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# The role of the right hemisphere in the recovery of stroke-related aphasia: A systematic review

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ABSTRACT

Stroke in the language dominant hemisphere is the most frequent cause of aphasia. In the course of post-stroke aphasia different mechanisms can contribute to the recovery of language: recovery from ischemia, compensatory rerouting of language modalities and neuroplasticity occur at different time scales after the initial injury. These mechanisms may occur spontaneously or may be induced or influenced by various therapeutic interventions. This report contains a systematic review of the literature concerning the debated role of the right hemisphere in the recovery from stroke-related aphasia. The existing literature was approached using the PICOS principle and well-established inclusion and exclusion criteria. Although many gaps remain in the knowledge on the role of the right hemisphere, there is some evidence of a facilitation of spontaneous language recovery in the acute and subacute phase. In the subacute and chronic phase, the right hemisphere homologous language areas, along with memory and attention-related areas, facilitate treatment related improvement. In contrast, in therapy-free periods in the chronic stage, the right hemisphere no longer contributes to language recovery or may even be inhibitory. Injury-, language- and therapy-related variables impact on the role of the right hemisphere in aphasia recovery.



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## 1. Introduction

### 1.1. The recovery of aphasia: general considerations

Aphasia is a language disorder due to an acquired brain injury, acute or degenerative, in individuals who have had a normal language development (van Borsel, 2008). In about 70% of the cases the lesion is located in the left hemisphere (Hoffmann & Chen, 2013). Aphasia is characterized by one or more affected language modalities. Comprehension and production problems can occur both in spoken and written language. The severity of these disorders varies individually and can range from mild to very severe, resulting in impaired communication, participation and quality of life. In about 85% the cause of aphasia is a stroke (Peters et al., 2014), which leads to loss of neurons with disruption of network functions and results in language dysfunction (Kuks, 2007). In the majority of patients the language problem becomes chronic (Laska, Hellblom, Murray, Kahan, & Von Arbin, 2001; Maas et al., 2012.)

After a stroke, people with aphasia may exhibit a degree of spontaneous recovery, which is most noticeable during the first weeks or months post stroke onset. In addition, language therapy can be beneficial for further recovery (Aerts, van Mierlo, Hartsuiker, Santens, & De Letter, 2014; Nickels, 2002; Pulvermuller et al., 2001; Robey, Schultz, Crawford, & Sinner, 1999). Several physiological mechanisms underly spontaneous or therapy-related aphasia recovery. Based on the underlying physiological mechanisms aphasia recovery is divided into the acute, subacute, and chronic phase. The clinical progress in the acute phase, the first three weeks after a stroke (Bartha & Benke, 2003; Kiran, 2012), depends on the extent to which (a part of) the perfusion can be restored. If a successful reperfusion and a restoration of a normal glucose metabolism is realized, this may have a positive impact on the recovery of language functions (Heiss, Kessler, Karbe, Fink, & Pawlik, 1993; Hillis et al., 2001. Kiran, 2012). The decrease of cerebral edema and the disappearance of local inflammations may further contribute to recovery (Baldwin & McCoy, 2010). In this phase, the so-called “penumbra” plays a crucial role. This is the zone around an irreversibly damaged core infarction. Penumbra tissue is able to survive but is dysfunctional as a consequence of inadequate oxygen supply (Astrup, Siesjo, & Symon, 1981). If the local perfusion does not improve, spontaneously or by therapeutic intervention, neuronal loss will occur (D. W. Heiss et al., 1992). The recovery of the penumbra is a predictor of clinical progress (Baron, 1999).

In the subacute phase, up to six months after a stroke (Kiran, 2012), recovery of language functions can occur as a function of plastic changes in the brain or due to restoration of diaschisis. Neuroplasticity refers to the ability of the brain to form new neural connections or to repair damaged connections. Neuroplasticity is characterized by two phenomena namely sprouting, the growth of new dendrites at the level of the axons (Carmichael, 2006), and the activation of silent synapses (Bach-y-Rita, 1990). In addition the restoration of diaschisis may contribute to language recovery in this stage. Diaschisis is the occurrence of functional defects in an intact part of the nervous system as a result of a lesion at a distance that is structurally connected to it (von Monakow, 1914). There is a positive correlation between the decrease in diaschisis and recovery of language functions in the subacute phase (Cappa et al., 1997; Jarso et al., 2013.).

Aphasia recovery in the chronic phase, after six months (Hillis, 2005), is mainly therapy-related as spontaneous recovery and restoration of diaschisis are minimal at this stage (Hillis & Heidler, 2002; Robey, 1998). Consequently it can be concluded with more certainty that the measured neuroplasticity after a therapy is the direct result of the therapeutic intervention, in contrast to the acute and subacute phase where a possible degree of spontaneous recovery should be taken into account.

### 1.2. The right hemisphere in aphasia recovery

Within studies where spontaneous or therapy-related recovery is examined, the laterality plays an important role (Barbancho et al., 2015 .; Crosson et al., 2009; Pulvermüller, Hauk, Zohsel, Neininger, & Mohr, 2005; Saur et al., 2006). The central question is whether a transfer of language functions occurs to the perilesional areas, the right hemisphere or a combination of both (Turkeltaub, Messing, Norise, & Hamilton, 2011). Especially the role of the right hemisphere in language reorganization after stroke is a matter of debate.

During the development of the brain and the acquisition of language, one hemisphere becomes dominant for language functions. Most of the time, the primary language areas are situated in the left hemisphere (Knecht et al., 2000), resulting in