disorders that lead to the recurrence of a grasp reflex are severe, general brain damage, like the persistent vegetative state, which was also formerly referred to as apallic syndrome or coma vigil.
5. The medical examination for the possible existence of a grasp reflex must be

carried out by a physician who is regularly involved with differential diagnostics and neurological special diagnostics on brain-damaged people, since the grasp reflex does not usually form part of a standard neurological examination.

6. The assessment of a grasp reflex cannot be carried out by a forensic firearms examiner or expert.
7. The grasp reflex is sometimes cited to explain allegedly accidental shots. In reality, however, it has no forensic significance and the indication of a grasp reflex to explain fatal shooting incidents should be considered subterfuge.
8. Other neurosurgical problems in the field of forensics include the ability to

act during oedema formation in the brain as well as the correct determination of the cause of death. Again, clinical neurological and neurosurgical aspects must be considered here to ensure the quality of the forensic assessment.

9. Any intracranial haemorrhage, regardless of size, should be considered as potentially life-threatening due to the underlying brain and vascular damage. This also applies in cases with no complications, which are often wrongly assessed with regard to their danger to life.
10. Cognitive assessment is recommended to assess the long-term physical damage after surviving craniocerebral trauma.

<sup>1</sup> In contrast to those with healthy brains, there is considerable enlargement of the cerebral chambers on the left side, a considerable narrowing of the cerebral cortex as well as calcifications in the cerebral chambers.

<sup>2</sup> While in an autopsy, the structures are destroyed by the dissection and their localisation is no longer clearly comprehensible, post-mortem imaging can be used to depict the bone splinters of the skull in their real structure and localisation.

<sup>3</sup> The structures at the brain base lie close to each other, so head wounds usually result in collateral damages to neighbouring structures.

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